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Editorial

Human capital and cooperation: the critical success factors for sustainable growth and development



Marco Villa COO Technip Energies President of ANIMP As the new President of ANIMP, the Italian Association of Industrial Plant Engineering Companies, I am pleased to introduce the latest number of *Industrial Plants*, our yearly publication for international audiences.

Our Association includes engineering firms and general contractors, plant component manufacturers, service suppliers as well as universities and consulting firms, with the main focus on designing and building large industrial plants in every corner of the world. With more than 500 current members, ANIMP strives to develop a world-class supply chain, competitive globally in any industrial plant market, in order to promote growth, development, innovation and international cooperation.

And this year we are celebrating our 50th anniversary! These last few years have been characterized by two unpredictable, unexpected and dramatic events: the pandemic and the Russia-Ukraine conflict.

While on the one hand they have brought about a recession, a significant increase in the price of gas and therefore of energy, as well as more inflation accompanied by a stringent monetary policy of higher interest rates, they have also highlighted the awareness that the world requires an energy system that balances accessibility, availability and sustainability.

Consequently, there is an urgent need to increase the investments in the energy industry and to accelerate the development of new projects, with a particular focus on natural gas, LNG and zero carbon solutions - and let us not forget the fundamental need to decar-

bonize and to modernize our traditional industries. This opens huge new opportunities in our markets.

The market evolution towards the energy transition also requires a different way of working, characterized by an increasingly growing commitment for more emphatic cooperation together with our clients - right from the conception of new investments. This is needed in order to be able to select the right combination of efficient and low- or zero- carbon energy management systems.

"The markets evolution towards the energy transition requires us to adopt a different way of working, characterized by an important and increasingly growing commitment to cooperate with our Clients right from the conception phases of new investments

Digitalization will play a key role in reducing the investment costs, the operating costs and the carbon emissions of all infrastructural projects. An example of this is the *digital twin* which - thanks to the use of simulations, real-time data and artificial intelligence - allows us to reduce the cost of new investments, via better planning and cost optimization in order to achieve greater productivity and to mitigate operational risks. The technology world is also undergoing a rapid evolution. In fact, although there are some technologies already in existence that we must continue to improve, most of the technologies that will characterize the energy transition are nascent and need skills and resources to develop them from the pilot stage to full industrial scale. Therefore, all of us must make our talents and experience available for this task.

However, the success in developing technologies lies in one word: collaboration. The industrial world, the startups, the universities, the research organizations in various fields, the Governmental institutions and the financial world will have to work increasingly collaboratively, throughout the globe.

"The success in the development of technologies and optimal plant solutions lies in the development of human capital and collaboration

The challenges awaiting us are indeed characterized by technology, innovation and partnership, but they will be solved successfully primarily thanks to the development of human capital. The engine of development is neither thermal nor electric – this engine is human. We need growing skills and younger generations to come and to develop a cleaner energy industry. Only with everyone's

contribution and by working together we can plan a sustainable future.

"The Italian industry looks at the future with optimism, since historically we have always excelled in inventiveness, flexibility and capacity to adapt to new and unpredictable circumstances

Therefore, in spite of the current difficulties, risk and uncertainties, we look at the future with substantial optimism. We trust our skills, capabilities, flexibility and imagination. Historically, the Italian industry has always excelled in entrepreneurship, in inventiveness, in its capacity to adapt to new and unpredictable circumstances, in the speed of adoption and optimization of new breakthrough technologies. Indeed, in the industrial plants sector, we are one of the world leaders, with more than 5,000 companies, large and small, employing more than 400,000 people, active in this field.

We are therefore ready for the new challenges. In ANIMP, we also remain particularly grateful to the Italian and other partner industries for their strong and continuing commitment and support.

Marco Villa

Marco Villa

Marco Villa, the President of ANIMP since 2022, is the Chief Operating Officer of Technip Energies. Previously he was President of TechnipFMC Onshore / Offshore (now Technip Energies) for Europe, the Middle East, India and Africa. From 2003 to 2017, Marco Villa held various management positions in Technip, including President Europe, Middle East, India and Africa, President and CEO of Region B, Chief Financial Officer of Region B and Head of Export & Project Finance of Technip Italy. Before joining Technip, he had worked as a financial specialist in Finmeccanica, the Italian multinational company specializing in the aerospace, defense and security industries, and as the head of the Finance and Risk Management Division of Telespazio (Telecom Italia Group), a European services company for space flights. He graduated with honors in Economics and Commerce at the University of Rome.

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eFuels and their production, an immediate solution for the Energy Transition

Technip Energies is already committed to eFuels production, in particular to SAF, through the agreement with Arcadia eFuels to develop first Power to Liquid commercial plant

Luciano De Gaetano, Project Director of Arcadia eFuels projects Technip Energies Italy

> he fight against Earth global warming and climate change is becoming more and more urgent, with a growing number of countries committing to net zero emissions by 2050: achieving this means a huge decline in the use of coal, oil and gas.

One of the pillars of world Energy Transition from traditional fossil sources to renewables (solar, wind, geo, hydro) are the so called eFuels, or synthetic fuels, which have the advantage to be used in currently available engines and distribution facilities.

"eFuels, or synthetic fuels, have the advantage in that they can be used in currently available engines and distribution facilities

In particular, the use of eFuels is of outmost importance in those kinds of applications (i.e. aircrafts engines), where possible alternatives (electricity, hydrogen) are today not viable. At same time, eFuels are excellent energy carriers, thanks to their high energy density, and because they can be transported at room temperature and pressure; such feature largely overcomes the problems related to natural intermittent production of renewables and limitations in their storage and distribution.

Moreover, after the European Commission has presented a plan to allow sales of new cars with internal combustion engines after 2035 if they run on eFuels only, a huge interest for them and for their production has grown in the industrial community. As a matter of fact, today there are basically no industrial plants in operation to produce such type of fuels.

What are eFuels?

In general eFuels, such as eGasoline, eDiesel, eKerosene (or eJet Fuel), eMethanol, are all fuels in gas or liquid form that are produced from renewable sources or decarbonised electricity. This raw material differentiates them from biofuels, which are primarily produced from biomass.

Specifically, eFuels production is obtained through the generation of Green Hydrogen. This type of hydrogen is produced by means of an electrolysis process, powered by a significant amount of renewable electricity, that breaks down water (e.g. seawater from desalination plants) into its components of hydrogen and oxygen.

In a second process step, with the aid of e.g. Fischer-Tropsch synthesis, the hydrogen is combined at high pressure and temperature with CO2 recovered from air or from biogenic sources, and converted into a synthetic crude, eventually separated in different cuts. Because electricity is used for the production of eFuels, the overall process is known as a Power-to-Liquid (PtL). The climate neutrality of eFuels derives from the fact

that electricity from renewable energies is used in their production and only as much CO2 is emitted during use as was previously bound during production.

What are SAFs?

Among eFuels, great significance is taken by the Sustainable Aviation Fuels (SAF): they are the jet fuels, derived both from renewable sources and from biomass, used for aircrafts engines.

Their production is probably the most urgent among all non-fossil fuels because the potential alternatives to them seems today not practical: the full electricpowered flight will only be possible for short-haul journeys in the foreseeable future due to the weight of the batteries required, while use of hydrogen, which has an energy density per unit volume that is one quarter of traditional jet fuel, would imply a redesign of much of the aircrafts, from the propulsion system to fuel storage,





as well as important changes to airport and re-fueling infrastructures.

On the contrary, SAF can be used immediately: a market leader has already conducted the first tests of 100% SAF in their jet engines, demonstrating that current engines for large civil and business jet applications can operate with 100% SAF as a full "drop-in" option. At present, however, SAF is only certified for blends up to 50% with conventional jet fuel and can be used on all current commercial engines. Moreover, a very recent EU declaration has set the growing percentages of eFuels in SAF blends from current days until 2050.

Arcadia eFuels ENDOR Project

Technip Energies Italy (TEN) has recently signed with Arcadia eFuels (AEF), a company fully committed to build facilities to produce the world's future fuels an Agreement, to develop a Front End Engineering Design (FEED) for the worldwide first PtL industrial plant able to produce 2000 BPD (approximately 100 million liters per year) of eFuels, mainly eKerosene for SAF application.

Denmark. In such country, the renewable electricity produced by the offshore windmills is already quite large, and in few years it will become of a magnitude not manageable by the electrical grid. Therefore, eFuels will become an excellent alternative to exploit such excess of energy. Site preparation of the area identified to build the plant is already on-going, while building and environmental permits' applications are under development: AEF counts to get

both in place by end of 2023.

For the core units of the plant, AEF has selected the G2L[™] eFuels technology provided by SASOL and TOPSOE (as Single Point Licensor, SPL), both already committed since years to find clean energy solutions: in developing the FEED, TEN will benefit of the successful cooperation, established in previous gas-to-liquid experiences, with these global technology leaders.

A key element in the process scheme is the Water Electrolysis Package, necessary for producing hydrogen which will be used, together with recovered bio CO2, as feedstocks to G2L[™] eFuels units. AEF and TEN are currently selecting the best option for a system, whose size will be in the order of 250 MW, able to generate sufficient amount of hydrogen to satisfy plant production. For the preparation of water needed by the Electrolysers, AEF has already selected technical solutions which will be provided by Veolia Water Technologies.

By leveraging engineering expertise and technological capabilities to complement/integrate G2L[™] eFuels process, water production & electrolysis, and some other innovative solutions applied to optimize overall plant CAPEX and efficiency, TEN will definitively support AEF in bringing this challenging project to FID and to roll it



The location selected by AEF for this facility is the harbor of Vordingborg (southern part of Zeeland), in



over to the execution phase once FEED will be completed.

At large, AEF and TEN have established as well the basis for long lasting cooperation, joining forces to develop technological and engineering solutions (i.e.

high degree of modularization) for this first plant in Denmark which can be potentially re-applied in other worldwide locations, which AEF is currently seeking based on renewable electricity and CO2 availability at relatively low cost due to their proximity to sources.



Luciano De Gaetano

Luciano De Gaetano, has graduated in Chemical Engineering at Rome University "La Sapienza" he holds an MBA in International Finance at St. John's University of New York. He has been working in Technip Energies Italy since 1997, with assignments with increasing levels of responsibility first in the Process Department and then in Project Management Teams, for diversified typologies of Oil&Gas plants. He is currently engaged for TEN in the role of Project Director of Arcadia eFuels projects.



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Hydrogen-rich compressor packages for refinery applications

Clauger-Technofrigo supplied engineered compression packages for a tail gas application at a refinery in Azerbaijan. Utilizing GEA's largest screw compressor in the range, the GEA model "XH", this system is part of a modernization program of the refinery complex in Azerbaijan

Silvana Bazzani, Head of Sales Giuseppe Camposeo, Engineering Manager PGE Division, Clauger Technofrigo



Clauger-Technofrigo tail gas compression packages featuring GEA XH oil-flooded, single-stage screw compressors

lauger-Technofrigo's hydrogen rich gas compression packages were selected as part of Pressure Swing Adsorption (PSA) technology to supply high-quality hydrogen for the modernization of an Oil Refinery in Azerbaijan. Pure hydrogen is essential to the refining

process, where it is used to decontaminate oil and facilitate catalytic processes that produce clean-burning fuels, including those that meet Euro V standards for vehicle emissions.

"Clauger-Technofrigo's hydrogen rich gas compression packages were selected as part of Pressure Swing Adsorption (PSA) technology to supply high-quality hydrogen for the modernization of an Oil Refinery in Azerbaijan The PSA technology will help Azerbaijan meet the growing domestic demand for transportation fuels. Hydrogen technology is an important element of this modernization program aimed to remain among the most advanced refineries in the region, further improving environmental protection along with the quality of life in Azerbaijan.

When completed, the modernization will enable the refinery to process 7.5 million metric tons per annum of crude oil blended from local sources. Hydrogen is key in the refining process, being produced as a byproduct of refining, and intentionally from a steam methane reformer. PSA technology purifies this hydrogen so it essentially can be recycled into the refinery to remove impurities and to perform catalytic processes that transform crude oil into clean fuels and other products.

Tail gas treatment

The new gas compression unit receive tail gas – a gas mixture composition with up to ~70% hydrogen - from the PSA System and is the key to stabilize operating pressure in the PSA. Hydrogen-rich gas from the PSA at almost atmospheric pressure is compressed up to 6,7 bar(g) and then cooled down to 40°C before returning to the refinery's network.

"The core of the package is an API619, single stage oil-flooded screw compressor

The core of the package is an API619, single stage oil-flooded screw compressor. Oil carryover in the compressed gas is dramatically reduced into several oil separation stages to reach 1 ppm of oil content.

The compressor is fully packaged in a multi-skid philosophy. The gear multiplier between compressor and 1.3 MW electric motor to increase flow capacity and the complete oil circuit with all necessary redundancies typical of refineries are all skid-mounted with the highest degree of preassembly.

We had to remove some parts to allow shipment of the same and arrive to a final dimension of 12m (L) x 3,28 m (W) x 4,7 m (H). See figures before and after disassembly done in workshop:



AFTER

BEFORE



18

The complete driver compressor system consisted of:

- Oil flooded screw compressor;
- HSS coupling;
- Gearbox;
- LSS coupling;
- Induction motor.

The operating speed of the screw compressor was 3400 rpm. The operating speed of the

induction motor was 1490 rpm with a gear ratio of \sim 2.3 (fig. 1).

A torsional analysis according to API 619 5th Ed., 2010 was carried out, adopting a lumped parameters model with a definite number of inertial masses connected each other by mass-less shaft intervals having proper torsional stiffness and damping (**Tab. 1**).

Torsional natural frequencies and relevant vibration mode shapes were calculated and compared with the excitation harmonics as shown in Campbell Diagram (fig. 2):

To avoid resonance during transient phases, an additional transient calculation was performed to investigate the response of the system during the following events:

- start-up;
- motor 3-phase short circuit;
- motor 2-phase short circuit;
- motor phase opposition reclosing.

The four transient events were deeply evaluated and as a consequence a special coupling design was adopted.

Added Ip Added Kt Station kg-m² N-m/rad * ka Description 1717.7 52.8 6.48E+06 ction Motor 2 142.2/2 0.605 2.90E+06 LSS half coupling 3 142.2/2 0.605 4.88E+06 LSS half coupling 4 342 6 001 LSS OF 5 79 0.226 1.93E+06 23 HSS gear 6 55.9/2 0.14 8.81E+05 2.3 HSS half coup 7 55.9/2 0.14 3.97E+06 2.3 HSS half coupling 8 1277 15.497 2.3 Screw Compressor



Figure 1



0.15-714

5L2-5m

Figure 2





Table 1

Clauger-Technofrigo workshop has been assembling packages of all sizes for many years, however this time the height of the compression package was giving some headache to the workshop manager, Monica Brunetti. "Every time we have packages with such dimensions and vertical separators, we need to do a detailed study to consider all factors, including height of doors of our workshop! After packing height of package was 5,25 m, with a significant weight of 43 tons. Sometimes, and this is the case, we reach dimensions that are very near to the limits of our internal facilities. Anyway, it is always amazing to find new challenges and solve them. When we are able to reach a good result, that meet Client expectations, it is always satisfactory and all efforts all fully repaid".

Once the Tail Gas Compressor Package arrived at Oil Refinery, it was time for the installation, commissioning, and start-up to begin. The commissioning process involved the preparation and testing of the equipment to ensure that it was functioning properly and meeting the required specifications.

The control logic for the package was implemented in the client's Distributed Control System (DCS), ensuring that the compressor was operating smoothly and efficiently.

"With the hard work and dedication of the technical team, the Tail Gas Compressor was successfully put in service and integrated into the refinery's operations, providing a reliable and efficient source of a fuel gas to the plant facilities

The start-up of the compressor involved several steps, including the initial testing of the equipment and the fine tuning of the compressor to ensure that it was working optimally.

Once the compressor package was fully commissioned and operational, it was important to ensure that it was working in harmony with the PSA (Pressure Swing Adsorption) unit. This was achieved by tuning the package to work optimally with the PSA unit, which helped to maximize the efficiency of the overall system. Overall, the installation, commissioning, and startup of the Tail Gas Compressor Package at Oil Refinery was a complex process that required careful planning, expert technical knowledge, and meticulous attention to detail. However, with the hard work and dedication of the technical team, the Tail Gas Compressor was successfully put in service and integrated into the refinery's operations, providing a reliable and efficient source of a fuel gas to the plant facilities.



Silvana Bazzani

Silvana Bazzani is the Head of Sales at PGE, Clauger Technofrigo. She holds a Master Degree in Chemical Engineering and has 20 years experience in sales of compression and refrigeration solutions for Energy, Oil & Gas and Chemical Markets.



Giuseppe Camposeo

Giuseppe Camposeo is the Engineering Manager of the PGE Division at Clauger Technofrigo. He has a Master Degree in Mechanical Engineering and MBA. He specializes in rotating machines including screw, reciprocating and centrifugal compressors for gas compression and refrigeration application plant in Energy, Oil & Gas and Chemical Markets.

Think global, act local: a winning growth concept for outlet markets

For 20 years, Cortem Group has embraced the philosophy of delocalization of commercial and product assembly activities to reach customers from all over the world faster in the face of increased in local content requirements

Francesca Merola, Communication & Marketing Specialist Cortem Group



ompanies of international scope deeply feel the theme of localization or relocation. The production relocation, which consists in a transfer or duplication of production activities in foreign sites in order to

obtain advantages, is a very complex phenomenon that fits into the wider context of international trade, which, despite being closely connected to modern society, has its origins as far back as the fifteenth century, or rather with the discovery of America, an event which also marked the birth of the world economic system.

International relocation has proved to be a successful economic strategy not only thanks to the ability to develop price containment policies that have allowed the achievement of better performances on international markets, but also thanks to the proximity to the outlet market, the increase in competitiveness business and diversification. In recent years, there has also been a rapid growth in Local Content Requirements, especially in strategic sectors such as Oil & Gas characterized by large economic revenues. These are policies imposed by governments that require companies to use goods produced or services supplied nationally to operate in each market and thus achieve employment, industrial and technological development objectives.

Cortem is the story of a small Italian company that began operating, initially with just a few people, in a niche sector such as the explosion-proof sector at the end of the 60s and which, over the years, has grown and structured itself as solid basis for diversified activities which led to an inevitable internalisation. Cortem today is a group that boasts 3 Sister Companies located in Singapore, Dubai, and Buenos Aires, 10 distribution hubs, 250 employees and a large sales network and represents one of the main players in the



explosion-proof market with a turnover of approximately 50 million euros.

"Cortem was a small Italian company that began operating in the '60s in a niche sector such as the explosionproof markets, and which, over the years, has grown and structured itself on a solid basis for diversified activities - which led to an inevitable internalisation



The concept "think global, act local" has always proved to be the winning model in the Group's strategies, increasingly dynamic in the creation of branches and in the delocalization of product assembly activities and commercial activities, while maintaining centralized production activity in Italy.

Explosion protection is often a forced choice. It is, in fact, the legislation that requires the application of certain standards of protection. For this, in addition to continuous research for the development of innovative quality products and the process adaptation of the products themselves to international standards, Cortem Group has always paid great attention to customized and engineered solutions in perfect "made in Italy" style.

Cortem's is the story of an Italian company, similar to that of many other Italian companies, in which the family business model and the managerial approach have amalgamated in a winning way; a story that teaches us that, to obtain the right balance between tradition, growth and innovation, there is a need for diversification and flexibility, in products, markets, production structures, in responses to customer needs.

"I have been working for Cortem for 7 years but I have known the company for much longer and I can say that it is an excellent example of Italian entrepreneurship which presents itself on the world market as a point of reference in the field of explosion-proof equipment, with solid historical roots, important technical skills and a globally recognized and appreciated brand." – explains Marianna Saragaglia, Commercial Director of the Group and Managing Director of the UAE branch Cortem Gulf - These will be the key principles that will continue to guide Cortem Group in the future because it certainly has the ability and expertise to increase its presence on the market, both at geographical area, and by entering other product sectors".

The relocation of Cortem Group began in the early 2000s with the aim of positioning itself in the heart of the desired markets to benefit from a much wider market, increasing competitiveness and diversification.

In 2003, the Sister Company The Ex Zone was opened in Buenos Aires, Argentina, the Cortem Group's reference center for the South American market. The Ex Zone spreads over an area of 600 m², of which 500 m² used as a warehouse. The organization, products and production system are checked annually by international laboratories according to the ISO 9001: 2015 quality standards. The management from the Italian headquarters, who has gained thirty years of experience in the Ex-market, and the local staff, who have a deep knowledge of regulations and electrical installations, are able to offer the highest levels of technical and

Marianna Saragaglia,

Commercial Director

Managing Director of

of the Group and

the UAE branch

Cortem Gulf

commercial assistance.

In 2006 Cortem Group arrives in the United Arab Emirates, a key country for the Oil&Gas sector and full of great opportunities for the explosion-proof sector. Since 2015 it has been operating on the UAE market thanks to the Sister Company Cortem Gulf based in the Jabel Ali free zone of Dubai where it occupies an area of 2,000 m² which houses commercial, administrative, and technical offices, an assembly and final control area and a warehouse. In it, Cortem was able to combine the western style of the Italian headquarters with the specific trends of the Emirates. "Local content is deeply felt in the UAE, governments invest in foreign companies that bring technological value and expertise to the UAE industry for the development of the local productive fabric. - explains Marianna Saragaglia, Managing Director of Cortem Gulf - For this reason, Cortem Gulf joined the ADNOC In-Country Value (ICV) program obtaining the certification in 2019. This important milestone marks Cortem Gulf's strategic commitment to the market in the Gulf countries. strong ties with local and foreign companies, solid investment plans in the United Arab Emirates, the use of local workers. Furthermore, it represents the long-term investment in the business of this area with important future growth plans."

Finally, in 2015, Cortem Group flew overseas and opened its own company in Singapore, Cortem Elfit South East Asia, to support its commitment in Southeast Asian countries and provide high-level design, sales, and assistance services in the whole region. The large headquarters of Cortem Elfit South East Asia consists of offices, a warehouse, and a production plant where mechanical machining and electrical operations are conducted.

Internal control of all production and sales processes, from technical analysis for product selection to drawing preparation, assembly, and after-sales assistance, is the method by which Cortem guarantees quality, safety and the reliability of its



products and services in every company of the Group. Furthermore, Cortem guarantees the production, technical and regulatory standards of the Group both of the Sister Companies and of the Hubs with annual Audits.

The services offered by Cortem Group in all its offices are:

- in-house design of standard solution
- in-house engineering design preparation for customized power & control panel solutions
- in-house assembly of junction boxes, power and control panels meeting IECEx, ATEX and ISO standards



"Today the Cortem Group - one of the main players in the explosion-proof market - has 3 Sister Companies in Singapore, Dubai, and Buenos Aires, 10 distribution hubs, 250 employees and an extensive sales network

- in-house aftersales and back-office support teamwide local stock & spare part depot
- regional training center to keep the customer informed on Cortem products and the explosion-proof legislation, often little known.

Conclusions

The concept "think global, act local" has always been the winning model of Cortem Group strategies, increasingly dynamic in the creation of branches and in the delocalization of product assembly and commercial activities. Cortem today is a group that boasts 3 Sister Companies located in Singapore, Dubai, and Buenos Aires, 10 distribution hubs, 250 employees and an extensive sales network and represents one of the main players in the explosionproof market with a turnover of around 50 million euros.



Francesca Merola

Francesca Merola has held the role of Communication & Marketing Specialist in Cortem Group since 2008.

Indra, a truly 'Made in Italy' experience at the service of the 'Tailor-made' valves production

At the forefront in the design and manufacture of ball and needle valves in various configurations and sizes

Emilio Renato Imbriani, Managing Director Indra Srl



ounded in 1987, with its 36 years of activity, Indra Srl is nowadays at the forefront in the designing and manufacturing of ball and needle valves in various configurations and diameters, from integral double block & bleed and

split body versions to instrument manifolds, strictly produced in according to the most stringent quality standards of safety and efficiency.

Main characteristics of the company are the 'Made in Italy' production and the 'Tailor made' approach, qualities that represent the trademark.

The quality requirements

To guarantee the high quality standards of Indra products, the contributing elements are: the use of raw material of prevalent Italian and European origin (Indra does not use Chinese or Indian supply chain), the product monitoring from engineering to production and the wide range of tests carried out in house, that ensure a tracked product during all its development phases.

The raw material is carefully selected, as it is a fundamental and decisive requirement for the final choice by customers. The excellent quality is deemed a 'must' and the selection becomes then an essential

"To guarantee high quality standards, Indra uses raw materials mainly of Italian and European origin, carefully monitors the products from engineering to production and carries out in-house a wide range of tests

starting point because the good product performance depends on that.

The experience in understanding the 'typical' of the installations, the choices aimed at innovation and the maximum versatility, allow Indra to develop customized solutions, according to customers' specific needs.

The ability to handle the requests, analyzing and implementing even the most complex ones, has made our a Tailor made production, a quality that has allowed the company to be appreciated and recognized over the years within the market.

"Experience and flexibility allow Indra to develop customized solutions designed for customers' specific needs

All the products are machined from the most standard materials, but also from those 'exotic' materials used for critical applications (Duplex, Super Duplex, Monel...).

The areas of application

The combination of these facets has allowed *Indra* to establish itself over the years in the various sectors of industry: primarily in the Oil & Gas, in the petrochemical sector, to arrive recently in the Power, LNG and Hydrogen markets.

"The products are mainly used in oil & gas, petrochemical, power, LNG and hydrogen sectors

Indra product line is perfected with complementary materials and accessories, something that makes Indra a privileged and reliable partner for those companies that supply 'packages' of various matching goods. The solutions developed by *Indra* are mainly used in the oil & gas, petrochemical, off-shore platforms and in the energy sector, used as components of plants and machineries with an high commercial and technological value. Hence the need to guarantee the highest quality. Today the company has modern machinery for very precise mechanical processing, with testing phases of the single items during the production process.

LNG and hydrogen: new challenges

Indra is currently diversifying and adapting its production for sectors not previously supplied. The LNG and hydrogen sectors are two of these, in which *Indra* has been introduced by some key customers who, recognizing the high standards of reliability and safety of the products, have relied on the company for the design, construction and supply of valves in these sectors.

This happened in particular for *Indra* cryogenic valves, selected for important LNG projects. Some of the most relevant and representative supplies are: *Yamal LNG Project* (2012) and *Arctic LNG Project* (2019); and as regards the Power sector, *Indra* has taken on an important role in projects such as *Stef* (*Sener EPC*) and *LNG Coastal Depot Ravenna* (*EPC Edison*).

The quality and reliability of the products made have kept *Indra*'s request for support active for the creation of new cryogenic valves designed for applications suitable for these specific sectors.

Indra works constantly to consolidate its position in these markets, hence the need for specific development actions and strategies aimed at obtaining key qualifications from end users.

In parallel with the market penetration activities and the improvement of customer assistance with the reduction of delivery times, Indra directs its resources also to increase its equipment and structures, including the construction of a bunker for high pressure tests, for specific internal tests for the aforementioned sectors.

The Indra valve line is therefore in constant evolution for the study and production of ball valves and needle instruments in multiple configurations.



The certifications

Indra is ISO 9001, 14001 e 45001 certified, proof of a company that works according to growth targets and continuously improving, able to meet specific technical requirements and high performances.

The headquarters is in Magenta, west of Milan, in a 4.000 sqm owned building, 3.000 sqm of which are designated as a production area.

A new machining center was recently purchased to improve the production capacity, an important investment deemed essential to achieve and satisfy a 'high-end' demand.

The certifications play a fundamental role to guarantee the quality of the products, indispensable are those of the product achieved according to the regulations in force in the EEC countries and / or outside the EEC area.

The international role

Indra has always considered its foreign presence important, for this reason the company has built its commercial network over the years in some strategic areas through carefully selected distributors and agents.

The participation in exhibitions and in the most important events in the oil & gas sector is another aspect that underlines Indra's will to affirm its role as a protagonist in both the domestic and foreign markets.

Main projects

Indra has recently actively participated in important projects that have covered several sectors.

Among the most relevant we report:

- Arctic LNG
- Yamal LNG Project

for the LNG sector. And also:

- NASR Full Field Development Package II Phase
 I and Phase II;
- IGD E2 LG8;
- Ruwais Refinery complex (Takreer);
- Al-Zour Refinery Project;
- Coral South Development Project;
- BAB Integrated Facilities Project

These are just some of the most important projects that have seen the supply of *Indra* products.

Indra product overview

Iblok Line

In the oil industry, safety holds fundamental importance and it is the requisite at the origin of the development of



the lblok valve line. In the DBB version they replace the traditional "*Christmas Tree*" installation of multiple valves, by combining multiple functions in a single valve body.

Those valves, besides improving efficiency in process installations, offer relevant advantages of reduction of costs, installation and maintenance times. All valves can be equipped with accessories such as blocking systems, electrical signals, actuators etc., improving their safety and efficiency requirements.

SIL4 Modular Manifold for HIPPS systems

A recently manufactured product suitable to guarantee a high standard of safety, efficiency and quality in the HIPPS systems is the SIL4 Modular Manifold, designed specifically for instrumental control applications.

The *SIL4 Modular Manifold* permanently guarantees the continuity of information between the process and the pressure sensors: human error is completely eliminated and, in the condition of having to replace and / or check electrical or mechanical damage to one or more sensors pressure, one or more sensors always remain active through the various available configurations identified as 1002, 2003, 1004 and others...

The peculiarities of the *SIL4 Modular Manifold* consist of:

- compulsory nature of a series of sequential operations, never superimposable;
- reduction of construction costs for a high pressure system;
- protection of the line from overpressure;
- reduction of polluting emissions into the atmosphere due to high pressure lines.



The standard construction of the *SIL4 Modular Manifold* does not provide for the use of optional containers, however in outdoor installations it is recommended to use them to protect both the Manifold and the instruments connected to it. For this purpose, a stainless steel and polyester container has been designed and manufactured to safeguard all the components of the system. The container will have different sizes depending on the 1002-2003-1004 configuration selected for the Manifold.

DBB Twin pattern valve

Another product made by Indra is the DBB Twin pattern valve. The valve is realized from a monobloc made of the most common Aisi 316L or of exotic materials. The extremely compact dimensions facilitate assembly in combination with the process variable control instrumentation (pressure transmitters, pressure switches, pressure gauges, etc.) in small spaces. The DBB Twin valve has a single process connection and two totally separate outlet connections, each of which is made in the DBB configuration. The separation of the outgoing lines allows to control the process through one tool, while any other maintenance is being performed. The DBB Twin valve can also be made with separate inlets, so as to have two pressure lines completely independent of each other. The DBB Twin valve is made both in the ball and needle version and in the materials required for the application, including exotic ones.

Peculiarities of the DBB Twin pattern valve:

- compactness of the installations;
- cost reduction in the construction of the plants;
- continuous monitoring of process pressure;
- choice of materials;
- diameter and rating of the inlet flange from ½ "to 6" - # 150 / # 2500;
- special versions Api 10.000.



Emilio Renato Imbriani

Emilio Renato Imbriani, the Managing Director of Indra Srl, a company born in 1987 and grown over the years; a company that has been able to build its role as a valve manufacturer, becoming a point of reference for leading companies in the sector in tackling and solving plant engineering and reliability problems of the supplied products, first in the Italian market, and later internationally. Indra has always been characterized by the desire to overcome the boundaries of its comfort zone, with a competitive approach, essential to respond promptly to the requests of increasingly complex markets. Indra's strategy is to offer high quality products, customized and created specifically to meet the particular needs of the customers.



 Engineering
 Manufacturing
 3D Checking
 NDT Testing
 Bunker " High Pressure Test"
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 Image: Comparison of the state of the stat



A wealth of sustainable initiatives in DHL Industrial Projects

With decades of experience in a wide range of industries, including technology, pharmaceuticals, energy, automotive and retail, DHL Global Forwarding offers highly specialised and customised solutions

Andrea Rimondini, Head of the Industrial Projects Division DHL Global Forwarding, Italy



HL Global Forwarding (DGF) is one of the world's largest and best known air and ocean freight logistics companies providing a portfolio of products and solutions covering the entire

supply chain management. DHL supports its customers along the entire process chain, from freight forwarding - ensuring reliable, flexible and efficient deliveries to and from every country in the world - to the implementation of complex industrial projects. With decades of experience in a wide range of industries, including technology, pharmaceuticals, energy, automotive and retail, DHL Global Forwarding offers highly specialised and customised solutions.

"DHL supports its customers along the entire process chain, from freight forwarding - ensuring reliable, flexible and efficient deliveries to and from every country in the world - to the implementation of complex industrial projects

DHL Industrial Projects is a highly specialised division of DHL Global Forwarding that deals with the forwarding of large and highly complex plants, ranging from refineries to petrochemical plants to civil works. DHL Industrial Projects' main customers are the EPCs (Engineering, Procurement and Construction) companies, which receive the best and most competent services and are supported "from A to Z" throughout the implementation of their projects, such as the renovation and upgrading of traditional plants, refineries, and power lines, with ad hoc interventions on infrastructure and civil engineering works, with a view to efficiency and sustainability. The Industrial Projects world also includes a whole series of significant activities that allow special loads to be transported to their destination efficiently, such as reinforcing bridges with hydraulic jacks, repaving sections of roads, or creating river fording routes from scratch. All activities that require special attention.

"DHL Industrial Projects is a highly specialised division of DHL Global Forwarding that deals with the forwarding of large and highly complex plants, ranging from refineries to petrochemical plants to civil works

With the ambition to bring innovation to the industry through a willingness to get involved and experiment, DHL Global Forwarding's Industrial Projects division is in charge of implementing customised logistics solutions and strategies according to different application cases, transporting parcels from 1 kg up to 2,000 tonnes according to the needs of the client companies.

The focus on EPC's customers is utmost; we want to respond to their needs in a precise and timely manner, which is why we always involve them in the planning phase, in order to identify the best solution together with them. The relationship with the customers and the management of their needs is a very delicate activity that requires a high level of attention and expertise; the objective is to guarantee the best possible performance under the banner of essential criteria such as security, scalability, experience, real-time visibility and

sustainability.

With regard to safety, DHL industrial Projects is committed to the highest HSE and compliance standards. All operations are carried out strictly following the guiding principles of 'zero harm' and 'zero tolerance', protecting people, goods that are moved and the environment. Scalability is also a very important value: over the years, DHL Industrial Projects has supported customers of all sizes to successfully execute their projects, whether it be single moves or ad hoc shipments, capital and maintenance, repair and operations (MRO) projects, including global management of multiple suppliers. Project management expertise is another focal point of DHL Industrial Projects' mission. Global presence, local knowledge and experience in operating in the harshest of environments, in-house engineering and on-site presence means that DHL Industrial Projects can take complete charge of the projects it oversees. Last but not least, a proprietary web-based material management system (MMS) enables data collection, management and reporting to improve operational control and cost savings through accurate performance data and detailed visibility of expenses.

The DHL Global Forwarding Italy Industrial Project Competence Centre takes care of the operational management required to identify the most suitable solution for each type of transport, from vehicle rental and what it entails in terms of resources and costs, to pure operations. The Industrial Projects team, which can count on the collaboration of 650 employees in 90 countries, manages entire projects with a 'smart and flexible' approach to the challenges that each one may entail by coordinating the organisation, planning, implementation and improvement of procedures.

Innovation and focus on sustainability

The Industrial Project division also places great emphasis on sustainability. In fact, as part of its ESG (Environmental, Social, Governance) strategy announced in March 2017, the Deutsche Post DHL Group has published a new roadmap for environmental protection involving all its operations, with the goal of achieving zero-emission logistics by 2050.

To reduce the climate impact of global freight transport, DHL Global Forwarding is promoting the development and use of fuels produced from renewable energy. The largest investments are in aviation, where the company aims to cover at least 30 per cent of its aviation and airline fuel needs with sustainable fuels by 2030 - to date, the Group has purchased more than 830 million litres of sustainable aviation fuels. The development of new fuels is accompanied by the search for new partnerships: this is the case with the collaboration with the US airline United Airlines and the new Eco-Skies AllianceSM programme. Together with other industry leaders, it is planned to purchase 3.4 million gallons of Sustainable Aviation Fuel (SAF) that can reduce emissions by almost 80% compared to conventional fuel. The division's recent investment of 33 million gallons of SAF with Air France KLM Martinair Cargo (AFKLM) will eliminate at least 80 thousand tonnes of emissions. Building partnerships with stakeholders along the supply chain is key to accelerating the transition to low-carbon and ultimately zero-emission transport.

In addition, by 2030, 8,000 electric vehicles will be used for long-distance deliveries, with 60 per cent of the fleet being electrified. Today, DHL already has more than 20,000 electric vehicles.

In case of ocean freight transportation, DHL Global Forwarding has activated the "Go Green Plus" service for both LCL (less-than-container-load) and FCL (fullcontainer-load) shipments, with a view to clean and sustainable sea freight. As part of the "GoGreen Plus" programme, customers of the various Deutsche Post DHL Group divisions are offered various solutions to minimise logistics-related emissions and other environmental impacts along the entire supply chain, such as the use of sustainable fuels. One of this, the Insetting Solution, is based on the use of Sustainable Marine Fuel instead of the fossil fuels for the transportation. Thanks to the "Book & Claim" solution, DHL is able to pass on the benefits of reduced greenhouse gas emissions (Scope 3 emissions) to its customers, helping them to meet their climate targets. The "GoGreen Plus" product offering is part of the Group's medium-term sustainability roadmap for 2030 and contributes to the goal of having at least 30% of fuel needs covered by sustainable fuels. In fact, to reduce greenhouse gas emissions, in line with the Paris Climate Agreement, the Group will spend EUR 7 billion on sustainable fuels and technologies by 2030. Since January 2021, by using certified sustainable marine fuels (SMF), DHL has managed to reduce more than 35 thousand tonnes of Tank-to-Wheel (TTW) emissions for all LCL ocean shipments from harbour to harbour and offset more than 52 thousand tonnes of Well-to-Wheel (WTW) carbon emissions related to the pick-up and delivery of goods to and from harbours.

Recently, DHL Global Forwarding and GoodShipping, the global pioneer and market leader in insetting to decarbonize the container shipping industry by changing the marine fuel mix, have announced they are further expanding their long-standing partnership. With the latest purchase of approximately 60 million litres of Sustainable Marine Fuel, DHL will reduce a total of 180,000 tonnes of TtW-CO2 on both FCL and LCL shipping until 2024. This commitment is equivalent to



the amount of marine fuel burned by 10 container vessels on their journey from Asia to Europe. DHL Global Forwarding has been working with GoodShipping for five years, sharing the same aspiration for greener ocean freight via insetting.

As part of their joint industry impact, DHL Global Forwarding and GoodShipping also aim to pilot a new insetting accounting framework of the Smart Freight Centre. The new framework transfers the approach of allocating emission reductions from sustainable fuels to specific customers by decoupling the accounting of the fuels' environmental attributes from their physical flow to a general industry standard. In that way, customers can contribute to and report on emission reductions in their transport value chain even if the reduction is not physically linked to their specific transport activity.

DHL Global Forwarding has successfully implemented sustainable logistics solutions for its customer Grundfos. Since one year DHL supports the world's largest pump manufacturer and water solutions provider to decarbonize ocean and air freight shipments by providing "GoGreen Plus" insetting solutions. Both companies share a sustainable vision and regard this partnership as an important milestone on their sciencebased path to carbon neutrality.

DHL Global Forwarding focuses on reducing Grundfos' carbon emissions in ocean freight transportation for both less-than-container-load (LCL) and full-container-load shipments (FCL) via its "GoGreen Plus" service. The LCL "GoGreen Plus" service comes even without any additional costs for customers. Last year, both companies also launched a pilot project which aimed to reduce carbon emissions in air freight shipments

(AFR). Grundfos accessed DHL Global Forwarding's AFR "GoGreen Plus" service which cuts emissions in air transportation by using Sustainable Aviation Fuels (SAF).

"Grundfos produces more than 16 Mln pumps a year and ships more than 20.000 containers over the ocean every year. Grundfos always pioneered in water solutions to address the water and climate challenges in the world and improve quality of life for people. That is part of our core and DNA", says Dirk van der Heijden, Senior Director Global Logistics in Grundfos. "A testimony of that DNA is that Grundfos is the first company in the water solution sector to receive the full validation from SBTI (Science Based Target Initiative) of our net-zero emission target by 2050. The use of alternative biofuels from DHL Global Forwarding as one of our global ocean partners allows us to decarbonize our Ocean transport port to port. At the same time together we stimulate the freight industry to invest in a sustainable future. An industry which is critical for our company Grundfos".

Other sustainable initiatives

The Mission 2050 - Zero Emissions programme aims at an ambitious target to reduce to zero not only carbon emissions from transport but from the entire logistics industry. DHL Global Forwarding has initiated and is planning a number of initiatives to raise awareness among its employees towards reducing its environmental impact and zero-emission logistics. For example, DHL Global Forwarding Italy decided to support the WWF Le Foppe e Vimercatese Association by contributing to the expansion of the Martesana Oasis and inaugurating, in May last year, over 250 square metres of ponds and an insect house. A project that has added educational-didactic value in meetings with citizens and schools. In addition to the Oasi della Martesana, in September 2020 DHL Global Forwarding Italy contributed to the planting of 2,500 trees including larches and firs for the reforestation of Val di Zoldo, one of the areas heavily affected by the Vaia storm in 2018. Clean and environmentally friendly logistics is at the heart of every new programme and initiative DHL Global Forwarding decides to invest in. Sustainability and action to keep global warming below the 1.5 degrees set by the Paris Agreement is the most important issue today and requires a systemic and strategic approach from the public and private sector. For this reason, DHL Global Forwarding decided to expand its service portfolio with "GoGreen Plus", giving its customers the opportunity to replace the heavy fuel normally used with marine and aviation biofuels.

To date, more than 370,000 SMF has been used for all LCL ocean shipments since the start of the decarbonisation process. More than 2,500 DHL Global Forwarding customers use the "GoGreen Plus" LCL service and in doing so the company is committed to supporting its customers in achieving their sustainable goals at no extra cost. The results the company has achieved so far mark an important step for DHL Global Forwarding, confirming that it is on the right track in promoting sustainable logistics solutions for Mission 2050.



Andrea Rimondini

Currently Industrial Projects Head of DHL Global Forwarding Italy, he has been with DHL since 2020, after twenty years spent in large companies in the logistics and transportation sector, such as Fagioli, Saima Avandero (today DSV Italy) and Saga Italy (now Kerry Logistics Italy). He has to his credit the leadership and organization of numerous large and complex transportation projects worldwide, for major clients such as Saipem, Tecnicas Reunidas, Reliance, Technip, AGIP KCO, Tecnimont.


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Offshore O&G, surfing the uncertainty

Flexibility and automation to win the challenge of environmental and economic sustainability. Fores Engineering illustrates a range of key elements for a successful project design and execution

Fabio Nardone, Head of Business Development Fores Engineering



n their latest book *"How big things get done"*, Bent Flyvbjerg and Dan Gardner start their discussion from the outcomes of their research carried out on more than 16.000 big projects, which reveals that just 8.5% of the sample respects the time and costs initial estimate, and only 0.5% succeeds in producing the expected benefits.

This trend that leads the course of megaprojects of the Oil&Gas industry too, coupled with the growing uncertainty of the market, causes the main End Users and Operators to seek for solutions to enhance flexibility in project management and operation, in order to reduce risks and costs along the entire life cycle of the asset. Together with flexibility, more and more industrial players prioritize asset configurations that reduce the environmental impact during operations (like, for example, integrating sustainable energy sources for plant power generation) aligning with market requirements and stakeholders' expectations. In response to these growing concerns, in the last ten years FPSOs (Floating Production Storage Offloading) have emerged as the most cost-effective and flexible technological solution to exploit reservoirs located in remote or deep-water locations: investments in auxiliary infrastructures (pipeline, in particular) are eliminated, costs for construction and commissioning are reduced, while scale economies may be achieved thanks to the modular architecture of Topside process and auxiliary systems, more easily replicable on projects with similar characteristics.

"With growing concerns about environmental sustainability and uncertainty in the market, the offshore industry is shifting towards more sustainable and flexible models, like FPSOs and NUI, to support time to market and overall investments for O&G operations

Furthermore, thanks to a higher mobility compared to fixed offshore platforms, FPSOs can be easily decommissioned and relocated or repurposed (after the necessary upgrading of facilities and equipment), strongly contributing to reduce the operators' environmental impact.

An FPSO vessel is designed to receive, process, store, and offload oil and gas from offshore fields. The vessel is equipped with production facilities such as separators, pumps, compressors, and other processing equipment to separate and treat the hydrocarbons. The so processed oil and gas are then stored in tanks on board the FPSO until they are offloaded to shuttle tankers or pipelines for transport to shore.

FPSOs are designed to be self-contained and capable of operating for extended periods without requiring a connection to shore; their structure is like a tanker vessel, with a large Topside process facility.

While the construction of the hull is dominantly executed in Asia due to the larger availability of proper yards and reduced fabrication costs, the Topside facilities are still largely supplied by international EPC contractors, who leverages on an experienced international supply chain. As per traditional offshore installation, the challenge for the supply chain is still to combine high quality and safety standard with a compact and light design; however, the execution strategy needs a more flexible approach: a modular design will regularly be the standard for large and complex systems, like process or power generation units, dominating a large footprint on the FPSO Topside, while an integrated skid design will still be preferred to accommodate auxiliaries in the remaining footprint availability, in order to optimise the overall layout.

System Integrators with a large portfolio of solutions for FPSO Topside, need to leverage on their internationalisation to set up and manage proper partnerships for the module construction (project long lead items) in areas as close as possible to the integration yard of the FPSO, frequently placed in a very different location from the asset production location (es. China vs Brasil).

Similarly, the capability to execute the necessary lots of integrated skids, often in a fast-track delivery, is a key element to support the overall project budget in terms of costs and schedule.

The wide engineering capability and portfolio of solutions coupled with the experience gained



"Thanks to the strong know-how in design and engineering, and the experiences in executing Offshore challenging projects throughout 30 years in the 0&G sector, Fores has accrued several references on Topside integrated systems, currently performing in several Standard Platforms and FPSOs applications

supporting the execution of fast-track projects, are elements of the credible value proposition that Fores provides to the market, both in greenfield and brownfield applications, to support FPSO industry. As greenfield projects, Fores served leading companies and operators like Modec as well as EPC contractors like SBM and Saipem in several countries worldwide. For brownfield operations, Fores major references are with ENI for complete revamping and upgrading of Integrated Control and Safety Systems with "zero shutdown" during operations.

NUI model and digital tools for remote operations

Whilst FPSOs can be considered as a consolidated application to facilitate CAPex and OPex savings in Offshore industry, operators are switching from traditional models to NUI (Normally Unattended Installation) for new "fixed" installatons.

NUI is a type of Oil&Gas platform that is designed to operate without the need for constant human supervision. These installations are typically used in areas where it is not practical or safe to have workers stationed on a platform 24/7, such as in deep water





locations or harsh weather conditions.

Offshore NUIs are equipped with advanced automation and remote monitoring systems that allow them to operate with minimal human intervention and often powered by renewable energy sources such as wind or solar, and are designed to be highly self-sufficient.

Despite the fact that offshore NUIs are normally unattended, they are still subject to strict safety regulations and must comply with industry standards for equipment, maintenance, and emergency response. In the event of an emergency, the installation can be remotely shut down or controlled by personnel onshore. NUI model is increasingly popular in the Oil&Gas industry, as it offers a cost-effective and environmentally friendly way to extract resources from the ocean floor. They also help to reduce the risk of accidents and injuries associated with traditional manned platforms.

Higher flexibility, lower footprint and reduced costs for design, construction and management of the asset are distinctive elements of these solutions remotely operated, where human intervention is required only for maintenance operations in extraordinary cases; the absence of security and lodging facilities on the topside of the platform, avail a considerable saving in CAPex.

The high level of automation also helps to keep low OPex, compensating the higher cost for maintenance operation, to be performed onshore where the topside skids and equipment have to be transferred for major scheduled interventions.

Further optimisation of the whole system can be obtained through integration of innovative tools like digital twinning platforms backed up by Cyber Security systems.

In this regard, Fores has the capabilities to provide IoT-

ready solutions for plant interconnection and digital management; in particular, the company has developed a proprietary software platform (AIPMS® - Asset Integrity Performance Management Service) that collects and analyses real time data from the plant to provide diagnostic health and performance behaviour

"Nevertheless, NUI model still represents a challenge in terms of real effectiveness and sustainability: through its multidisciplinary capabilities, Fores can support operators to design and implement the solution that best fits with project features, time and costs

information on the asset. Through Artificial Intelligence and Machine Learning algorithms, data collected are processed to provide performance improvement and predictive maintenance recommendations, on a topdown logic (from the plant overall down to functional units, equipment and components). The result is plant production uptime improved, extended equipment lifetime and energy savings obtained, further elements that contributes to reduce project operational costs.

Digital tools like Fores' AIPMS are essential to align the plant production to a fluctuating market demand, in a scenario of unpredictable geopolitical events and speculations. These elements are even more important on NUI platforms to support the schedule of maintenance campaigns according to specific equipment and components predicted lifetime.

In this regard, Fores most significant reference is

Premier Oil platform recently installed in the North Sea, on which the company has designed and delivered a large portion of the Topside equipment, including the Power Generation System (with its fuel gas conditioning skid), equipped with a microturbine featured by the "air-bearing" technology to avoid periodic oil changes and plant shut down for maintenance.

Additionally, Fores designed and implemented the Integrated Control and Safety system (composed by PCS, PSD, ESD and F&G) as well as the Telecommunication system, both essential for data collection, processing and transmission from the platform to the onshore Control Room and, when necessary, for shut down of the plant through the Emergency Shut Down system. The ICSS and TLC system components have been purposely designed to be independent from each other and with a whole redundant architecture, further secured by a strong cyber security system, to perform 99,9% availability of the system and prevent unexpected shut downs and data leakage.

In a constantly changing scenario, the market requires up to date, integrated and reliable solutions, and with its vast industry expertise and commitment to safety and sustainability, Fores Engineering is the ideal partner for the industrial players engaged to design, build and operate successfully FPSO and NUI platforms.



Fabio Nardone

Fabio Nardone is the Head of the Business Development in Fores Engineering, since 2019 leading business growth and diversification, with a special focus on innovative solutions for the Energy Transition & Digital Transformation. He has been working in the Energy industry for more than 15 years in companies with high technological content in a very competitive arena. During his professional career, he has built up a solid experience in technological innovation and international strategic and commercial partnerships management, which are a pivotal for his current mission.

How PepperI+Fuchs supports the water treatment industry, by revolutionizing Explosion Protection

FPSO vessels, used in offshore production to handle a part of the oil and gas lifecycle, particularly benefit from the purge and pressurization protection system

Parastoo Parsi, Sales Manager Pepperl+Fuchs



epperl+Fuchs' purge and pressurization technology represents a modern, reliable, and straightforward approach to explosion protection. This innovative technology safeguards and monitors electrical solutions in

hazardous areas, extending equipments longevity and enhancing overall site safety. The technology's applications span various industries, including hydrogen production, ballast water treatment, oil and gas, and chemical processing plants.

Purge and pressurization technology operates by maintaining a positive pressure of clean air or an inert gas within an electrical enclosure, effectively preventing the entrance of hazardous gases, vapors, or dust.

Initially, the enclosure is purged with a flow of clean air or inert gas, eliminating any present flammable or explosive substances. Subsequently, the enclosure is

"Pepperl+Fuchs' innovative purge and pressurization technology represents a modern, reliable, and straightforward approach to explosion protection

pressurized with a continuous flow of clean air or inert gas, maintaining positive pressure and barring hazardous substances from entering.

This method is highly effective because it eliminates the risk of ignition of flammable substances within the enclosure. Consequently, even in case of an internal fault or spark, the clean air or inert gas inside the enclosure prevents the risk of an explosion.

Furthermore, this protection technology significantly contributes to prolong the equipment life by preventing corrosive gases and moisture to enter electrical enclosures. Pepperl+Fuchs, a leading company in industrial sensors and explosion protection systems, announced the acquisition of the Bebco EPS (Electrical Purging System) business in May 2018.

"Pepperl+Fuchs announced the acquisition of the Bebco EPS (Electrical Purging System) business in May 2018

The strategic acquisition aimed to expand Pepperl+Fuchs' portfolio of hazardous area solutions and to reinforce its position as a leading supplier of explosion protection systems. It combined two wellestablished companies with extensive experience and expertise in explosion protection.



As part of the acquisition, Pepperl+Fuchs obtained the Bebco EPS brand, along with its manufacturing facilities, testing capabilities, and certifications. This allowed the company to broaden its product range to include a comprehensive line of purge and pressurization technology solutions essential for protecting electrical equipment from ignition sources in hazardous environments. The acquisition also enabled Pepperl+Fuchs to enhance its global presence by increasing manufacturing capabilities and distribution networks in North America, Europe, and Asia.

There is a growing demand for hydrogen analyzer purge solutions, in the hydrogen industry. As a highly flammable gas, hydrogen requires meticulous handling to ensure its safe usage and transportation. By purging electrical enclosures with an inert gas like nitrogen, explosions and fires can be avoided by reducing oxygen concentration. Pepperl+Fuchs' purge and pressurization technology is an ideal solution in this industry, maintaining positive pressure within electrical enclosures and preventing the ingress of potentially hazardous gases and moisture.

In the shipbuilding industry, Pepperl+Fuchs' technology

proved to be invaluable.

Across the world oil tankers, floating oil production platforms, and cargo ships are in transit in international waters.

On their journey across the world's oceans, tankers and cargo ships use ballast water for stability and trim. The ballast water is being changed at regular intervals during loading and unloading, and it washes up at coastal regions all over the world. Organisms that do not naturally occur at the destination ports are carried along with the ballast water. These "stowaways" can upset the balance of the local ecosystem. Environmental damage can occur as a result of threats to native species or health risks from bacteria by introducing harmful organisms and pathogens into marine ecosystems.

Here is where the physical methods to be used to clean the organisms and microbes from the ship as a as a treatment system for the ballast water meet our protection method Ex p!

Explosion protection plays a pivotal role on board, whether it is to protect the ships' pumps from the proximity of the cleaning systems, or due to a potentially hazardous environment created by the cargo ships.

Pepperl+Fuchs has developed customized solutions for this purpose, delivering the perfect combination of purge and pressurization along with a ballast water treatment system.

Floating Production Storage and Offloading units (FPSOs) are vessels employed in offshore oil and gas production, combining production, storage, and offloading capabilities in a single unit. Designed to extract oil and gas from underwater wells, FPSOs can store, clean, and load these resources onto tankers or pipelines for transport to shore.

Systems like this have become the main method of protection in many offshore productions regions around the world. Like other applications in flammable environments, the electrical control of certain processes requires explosion-protected solutions to minimize the risk for people, the environment, and machines.

Given that FPSOs operate in flammable environments, they necessitate special precautions to ensure the safety of workers, the environment, and equipment. This means using equipment and equipments specifically designed and certified for hazardous environments or protected by a purge and pressurization system. By implementing these measures, the risks associated with offshore oil and gas production can be minimized, enabling safe and efficient operations.

Pepperl+Fuchs' packaged solutions of predefined and certified cabinets further reduce complexity for customers, simplifying installation and maintenance while lowering costs. The company's solutions also feature automatic temperature and leakage control, providing a feedback loop on the type of protection and issuing alarms when necessary.

With over 25 years of experience and thousands of solutions delivered in the purge and pressurization systems field, Pepperl+Fuchs is a global provider of comprehensive solutions for hazardous environments. The company offers design, engineering, manufacturing, and final certification from a single source, anywhere in the world. Customers can rely on Pepperl+Fuchs to keep their project finances and timelines under control while providing fully certified ready-to-use solutions.

The International Maritime Organization (IMO) defined rules for ballast water management in a convention adopted in 2004. Each ship must document its ballast water exchanges in accordance with the full requirements of the convention. In principle, there are two methods: One is to change the water at high sea. However, this technique is usually restricted due to weather influences, ship routes, or the design of the ship itself.

Another method is to perform ballast water treatment processes on-board using mechanical, physical, or chemical methods.

Filtering the ballast water and treating it with high concentrations of UV light to kill organisms and microbes is an environmentally friendly method. An appropriate system with a UV reactor is installed, usually in the central pump room. This room is classified as a hazardous area in oil tankers, floating oil production platforms, and ships carrying combustible materials. High voltages are needed to operate the UV reactor, Pepperl+Fuchs has developed a certified solution that combines a purge and pressurization system with other explosion protection equipments. This certified solution creates safe environments to operate high-voltage electrical equipment.

The central component of the solution is a purge and pressurization system. The purge and pressurization system from the Bebco EPS® 6000 series product range protects the electronic components in the reactor and the UV lights. To do this, the system automatically establishes the necessary overpressure and monitors it continuously. By purging with an inert gas, all ignitable gases and vapors are reduced to a concentration that is no longer explosive.

The purge and pressurization system is supplemented by an explosion-protected junction box and control components. Pepperl+Fuchs offers pressure measurement sensors, fill level sensors, temperature measurement sensors, and K-System junction boxes for intrinsically safe signal transmission. This customized, internationally certified solution is ready for connection and comes in explosion-protected housing.

The combined solution—made up of a purge and pressurization system and an explosion-protected package solution—meets safety requirements and is certified for worldwide use. This is a major advantage, as the ships do not simply travel the globe—they also need to call at ports around the world, where they will undergo repair or maintenance work. The self-contained, automatic Ex system makes this the best solution for this specific application.

Pepperl-fuchs is collaborating with industry leading ballast water treatment system providers in Europe with their system development, using advanced filtration and cyclonic separation stage for the removal of large organisms and sediment, in combination with an electrolytic cell for the production of free chlorine and the elimination of the remaining viable organisms.

This method contains ballasting and de-ballasting



stages of operation which at the latter a multiple Residual Oxidants (TRO) sensors samples the residual chlorine and successful neutralization of free chlorine. Their system, based on electro-chlorination technology, combined with Pepperl+Fuchs certified customized air purge cabinets allows efficient installation and operation on all types of vessels such as LNG Tankers , Crude Oil & Product Tankers, Bulk Carriers, Container Ships, Vehicle Carriers and LPG Tankers trading globally as well as onboard smaller coastal vessels and superyachts. This flexibility allows unrestricted trading under any given conditions regardless of the water's salinity, temperature and turbidity levels.

But the benefits for a FPSO don't finish here!

A well-known American control system manufacturer wanted to equip an FPSO vessel belonging to one of their end customers with a complete electrical solution. To achieve this, the control system manufacturer required different ATEX- and IECEx-certified enclosures for Zone 1 and temperature class T4 so that the solution could be equipped with remote I/O systems. The enclosure dimensions ranged from $1000 \times 1500 \times 450$ mm to $800 \times 2100 \times 1000$ mm (W/H/D). All enclosures should comply with the Ex pyb type of protection. In addition, the control system manufacturer required an external override function to enable the remote I/O systems to continue operating safely even when the purge and pressurization control unit is shut down.

To meet these requirements, the Pepperl+Fuchs engineers opted to use the 6500 Series purge and pressurization system. This system consists of a control unit, an enclosure protection vent, and a manifold valve, forming the basis for the required explosion-protected enclosure solution. The enclosures themselves are made entirely of SS316L stainless steel, making them suitable for the harsh offshore conditions aboard the FPSO vessel. Special vibration dampers, installed between the base and the enclosure, protect the enclosures and electrical components from any potential mechanical damage caused by engine vibrations and sea conditions. To ensure that the solution included the required external override for the purge and pressurization system, a combination of relays and contactors certified for use in Zone 1 had to be installed in the circuit. In case of problems on the FPSO, the remote I/O system is now able to override the purge and pressurization system control unit via an output and continue to operate safely, since air continues to flow through the needle valve and pressure is maintained. This function also makes it easier to carry out maintenance work on the control unit, since the entire process does not need to be shut down.

"In its Solution Engineering Centers in the USA, Europe, and Asia, Pepperl+Fuchs develops customized system solutions for special applications in potentially explosive areas

The additional contactors and relays ensure that the system is able to switch automatically between two power sources, in the event that one of the two power supplies fails. With this sophisticated purge and pressurization solution from Pepperl+Fuchs, the control system manufacturer's customer is now able to manage and monitor processes on its FPSO in the Indian Ocean safely and efficiently.

The end customer was provided with durable enclosure solutions, suitable for use in ATEX and IECEx zones, designed to withstand the harsh offshore conditions on board the FPSO vessel. The previously costly and timeconsuming process of coordinating various suppliers of individual components and applying for system certification was replaced by one-stop shopping at Pepperl+Fuchs: All services, such as design, construction, production, and end certification, were handled under one roof by the electrical explosion protection experts

In its Solution Engineering Centers in the USA, Europe, and Asia, Pepperl+Fuchs develops customized system solutions for special applications in potentially explosive areas—solutions that are ready to use and come with certification.

This offers many advantages, particularly for international projects. Every phase of the project, such as engineering, procurement, or design, can be managed around the world at the networked Solution Engineering Centers.



Parastoo Parsi

Parastoo is an electronics engineer graduated from Shiraz University, Iran.

She has been working with Pepperl+Fuchs for 18 years, has considerable experience in various technical and

sales roles at UAE, Australia. Now she lives in Italy and works as a Sales Manager responsible for Channel Sales in a number of countries in East Europe.



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SIL and IECEX certifications for SCAE: Another success in automation

Performance and Control for an Electrochlorination package. Electrical control cabinets with redundant PLC and diagnostic made by SCAE

Roberto Manzoni, Systems and Automation Department, Manager SCAE



lectrochlorination is the process of producing hypochlorite by passing electric current through salt water. This disinfects the water and makes it safe for other plants or even for human use, such as for drinking water

or swimming pools.

In this project, Hypochlorite solution is produced by sea water electrolysis from Hypochlorite electrolyzers (2x100%) fed from Transformer Rectifiers (2x100%). The produced Hypochlorite is stored inside Hypochlorite degassing storage tank (1x100%) along with Hydrogen as process byproduct. Hydrogen released from hypochlorite solution is diluted by Ventilation fans (2x100%) and then vented to safe location.

The process of electrochlorination is simple. It is the electrolysis of saltwater to produce a chlorinated solution. The first step is removing any solids from the saltwater. Next, the saltwater streams through an electrolyzer cell's channel of decreasing thickness. One side of the channel is a cathode, the other is an anode. A voltage DC current is applied, electrolysis happens producing sodium hypochlorite and hydrogen gas (H2). The solution travels to a tank that separates the hydrogen gas based on its low density. Only water and ordinary salt, (sodium chloride (NaCl)) are used. The chemical reaction is really easy and adding the electrical energy to sodium chloride in water, the result is the production of sodium hupochlorite and hydrogen gas. Companies may use seawater for this process due to its low cost. The water used is usually brackish water or brine (i.e. a solution with >0.5% salinity). In these cases, additional contaminant chemicals may be present in the water feed. The low voltage DC current still performs electrochlorination.

However, due to deposit formation on the electrode surface, also the electrolyzer must undergo a periodic cleaning with diluted hydrochloric acid. Best frequency of acid washing can be determined only on the basis of field experience

So, this project concerns the automation of a package consisting of electrochlorination process designed and managed by SCAE.

The project: Hardware and software design

The package consists of two electrolyzers, one transformer rectifiers, one tank, several valves, and electrical motors/components. Each item must be used separately in manual or together in an automatic cycle (Master/ Stand-by mode) in order to guarantee the best product based on field experience and these modes can be managed from the operator with an easy and clear selection from the Unit Control Panel. The electrical cabinet that controls the package is completely designed and manufactured by SCAE to meet the end user's requirements, from the enclosure material, to each required certification, to the high degree of automation of critical points in the end user's facility.

"The control and the precision of each part of the process were the critical point and they have been the starting points of the project

SCAE's electrical design team supported the customer in selecting the various components at each stage and provided all documentation in accordance with the customer's template.

That said, the cabinet has been designed and built in



stainless steel (AISI 316) and after painted as per customer specifications with a detailed procedure.

All incoming power supplies (mains, auxiliary and UPS) are fully redundant and a redundant communication with the DCS, managed via optical fiber (with two media converters to provide wired redundancy), has been created to allow the complete supervision of the whole package.

Consequently, following the specifications of the Customer and supporting them in the technical choice of hardware, SCAE has provided the CPUs in redundant mode.

The solution is a system that provides greater availability. The system has greater availability because it uses a redundant chassis pair which maintains process operation when some events, such as a fault on a controller, occur and could stop process operations on non-redundant systems. The redundant chassis pair includes two synchronized chassis with identically specific components in each of them.

So SCAE, by this system, can guarantee continued reliable operation of the customer's plant and application.

All the system has been tested during the FAT with the customer and will be tested during iFAT with DCS.

In addition, SCAE has developed software and HMI pages for easy management of the package, including dynamic utilities for all the electrical components, as well as preventive diagnostics to allow operators to perform optimal maintenance on machine components. Thanks to the expertise of SCAE software developers and SCAE electrical designers, all electrical components are constantly monitored and shown on the HMI.

Then, SCAE has prepared a communication via optical fiber protected with layer-3 switches to establish a tunnel for the remote control of the process in accordance with cyber-security norms requested by customer.

SIL and IECEX certifications

The icing on the cake of this project was the certification requested for SIL and the certification for IECEX zone of electrical cabinet provided by SCAE.

"SCAE has developed the SIL ASSIGNMENT ANALYSIS - Analysis performed by SCAE FS Engineer (TÜV Rheinland certified. ID-No # 18312/19) - with all the calculations of the level reached and manual for safety dedicated only to the functional safety loops

The analysis has demanded the selection of all the materials with attention for each detail in order to be in

"Each internal and external component installed on the electrical cabinet and even the enclosur has been selected with the required certification to permit the installation offshore of the supply, thanks to the IECEX Certification for Zone 2 reached by SCAE for this project

compliance related to the norm EN61508. Furthermore, even the environmental conditions and the safety rules requested for this type of projects have been the basis of the selection of all the materials and the electrical components performed by SCAE.

Another success for Automation made by SCAE.



Roberto Manzoni

Roberto graduated in Electrical Engineering at the Politecnico of Milano. He has many years of experience as Project Manager and as Electrical and Automation Project/Field Engineer, mainly in Compressors, Dryers and Nitrogen production field, for Oil & Gas; he has been working with the most famous multinational corporations for the realization of key projects around the world.

After having successfully conducted several SAT (Site

Acceptance Tests) both Onshore and Offshore, he has become SCAE Systems and Automation Department Manager; leading a team of coworkers. He coordinates and manages the development and realization of Automation Projects for the following areas: steel, cement, chemical and petrochemical industries, with particular attention to compliance with IEC 61508 and IEC 61511 standards, being certified as TÜV RHEINLAND FS ENGINEER (# 18312/19).



(Rendering courtesy of Martino Associati Energia)

Macomer waste-to-energy plant

Enhancing waste to produce new value

Luca Macci, Monsud S.p.A.

aste-to-energy plants, such as the Macomer one, are plants designed with the goal to create value. In facts, these plants, are capable of valorizing wastes to produce energy. This process, which requires a virtuous waste management, needs specifical skills and technologies. The design complexity is linked to the presence of a heat recovery system which results from waste combustion, unlike an incinerator plan that can only burn garbage.

"The project construction of a new 30 MW waste-to-energy line at the Macomer/Tossillo waste treatment system involves the design and construction of a new line that will replace the two existing ones

The criteria governing the technical and management choices of the project "construction a new line of wasteto-energy of 30 MWt at the Macomer/Tossilo waste treatment system", are due to the technical assurance of the plant, to the minimization on the environmental impact in the neighborhood and in general (greenhouse effect), to the maximization of energy production for economic advantages, to the attention on hydric balance and water cycle, to the improvement in the visual exposure, with the intention of architectural redevelopment, and to the decreasing the acoustic and the emissive effects. Thanks to the new technologies of reduction systems, the renovation of the plant, as the Autonomous Region of Sardinia reports, can lead to the introduction of additional environmental safeguards, which allow the emission to be much lower than the values required by the standard, for all pollutants and especially for particles and dioxin. The renovation of the waste-to-energy plant has become necessary to limit plant shutdowns and to reduce the amount of waste given to the landfill, which should be the last option considered for the disposal. Currently, from a technological point of view, there are no better choices than a waster-to-energy. The true alternative would be to achieve a total recycling rate, but the evidence shows, at least for now, this is a mind that has space only in the ideal world.

"The plant has the function of disposing, through the waste-toenergy process, of the fraction with fuel value contained in municipal waste and similar to non-hazardous urban waste downstream of the separate collection

Therefore, waste-to-energy is the combination of various processes aimed at achieving this following goals:

- Optimal waste combustion;
- Production of electrical energy with high thermodynamic efficiency;
- Minimize emissions in the environment.

The main processes which interact are:

- Preservation of the heat load and waste combustion;
- Temperature at the end of the post-combustion chamber (T₂);
- Heat recovery by producing superheated steam;
- Absorption of sour gas contained in the flue gases;
- Denitrification of the flue gases.

The Tossilo waste-to-energy plant is located to the south of Macomer, in an industrial zone and a in large area characterized by an alternation of non-irrigated



"The plant, installed in Sardinia, has a nominal capacity of about 61000 t/year of waste with an average calorific heat of 13188 KJ/kg

Fuctional sectors

agricultural areas and deciduous forests. The plant elevation is above 410 m and nearby stands the cleaner where rain waters and the processed ones are discharged.

The revamping project of the Macomer plant, costed over 50 million euro, includes the construction of a grate combustion line above 30MWt. The design criterion adopted, has been the one with maximum conservation of the existing plant, during the period of



Macomer waste to energy plant (A. Ruggiero's photo)

the construction of the new plant in order to not interrupt the service. The new line is structured in the following functional sectors, as represented in the figure.

Monsud S.p.A., a construction company operating in the civil and industrial engineering based in Avellino, has been engaged itself in the development of the executive project, which represents the third and last phase of the design, predicting the engineering of all works and fully defining the actions to be taken. The company, founded in 1979 by engineer D. Pierni, is an

expert in metal carpentry and energy systems.

"Particular care has been taken to prevent the release of dust, the maximization of efficiency and the recovery and treatment of process and storm water

The implementation of the project has been structured in six phases: the first one has involved the wrecking of some existing buildings, the planting of the yard and all the related works; during the second phase, excavation has been realized to carry the plans to the right

elevation; in the third phase, superficial and deep foundation works has been done; the fourth phase has been characterized by the use of reinforced concrete for vertical constructions and the start in building the main buildings in metal carpentry; the fifth phase has

been dedicated to complete the previous phase and, at the same time, to install the plants and the electromechanical equipment; the sixth and last phase, has been last destinated to the external arrangements and fixtures. For plants realization, the numerous excavations has been performed, for a total amount of 5640 m3. The most relevant ones are referred to a bunker in the waste hole, at the furnace-boiler building and the one hosting the thermal cycle.

The new line is sized to allow energetical performances reported in the following **table. 1.**

Other main functional features of the plant at the CTN are reported in the **table 2**.

The function of the plant is to

POWER AND PERFORMANCES		
Input power to the generator	7,91 MW	
Power at the generator clamps	7,09 MW	
Plant self-consumption utilities	1,006 MW	
Electrical energy net production	6,084 MW	
Input thermal energy	27,97 MW	
Boiler efficiency	83,87 %	
Combustion efficiency	81,56 %	
Gross return of the plant	25,35 %	
Net return of the plant	21,75 %	

Table 1: Power and efficiency at CTN point

dispose of, through the waste-to-energy process, the fraction with combustible valence contained in urban waste and comparable to the non-dangerous urban ones downstream the collection differentiated waste. The process is designed to operate 333 days/year (8000 h/years), with 91% of use rate, to incinerate a quantity of combust waste equal to 61120 Ton/year, with an average PCI equal to 12180 kJ/kg. The combustion line is also capable of operating with different thermal power waste. In the project phase, an horizontal boiler solution has been preferred because of the higher efficiency of pipe cleaning. The mechanical percussion cleaning system, compared to the classical

Oxygen level in combustion gases at the outputof the post-combustion chamber	68 % (in vol.)			
Time spent downstream of the last air injection	>2 / 850 sec/°C			
Input air temperature first	140 °C			
Input air temperature second	24 °C			
Waste-heat load	27,9 MW			
Flue gas flow rate	68644 Nm³/h			
Superheated steam pressure (out of the boiler)	50 bar.a			
Superheated steam temperature (out of the boiler)	410 °C			
Steam production	32,305 t/h			
Combustion gas temperature (out of the boiler)	195 °C			
Residue				
Waste + non-combustible from grate bottom (dry)	0,912 t/h			
Boiler fly ash	0,0446 t/h			
Particles from ELF	0,101 t/h			
Average daily concentration of flue gas pollutants at the chimney				
NO _x	30 mg/Nm ³			
PTS	0,75 mg/Nm ³			
SO ₂	5 mg/Nm ³			
HCI	3 mg/Nm ³			
HF	0,4 mg/Nm ³			
NH ₃	4 mg/Nm ³			
CO	15 mg/Nm ³			
COT	3,5 mg/Nm ³			

Table 2: Operating characteristcs at the CTN point

blowing cleanings, allowed to achieve uninterrupted operation period more than 8000 hours/year. The combustion diagram at the right, represents the allowable functional conditions at various loads.

The goal of the steam thermal cycle is to convert the thermal energy released from the waste combustion into electrical energy through a steam turbine connected to a generator. The heat transport fluidi s demineralized water and the cycle by which it evolves in the circuit is superheated Rankine type. To improve the efficiency, the plant as been equipped with a regeneration system that bleed almost 11% of the steam. The thermal cycle building, build by Monsud S.p.A., is designed with a steel load-bearing structure. This develops on two levels: on the ground floor there is a single room where is located the turbine room and the alternator; on the upper floor are arranged the degasser and the air-cooler system. The outer envelope as well as the coverage, is made of insulated sheet metal panels and in the higher range are used polycarbonated panels to add brightness to the interiors and to homogenized the envelope with the other project building. The foundations consist in audiences, continuous beams and pile caps connected by stiffening beams in the outer parts. To access the buildings, service walkways, stairs, grids and ladders has been designed to ensure the maintenance activities at the best and in the safest conditions. Grids are pressed-type and hot galvanized, the handrails are galvanized carbon steel tubes, ladders are hot galvanized.

The new waste-to-energy line at the waste treatment system consists of several sections that could be considered as autonomous entities, in reality the main need is too see the system as a single system, complete ad integrated especially in relation to the functional aspects and guarantee the continuity of service. In this context it is planned to implement a control system where the centralized vision of the



produced as a result of combustion. Studies held by the Autonomous region of Sardinia and the regional health system show no particular healthy issues in the Macomer zone, lacking significant scientific relations between the presence of the waste-to-energy plant and the healthy status of the residents. Boiler-furnace system structure (Renderign courtesy of Martino Associati Energia)



Luca Macci

Luca graduated in management engineering with a specialization in organizational engineering at the University of Rome Tor Vergata in 2022. He is currently an intern at Monsud S.p.A (Avellino, AV), a company owned by Mr. Domenico Pierni. During his university days he was able to approach the industrial world and in 2023, thanks to Monsud, he was able to take part in

the management of industrial projects. In 2022, in collaboration with Roma Tor Vergata University, he carried out an analysis of the monitoring system of environmental radioactivity on Italian territory, contributing to proposals for improvement. (Photo Simone Casconi)

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The newly integrated Trillium Pumps Italy supplies pumps for the Middle East Petrochemical Sector

Combining 235 years of Italian expertise in the engineered pump sector to create a global player

Alessandro Valle, Original Equipment Pumps Regional Sales Manager Trillium Pumps Italy



rillium Pumps Italy combines the experience and capabilities of the two Italian legacy brands in the engineered pump market: Gabbioneta Pumps and Termomeccanica Pompe. Operating

as "one plant - two locations," Trillium Pumps Italy is developing opportunities together, as shown in the recent contract awarded it was awarded for a key petrochemical plant in the Middle East thanks to its distinctive competencies.

"An example of a recent contract assigned to TPI thanks to its distinctive competencies for a key Petrochemical plant located in the Middle East

The plant where Trillium Pumps Italy's pump packages will be installed is part of the expansion project of an innovative polyolefin manufacturing complex which transforms crude oil derivates into plastic, for use in many applications across industries. One of the plant TMP VS1-type CPP model for sea water cooling at petrochemical plant



challenges was related to its construction on a sandy site environment, which required specific attention to the cleanliness of materials, demanding a total absence of impurities.

Trillium Pumps Italy's supply consists of vertical API 610 VS1-type pump packages to perform the sea water cooling service at the plant. The packages involve a high level of system integration, a distinctive competence especially developed by the Termomeccanica Pompe brand over the last decades to better meet customer needs. Indeed, EPC contractors are on the lookout for expert partners able to truly support them and act as single interfaces for their plant's complete pumping systems, i.e. inclusive of all the components that are critical to their operation – whether installed on the pump skid or outside it.

The packages supplied by Trillium Pumps Italy for the project at hand include:

 a vertical pump in super duplex s.s. with 9-meterlong shaft, and a flow >20,000 m³/h

- a 3500 kW condensing steam turbine
- a reduction gear coupling,
- an API 614 lube oil system,
- a sealing system complete of accessories (Plan 11/61)
- a steam condenser with relative ancillaries

The string test – i.e. the complete package test at full operating conditions – is also a key part of the supply and will be performed in-house at Trillium Pumps Italy's La Spezia test center

The new integrated Trillium Pumps Italy, with 235 years of combined experience from Gabbioneta Pumps and Termomeccanica Pompe and the support and leverage of the global organization of the Trillium Flow Technologies group, offers customers unparalleled innovation and flexibility in the provision of engineered pump solutions. In the case at hand, testing and systems integration capabilities were decisive factors in the customer's decision to assign the contract to Trillium Pumps Italy.



Alessandro Valle

A Mechanical Engineer with a Master's Degree from the University of Pisa, he joined Termomeccanica Pompe in 1995. He started as an Estimates Engineer in the Original Equipment (OE) Engineering Department. In 2000, he was promoted Sales Engineer of the OE Sales & Marketing Department, where he successively became Area Manager (2003) and Senior Area Manager (2007) for the Italian and Spanish Markets. When Termomeccanica Pompe became part of the Trillium Flow Technologies Group in 2022, Alessandro joined the company's Global Sales Team as OE Pumps Regional Sales Manager for Italy and Spain, also covering a Global Support role for Desalination, an industry he developed strong expertise in over the years.

The basis to establish the EPC Company through Project Finance & Method

With this article on the Best Practices in the EPC world, we analyze the methodologies in the ever-growing needs for project financing

Massimo Rebecchi, President and CEO Xylem

rivate Investment in major infrastructure projects is not unusual. Prior to World War I, railways, roads, bridges, power plants, ports, water works and gasdistribution systems were being built all over the world by private entrepreneurs. These projects were largely financed by private capital, provided by entrepreneurs willing to risk all in return for high rewards. Fortunes were made and lost.

During the 19th Century ambitious projects such as the Suez Canal and the Trans-Siberian Railway were constructed, financed and owned by private companies. However, the private-sector entrepreneur disappeared after World War I and as colonial powers lost control, new governments financed infrastructure projects through public-sector borrowing. The state and publicutility organisations became the main clients in the commissioning of public works, which were then paid for out of general taxation.

During this post-World War I period in Europe, states invested in the reconstruction of war-damaged infrastructure and new nationalised industries. After World War II most infrastructure projects in industrialised countries were built under the supervision of the state and were funded from their respective budgetary resources of sovereign borrowings.

This traditional approach of government in identifying needs, setting policy and procuring infrastructure was by and large followed by developing countries, with the public finance being supported by bond instruments or direct sovereign loans by such organisations as the



Today, Project Finance is being introduced in both developed and developing countries as an alternative way to finance infrastructure and industrial projects, both small and large

World Bank, the Asian Development Bank and the International Monetary Fund.

Development in the early 1980s

The convergence of a number of factors by the early 1980s led to the search for alternative ways to develop and finance infrastructure projects around the world. These factors include:

Continued population and economic growth

meant that the need for additional infrastructure – roads, power plants, water-treatment plants – continued to grow;

- The debt crisis meant that many countries had less borrowing capacity and fewer budgetary resources to finance badly needed projects; the debt burden required them to adopt an austere approach when planning fiscal spending, compelling them to look to the private sector for investors for projects which in the past would have been constructed and operated in the public sector;
- Major international contracting firms which in the mid-1970s had been kept busy, particularly in the oil-rich Middle East, were, by the early 1980s, facing a significant downturn in business and looking for creative ways to promote additional projects;
- Competition for global markets among major equipment suppliers and operators (particularly in the power and transportation industries) led them to become promoters of projects to enable them to sell their products or services;
- Outright privatisation was not acceptable in some countries or appropriate in some sectors for political or strategic reasons and governments were reluctant to relinquish total control of what may be regarded as state assets.

During the 1980s, as a number of governments, as well as international lending institutions, became increasingly interested in promoting the development of the private sector, a consensus developed. It supported tapping in the energy and initiative of the private sector, and the discipline imposed by its profit motive, to enhance the efficiency and productivity of what had previously been considered public-sector services.

It is now increasingly recognised that the private sector can play a dynamic role in accelerating growth and development. Many countries are encouraging direct private-sector involvement and making strong efforts to attract new money through new project financing techniques.

Such encouragement is not borne solely out of the need for additional financing, but it has been recognised that private-sector involvement can bring with it the ability to implement projects in a shorter time, the expectation of more efficient operation, better management and higher technical capability and, in some cases, the introduction of an element of competition into monopolistic structures.

Project Finance is being introduced in both developed and developing countries as an alternative way to finance infrastructure and industrial projects, both small and large. The concept is being used in transportation (tolled roads, tolled estuarial crossings and railways); energy (private power stations, waste-to-energy plants and gas-distribution pipelines); sewage and watertreatment plants; health care (construction and operation of new hospital buildings and clinical waste disposal plants); education (provision of student accommodation and facilities for universities, colleges and schools); and provision of government offices.



The Development of BOOT

Concessions

The search for a new way to promote and finance infrastructure projects led to the introduction of a technique, originally used in the 19th and 20th centuries, known as concessions. Concessions were widely used in many parts of the world to develop infrastructure. The Suez Canal is one of many examples of a privately financed concession and this method was also used to build canals, railroads, tramways, water works, electric utilities and similar projects in both industrialised and less-developed countries.

The BOOT formula adds to the old system of concessions, providing new possibilities for reducing or eliminating the direct financial burden which governments would otherwise bear. The objective is to transfer as much borrowing risk as possible to the private-sector promoter and the project itself. Therefore the BOOT promoter must finance the project. (The promoter typically does this by obtaining financing from groups of commercial banks, other financial institutions, export credit agencies and multilateral finance agencies.) Financing is made available on the strength of the project's projected revenue stream and its other assets, including the promoter's equity. Normally the lenders would have limited or no resources to the promoter or shareholder of the promoting company.

Project Finance

This financing technique, generally known as project finance, was perfected in the 1970s for major privatesector projects, mainly in the area of oil and gas exploration and extraction, but has been extended widely since then. Project finance techniques are now applied across the world to numerous privately promoted infrastructure projects including power stations, gas pipelines, waste-disposal plants, wasteto-energy plants, telecommunication facilities, bridges, tunnels, toll roads, railway networks, city-centre tram links and now the building of hospitals, education facilities, government accommodation and tourist facilities Financial markets have become increasingly sophisticated in 'engineering' financing packages to finance almost any type of reasonably predictable revenue stream.

Over the last two decades major international contracting firms, individual entrepreneurs and a number of developing countries have begun to promote infrastructure projects on a BOOT basis. Projects are financed on a limited-resource basis and built operated under a concession from the state or similar public body as a private venture. At the end of the concession the project is transferred back to the state or public body.

Equity and Debt Financing for PV Systems



Project Finance Promotional Loan

The BOOT formula adds to the old system of concessions, providing new possibilities for reducing or eliminating the direct financial burden which governments would otherwise bear

Activities included in Project Finance

- Project Financing (BOT, BOO, etc.)
- Local Governmental Funding

Shared Ownership

Mezzanine Capital

Crowdfunding

Bonds

- Multi-Source Export Credits
- International Commercial Loans Documentary Credits

What is BOOT?

One method used to involve the private sector in largescale infrastructure investments is where the private sector is granted a concession from the state to build, finance, own and operate a facility and after the time specified in the concession period is obliged to hand it back to the state. This concept is variously described as BOT, BOOT, BOO, BRT, BLT, BT and BTO, depending on the terms of the agreement.

The acronym BOT stands for 'build, own and transfer' or 'build, operate and transfer' (these terms are often used interchangeably). The 'owning' is an essential element since the main attraction to host governments is that the promoter's equity stake underwrites its commitment to a project's success. Other variants include BOOT (build, own, operate and transfer) and BOO (build, own, operate). In BOO projects the promoter finances, designs, constructs, and operates a facility over a given period but it does not revert to the government as it would using the BOOT strategy.

Further extensions of the concept are BRT or BLT (build, rent/lease and transfer) or simply BT (build and transfer immediately, but possibly subject to instalment payments of the purchase price).

Another approach, BTO (build, transfer and operate), has become increasingly popular in the Far East and is particularly preferred by power and telecommunications authorities. It is a simpler transaction or concept than BOT and BOOT that can be implemented in a shorter time without the need for the formation of a project company and with the project assets being owned by the public sector.

The Components of BOOT

B for build

This is probably the easiest part of the acronym to understand. The concession will grant the promoter the right to design construct and finance the project. A construction contract will be required between the promoter and a contractor. The contract is often among the most difficult to negotiate in a BOOT project because of the conflict that increasingly arises between the promoter, the contractor responsible for building the facility and those financing its construction.

Banks and other providers of funds will want to be sure that the commercial terms of the construction contract are reasonable and that the construction risk is placed as far as possible on the contractors. The contractor undertakes responsibility for constructing the asset and is expected to build the project on time, within budget and according to a clear specification and to warrant that the asset will perform its design function. Typically this is done by way of a lump-sum turnkey contract.

O for own

The concession from the state provides for the concessionaire to own, or at least possess, the assets that are to be built and to operate them for a period of time: the life of the concession. The concession agreement between the state and the concessionaire will define the extent to which ownership, and its associated attributes of possession and control, of the assets lies with the concessionaire.

O for Operate

An operator is to assume responsibility for maintaining the facility's assets and operating them on a basis that maximises profit or minimises cost on behalf of the concessionaire and, like the contractor undertaking construction of the project, the operator may provide funds to finance construction and be a shareholder in the project company. The operator is often an independent company appointed under an arm'slength agreement. However, in some cases the promoter operates the facility directly through the promoter company.

T for Transfers

This relates to a change in ownership of the assets which occurs at the end of the concession period,



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when the concession assets revert to the government grantor. Transfer may be at book value or no value and may occur earlier in the event of failure of the concessionaire.

Stages of a BOOT project

Build:

- Design
- Manage project implementation
- Carry out procurement
- Finance
- Construct

Own:

• Hold interest under concession

Operate:

- Manage and operate facility
- Carry out maintenance
- Deliver products/service
- Receive payment for product/service

Transfer:

 Hand over project in operating condition at end of concession period

The development of PPP

The concept of a PPP – Public Private Partnership has been adopted by various governments in recent years. Instead of the public-sector procuring a capital asset and providing a public service, the private sector create the asset through a single stand alone business (financed and operated by the private sector) and then deliver a service to the public sector client, in return for payment linked to the service levels provided.

Various governments in recent years have adopted the concept of a PPP – Public Private Partnership

There are three main categories of PPPs

- The introduction of the private sector ownership into state-owned businesses, using the full range of possible structures (whether by flotation or the introduction of a strategic partner) with sales of either a majority or a minority stake;
- Arrangements where the public sector contracts to purchase quality services on a long-term basis so as to take advantage of private sector management skills incentivised by having private finance at risk. This includes concessions and

franchises, where a private sector partner takes on the responsibility for providing a public service including maintaining, enhancing or constructing the necessary infrastructure.

 Selling government services into wider markets and other partnership arrangements where private sector expertise and finance are vital to exploit the commercial potential of government assets.

Generally, governments' key objectives when commissioning a PPP are:

- A. To maximise value for money of providing a service over a long time scale (25 to 30 years). Maximising efficiency and innovation helps to achieve value for money
- B. To transfer maximum risk to the private sector consistent with the governments' economic policy and status.

Why should public or state authorities consider PPP?

There are a number of factors, relating to public sector cash constraints and the underlying principles of PPP, which might cause governments to consider the introduction of a PPP.

- a. Public sector cash constraints in many countries, demand for new infrastructure projects is growing in quality and quantity. In addition there is the rising pressure for funds to renew, maintain and operate the existing infrastructure. Competition for such funding is often intense not just between infrastructure projects but also with the many other demands on public sector finance. PPP permits the authorities to substantially reduce capital expenditure and convert the infrastructure costs into affordable operating expenditure spread over an appropriate timescale.
- b. Principles of PPP: PPP allows each partner to concentrate on activities that best suit their respective skills. For the public sector the key skill is in developing policies on service needs and requirements, while for the private sector the key is to deliver those services at the most efficient cost.

Key Benefits of PPPs

a. Infrastructure created through PPP can improve the quality and quantity of basic infrastructure such as water, energy supply, telecommunications and transport as well as being widely applied to other public services such as hospitals, schools and prisons. The public have access to improved services now, not years away when a government's spending programme permits.

- b. Value for money PPP projects deliver greater value for money compared with that of an equivalent asset procured conventionally. The combination of design construction and operation outweigh the higher cost of finance. PPP focuses on procurement process on the whole life cost of the project not simply on its initial construction cost. It identifies the long term costs and assesses the suitability of the project.
- c. Transfer the risk of performance of the asset to the private sector. The private sector only realises its investment if the asset performs according to its contractual obligations. As the private sector will not usually receive any payment until the facility is available for use, the PPP structure encourages efficient completion, on budget and without defects
- d. Buildings and services which would not otherwise be affordable – this is a major benefit and helps public authorities to take a long term strategic view of the services they require over a long period.
- e. The concept helps to reduce government debt and frees up public capital to spend on other government services
- f. Innovation and best practice. The experise and experience of the private sector encourages innovation, resulting in reduced cost, shorter delivery times and improvements in the construction and facility management processes. Developing these processes aids best practice.
- Repairs and maintenance assets and services will be maintained at a pre-determined standard over the full length of the concession
- Enable investment decisions to be based on fuller information as it requires a defined analysis of project risks by both the government and lenders at the outset.
- i. The tax payer benefits by avoiding paying higher taxes to finance infrastructure development

- The government or public authority still retains strategic control of the overall project and service
- k. The process can assist in the reform of the public sector

Requirements for successful PPPs

i.

- Political support political support at the policy level is important for the private sector, because unless PPP is seen to offer continuing business opportunities, firms will be reluctant to develop the necessary resource that is required to bid for contracts.
- Enabling legislation PPP projects need to be supported by enabling legislation that is firmly embedded in the legal structure of the host country. A key aspect of this enabling legislation is the existence of a concession law that can be readily applied to projects.
- **Expertise** Both the public and private sectors must have the necessary expertise to deal with the PPP process.
- Project prioritisation The government needs to identify those sectors and projects that should take priority in the PPP process and undertake a review of the viability of each scheme before the project is procured. This avoids unnecessary failures and high bidding costs.
- Heavy Deal flow and standardisation. A regular and predictable flow of deals based on recognised risk allocation templates, assists the development of a successful PPP programme. Guidance on contract structure also helps to keep costs down.



The BOOT / PPP structure

In view of the flexibility of the BOOT/PPP structure and its variants, the legal and company structure differ from project to project, dependant on sector and country of origin. However, the normal structure would involve the creation by the promoters of a special-purpose, jointventure company in which the contractor, operator and banks may have a share. This concession company borrows in order to fund the construction on the security of the revenue that lending banks believe will be generated by the facility. All financial obligations must be serviced within the life of the concession. Concession financing is therefore similar to limited-or non-resource project finance, except that the revenues are received under the terms of a concession agreement. The project will be approached in a similar way to limited-resource project financing in which the risks are isolated and allocated to those most gualified to bear them.

Each structure created is unique to the project, but generally BOOT/PPP is essentially a concession or global-service contract offered by a government and financed and undertaken by the private sector. A BOOT project often requires a promoter to enter into a number of contracts with a variety of parties. It is possible, however, for any particular project to have all, some or none of these contracts. A typical simple structure created between the various parties is outlined in **Figure 1**. A more complex structure is necessary where the mending is sourced offshore in the international markets and is set out in **Figure 2**.

The allocation of risks between the typical parties to a BOOT structure, as shown in the diagram, is regulated by the various agreements which the parties enter into.

- The concession company promotes the project and has the ultimate liability to the government under the concession agreement.
- The concession agreement (sometimes referred to as the implementation or project agreement) is the primary contract between the government and the concession company and forms the contractual basis from which the other contracts are developed. It entitles the concession company to build, finance and operate the facility and imposes conditions as to design, construction, operation, of the project and establishes the concession or operation period.
- The equity investors' and lenders' security for their loans and investment is limited to the revenues to be received by the concession company. They will therefore have considerable



Figure 1 - Example of a simple BOOT/PPP Structure



Figure 2 - Example of an international BOOT/PPP Structure

interest in the revenue forecasts produced by the concession company. Likewise the two areas that place the concession company and equity investors and lenders at risk are the construction contract and the operating contract.

The construction contract: The parties would prefer a contractor to give a fixed price for completion by a fixed date without exclusions. This is rarely possible in projects of this nature. Finance providers are therefore only prepared to commit themselves to a fixed amount because if the project costs more their funds will be in jeopardy due to the interest burden. Lenders will not accept the risk of delay to completion, although they will normally provide a standby facility to offer some protection against time-andcost overruns.

- The operating contract: The lenders have to be assured that an experienced operator will be available on completion of construction.
- The offtake contract. This is one of the key contracts. As limited-resource projects are, by definition, funded on the security of the future cash flow, there has to be some form of buyer. Projects fall into two categories: those where the identity of the buyer is obvious, for example toll roads and some power stations and those where there is physical product which has to be sold, often on the world market. Where there is

a product involved it is essential to identify the offtaker or buyer and to establish the basic terms. Lenders prefer guaranteed minimum or 'floor' prices, but these are frequently There is then the need to unobtainable. establish whether the future price of the product is something upon which the potential lenders to the project are prepared to take a risk. There may be an opportunity for the offtaker to take some of the downside risk by providing a very low floor price, for example one which is below the level at which the debt would have to be rescheduled with the lenders risking such rescheduling. In exchange the offtaker would expect a high reward in good times.

EPC or EPCM contracts? Starting with understanding the difference between these definitions and their impact on Project Finance



he transformation of and engineering company into an organized EPC or EPCM. The first step is to understand the difference between these definitions, which will impact deeply the Project Finance.

An EPC or EPCM Contractor will perform the following main activities:

- Feasibility Studies
- Project Financing
- Contracting
- Basic and Detailed Engineering Services/FEED
- Project Management
- Procurement and Manufacturing
- Construction

- Commissioning, Startup, Training and Operations

Many different terms are tossed around the construction industry loosely describing the different methodology used to design and construct new facilities and turnarounds. Unfortunately, there are no tried and true definitions for the different methods and numerous variations of each of the most popular methods.

Determining the correct form of construction contract to pursue can have a great effect on the cost and risk associated with the construction project. The cost of construction varies inversely with the amount of business risk the "owner / financers" are willing to accept. The less business risk the owner wishes to assume, the higher the cost of construction and management. This follows the "risk-reward" motto for business.

"Determining the correct form of construction contract can have a great effect on the cost and risk associated with the construction project

The two most common types of construction contacts are EPC "turn-key" and EPCM. Each of these methods have variations that can be adapted to each project as needed; example (EPCC Engineering, Procurement, Construction, and Commissioning), etc.

EPC / EPCM Definition & Comparison

The EPC (Engineering, Procurement and Construction): means the company is contracted to provide engineering, procurement and construction services by the owner. Think Design & Construct style contracts, where the project is largely Contractor managed and the cost risk and control are weighted towards the Contractor and away from the Owner. The EPC contractor has direct contracts with the construction contractors.

The EPCM (Engineering, Procurement and Construction Management): means the company is contracted to provide engineering, procurement and

Task / Issue	EPC (Engineering, Procurement and Construction)	EPCM (Engineering, Procurement and Construction Management)
Equipment Supply Contracts	Negotiated & Signed solely between EPC contractor & Supplier	Negotiated & signed between Owner and Supplier /with EPCM contractor's advice and assistance
On-Site Construction Contracts	Negotiated & Signed solely between EPC contractor & Supplier	Negotiated & signed between Owner and Contractor /with EPCM contractor's advice and assistance
Supplier Selection	Suppliers chosen solely by EPC	Suppliers chosen by mutual agreement
Scope of Supply		
Equipment Supply Warranties	Warranties negotiated by Suppliers & EPC contractor and issued to EPC Contractor directly. Warranty to Owner from EPC contractor is negotiated separately between Owner and EPC Contractor and issued to Owner by EPC Contractor	Warranties negotiated individually with each supplier by Owner with EPCM contractor's advice. Issued directly to Owner from the suppliers and contractors
Process Warranties	Warranties negotiated by Suppliers & EPC contractor and issued to EPC Contractor directly. Warranty to Owner from EPC contractor is negotiated separately between Owner and EPC Contractor and issued to Owner by EPC Contractor (Usually in the form of a performance Bond)	Warranties negotiated individually with each supplier by Owner with EPCM contractor's advice. Issued directly to Owner from the suppliers and contractors (Usually in the form of a Performance Bond)
Construction Site Safety (General Liability Insurance, Workman's Compensation, Accident, etc.)	Site Safety solely the responsibility of the EPC contractor and sub- contractors; in accordance with Contractual Agreements	Site safety is monitored by EPCM contractor but site safety is the legal responsibility of Owner and Sub Contractors; in accordance with Contractual Agreements
Permitting (Environmental, Construction, etc.)	Permitting is the responsibility of the EPC contractor with the exception of permits that are required by law to be issued in the name of the Owner of the project	Permits are issued to the Owner directly with EPCM contractor assisting in filing the necessary paperwork
Project Budget Cost Overruns	The cost risks for a project are borne by the EPC contractor. Any cost overruns, for equipment and/or services within the EPC contractor's scope of supply, are for their own account and cannot be passed onto Owner unless "change conditions" occur or contractual agreements to the contrary	The cost risks for a project are borne by the Owner. Any cost overruns, for equipment and/or services are for the Owner account (with the exception of fixed price supply contracts) i.e. Final equipment pricing bids / on site cost higher than originally budgeted.
Project Budget Cost Savings	The cost risks for a project are borne by the EPC contractor. Any cost savings, for equipment and/or services within the EPC contractor's scope of supply, are for their own account and are not passed onto Owner unless contractual agreements to the contrary	The cost risks for a project are borne by the Owner. Any cost savings, for equipment and/or services are for the Owner account i.e. Equipment/Services bids are returned lower than budgeted.
Project Day-to-Day Expenses	The day-to-day expenses for the project, within the EPC contractor's scope of supply are borne by the EPC contractor	The day-to-day expenses for the project are borne by the Owner but are managed and administered by the EPCM contractor (up to pre- determined quantities, without Owner's need for intervention). Usually a small fund is established by Owner for day-to-day expenses
Project Financing	Project Financing is usually accomplished by substantial down payment by Owner to EPC contractor and the remainder of the fees issued with Irrevocable Letter of Credit (with partial payments) from Owner to EPC Contractor. This requires Owner to have all financing in place at the onset of the Project so as to secure letter of credit (LC).	Project Financing can be any combination of down payments, open accounts, and Irrevocable Letters of Credit from Owner to suppliers / contractors; whatever method is negotiated during contract negotiations. EPCM contractor will assist in all negotiations on Owner's behalf. This allows Owner to have partial financing in place at the onset of the Project with the remainder available as needed, dependant on contractual requirements
Legal Cost	Legal Costs are low for Owner. Owner negotiates only one detailed supply contract with EPC contractor. EPC contractor must negotiate individual contracts with suppliers / vendors. EPC contractor's legal costs are high due to multiple contracts. In the event of legal action is taken, Owner must sue EPC contractor, who in turn must bring legal action against appropriate suppliers / contractors. (Usually a longer process than EPCM legal actions)	Legal Costs are higher for Owner. Owner negotiates multiple supply contracts directly with suppliers / contractor; with the assistance of EPCM contractor. In the event of legal action is taken, Owner must bring legal action against individual suppliers / contractors. (Usually a shorter process than EPC legal actions)
Administration	Owner's administration costs are low with EPC contract. Only minimal staff (management, QC, legal, etc.) needed to administer/monitor project. May have negative effect on project "ownership" feeling within Owner's organization (Hands off).	Owner's administration costs are higher with EPCM contracts. Substantial staffing levels needed to assist/compliment EPCM contractor in administering/monitoring project. Promotes "ownership" feeling within Owner's organization. Project staff often transferred to operational staff after project completion.

construction management services. Other companies are contracted by the Owner directly to provide construction services and they are usually managed by the EPCM contractor on the Owner's behalf. Think Professional Services contracts, where the project is largely Owner managed and the cost risk and control is weighted towards the Owner.

Below is a simplified Chart showing the differences in the type of contracts and how each would differ under the same situations: The list below is not a complete list of differences between EPC and EPCM contracts but it does address many of the major contractual differences. The way each of these issues is handled can be modified during contract negotiations to suit the situation and overall goals of the project.

EPC and EPCM contracting are both very prevalent types of contracts within the construction industry. Dependent on the level of risk the Owner of a project is willing to accept, budget constraints, and the Owner's organization core competencies, will determine which method is best for their project.

EPC contracting tends to be more expensive, to the Owner, due to the shift of project risk away from the Owner and to the EPC Contractor. On average, a project's cost 10% - 20% more using EPC style of contracting than a project using the EPCM style of contracting. This is due in large part to the project's risk being more evenly distributed between the Owner and contracts / suppliers.

Construction contracting trends have been leaning towards the EPCM style of contracting and away from EPC contracting for several reasons but both methods have their place in business today.

EPCM Advantages

- Lower Overall Cost
- Staff's Sense of Ownership
- More Control over Process
- Better for less defined projects with anticipated changes to scope of supply

- Less Legal Litigation (Identify issues early and remedy situation before larger problems arise)

- Owner's Financing Flexibility

These are just a few of the advantages of EPCM style of construction contracting.

EPC contracting has it place in the construction industry as well. Under certain situations, it makes better sense to use this type of construction contracting than other methods.

EPC Advantages

- One Stop Shopping "One point of Contact"
- "Hands off" approach to project
- Minimal Staffing Requirements
- Minimal Legal Risk

- Best for well-defined projects with Detailed Engineering Complete before EPC Contractor selected (Minimal Unknowns).

"These contract methods can be tailored to the individual projects / owner's needs. Each company must decide for themselves as to which method of construction contracting is best for their particular project and situation

As stated before, these construction contract methods can be tailored to the individual projects / owner's needs. Some companies can go as far as breaking up each portion of the EPC / EPCM (Engineering, Procurement, Construction / Construction Management) to separate companies. One company can do the engineering; another can do the procurement, while still another can do the construction / project management).

Each company must decide for themselves, with the advice of legal and financial counsels, as to which method of construction contracting is best for their particular project and situation.



Massimo Rebecchi

Massimo Rebecchi is graduated in Civil Geotechnical Engineering. He he has achieved PhD in Minerals and Petroleum Engineering in the United States. For years he was freelance professional as Mud Logger and Drilling Project Manager. He attended important construction projects under CCC-Sicon Oil group.

As a GE consultant in Nuovo Pignone since 2010, he attended several strategic Projects. During this experience he established Xylem srl in Milan. As President and Managing Director he satisfied the Opertions, Project and Quality requirements of several Main Contractors.

Today Xylem is a Lead Business Consultant Company in Industrial Construction (Oil, Gas, Process, Mills, Rail) for Operations, Project Management and Sourcing Quality Management located in Italy, Emirates, France and Algeria.

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Processes for Waste-to-Fuel generation

The waste-to-chemicals process perfectly represents a ready-tobusiness technology and an economically feasible solution which is able to promote circularity also in the hydrogen production sector

Giacomo Rispoli, CEO Alessia Borgogna, Business Development Waste-to-Chemical Analyst MyRechemical, a subsidiary of NextChem (MAIRE Group)

> ne of the main reasons behind the climate change issue is the disparity between the characteristic time of anthropic carbon consumption and the natural carbon sequestration paths. This unbalanced condition

must be rebalanced. One of the most rational paths to success for this aim is by promoting circularity in fuel and chemical production. The waste to chemical process perfectly represents a ready-to-business technology and an economically feasible solution which is able to promote circularity also in the hydrogen production sector. Generally, waste to chemical technology is able to produce fuel with a lower carbon footprint by exploiting a carbon and hydrogen source which is commonly disposed of: waste. The proposed technology is able to convert the carbon and hydrogen contained in those wastes which are the most difficult to be recovered or recycled: - Refuse Derived Fuel (RDF), which comes from the mechanical and biological treatments of Municipal Solid Waste (MSW) and -Plasmix, which is the residual fraction of the recycling treatment of sorted plastic (about 40% in volume).

Core

Waste management is one of the most impelling issues of our society. By 2050, the population is expected to grow. Along with the population, waste will have the same increase. Not only proportionally, since the



Figure 1. Global waste production projection. (Reference:What a waste. World Data Bank. Trends in Solid Waste Management (worldbank.org)

expected growth of the Gross Domestic Product of the lower and middle countries implies a much more pronounced growth of waste production. By 2050, annual global waste production is expected to be 3.4 billion, as depicted in the graph below.

"A healthy approach to waste management is the one which follows the so-called waste hierarchy; reduce; reuse; recycle; recover energy; dispose

A healthy approach to waste management is the one which follows the so-called waste hierarchy; reduce; reuse; recycle; recover energy; dispose. The first actions are related to those that each of us can implement. The reduction of the amount of waste produced relies on everyday life activities. Each of us can devote his efforts to reducing the amount of waste individually generated. In addition, he can apply the concept reuse, asking himself "should this material really to be thrown away?". And if you have to resort to throwing it out, differentiating, if possible. This is where the citizen's task ends and industry, technology and innovation take over. The differentiated product classes

"Waste to chemicals represents a valid alternative to fractions of waste that are not mechanically recyclable, which can then be chemically converted to produce, for example, fuels

can therefore be mechanically recycled. But not all the differentiated fractions can actually be recycled. A fraction of waste always exists, larger or smaller depending on the type of material and collection. This is where innovation comes in. Waste to chemical represents this: a valid

alternative to fractions of waste that are not mechanically recyclable, which can then be chemically converted to produce, for example, fuels.

The typical feedstock of a Waste to chemical process are Refuse Derived Fuel (RDF), which is the dry fraction of unsorted municipal solid waste and the nonrecyclable plastic; any other waste fraction that is impossible to recycle in an alternative way can be sent through the process. An example of the average compositions, by weight fraction, of the two mentioned fractions is reported in the table below.

It is important to notice the content of carbon and hydrogen. These elements are usually taken from fossil resources. The rationale in a Waste the chemical process, is instead to produce fuel or chemicals by converting the carbon and hydrogen contained in the waste which would otherwise be disposed of or at best recovered only in terms of energy.

The conversion of carbon and hydrogen is performed by a high temperature melting gasifier which is the core of the process. The particularity of this technology is that it is able to convert feedstock with a high content

	RDF	Non-recyclable plastics
С	40-55%	47-61%
н	5-8%	5-7%
0	20-28%	14-20%
CI	0.5-3%	0.8-1.5%
Ν	0.5-1.5%	0.2-0.5%
S	0.1-1%	0.02-0.3%
Moisture	10-20%	5-9%
Ash	5-20%	7-20%

Table 1. Average elemental compositions of Refuse Derived Fuel and Non-recyclable plastics.

of inter fraction, such as RDF. The reactor is able to melt the ash fraction of the waste to produce a vitrified granulate applicable as a raw material for ceramic and concrete production as substitution of minerals. Meanwhile, the reactor is able to convert the combustible fraction of the waste into a valuable gas, called syngas, composed mainly of hydrogen and carbon monoxide.

The waste to chemical process is composed of five main sections, as seen in **Figure 2**.

1. High temperature gasification. As mentioned above, this is the core of the overall process, since the combustible fraction of the waste is converted into syngas, while the inert fraction of the waste is melted – thanks to the high temperature reached – and collected as a vitrified granulate material.

The reactor, according to the temperature profile, can be schematized as divided in three zones, as seen in **Figure 3**:

- a. Melting zone. Where pure oxygen is fed as a combustion and gasification agent. The exothermal nature of the oxidation reactions allows the temperature to reach above 1600°, thus making it possible to melt the inert fraction specifically contained in the waste.
- Partial oxidation zone. A balance of gasification reactions implies the further conversion of the combustible fraction, but also a reduction of the average working temperature (700°C).
- c. Stabilization zone. Called stabilization since the gas produced is slowed down when it reaches the enlarged reactor section, and further converted by the introduction of more oxygen which allows the temperature to elevate up to 1100°. In this way a very valuable syngas is produced: free of TARS or dioxins.

2. Syngas cleaning and storage. As the syngas is coming out from the gasification reactor, it is abruptly cooled from 1100°C to 90°C in order to freeze the composition and avoid the formation of toxic compounds. The cold syngas is sent to two scrubbers and an electrostatic filter to perform a preliminary cleaning. The cleaned syngas is then sent to a gas holder in order to control the potential fluctuation of flowrate.

3. Syngas compression and purification. Syngas from the gas holder is compressed and purified through several steps, including adsorption beds, hydrolysis, and sulfur removal, in order to achieve a thoroughly polished syngas which cannot contaminate the catalysts of the following step.

4. Syngas conditioning. Both methanol and ethanol would require a higher H2/CO ratio than the one coming directly from gasification, which is about 1. Thus, according to the final product desired, the


Figure 2. Block scheme of the steps of which a typical Waste to Chemical process is composed.

syngas composition must be adjusted to meet the synthesis requirements.

5. Final synthesis. The syngas can be separated to obtain hydrogen, and either methanol, through catalytic synthesis, or ethanol, through biological fermentation, can be produced.

The scheme described above is the conventional configuration of the waste to chemical process, which allows about half of the carbon in the waste to be converted into new molecules, methanol or ethanol. Here below the two process schemes for production of methanol **Figure 4** or ethanol **Figure 5**.

Further, it could be proposed the coproduction of methanol or ethanol with hydrogen. The hybrid schemes would allow to produce about 1500 KTY of hydrogen which is the right amount for the developing of hydrogen valley to shape the utilization of low carbon hydrogen in new sector such as sustainable mobility.

One possible upside of the scheme is the simultaneous production of hydrogen together with methanol or ethanol. Such co-production allows low-carbon hydrogen to be placed on the market at a lower price than green hydrogen from electrolysis, thus stimulating the implementation of the required infrastructure for hydrogen use.

Nevertheless, in a long-term scenario, when the power grid will most likely be able to rely on a 100% (or nearly)



Figure 3. Sezione trasversale del reattore di gassificazione.

share of renewable sources, an improved integrated waste to chemical scheme can also be implemented. Thus, green hydrogen produced through green power can be directly added to the syngas in order to fulfill the requirements, another way of conditioning, by which all the carbon contained in waste is converted into final molecules and the yield of the process is doubled.

The methanol and ethanol produced by this scheme can be applied as precursors for other chemical syntheses and then plastics, thus closing the loop (of



Figure 4. Waste to methanol block scheme.





waste). But also, methanol and ethanol can be applied

"The advantage provided by waste to chemical processes is twofold: it constitutes an alternative to the conventional fossilbased fuel production and it functions as a novel, more efficient, and circular fashion for waste disposal as low carbon fuel in substitution of fossil ones. In detail, methanol can directly substitute bunker oil for the shipping sector. According to the ReFuelEU, the maritime sector has to reduce the GHG emission by 75% WITHIN 2050. Meanwhile, a sustainable aviation fuel can be produced from ethanol in order to decarbonize the aviation sector, which would help to achieve the European target of at least

63% Sustainable aviation fuel share by 2050.

Conclusion

The advantage provided by waste to chemical processes is twofold: on the one hand, it constitutes an alternative to the conventional fossil-based fuel production; on the other hand, it functions as a novel, more efficient, and circular fashion to dispose of waste. Such a twofold feature is reflected in the economics. The gate-fee coming from the disposal of waste compensates for the additional costs which come with such an innovative, sophisticated and environmental-friendly system, rendering the final cost of the product competitive with the cost of conventional products.



Giacomo Rispoli

Giacomo Rispoli holds a degree in Chemical Engineering from the University of Rome. He joined Nextchem at the beginning of 2020 with the responsibility of leading Waste to Chemical Business Unit based mainly on the valorization of syngas production coming from waste gasification along with the chemical products that can be generated. This approach is a very innovative way to convert waste reducing significantly at same time the CO2 production. This business line became at the end of October 2020 a legal entity with the name MyRechemical and he is the CEO. Previously, he spent 33 years in Eni Refining Business covering many responsibilities.



Alessia Borgogna

Alessia Borgogna is Business Development Waste-to-Chemical Analyst at MyRechemical, a subsidiary of NextChem (MAIRE Group). Previously, she occupied the position of Junior Process Engineer at NextChem, having joined the company in 2019 after earning her PhD in chemical and environmental engineering. During her PhD studies, she was a visiting student at Karlsruhe Institute of Technology (KIT). Prior to her PhD, she earned an MS degree in chemical engineering in 2016 and a BS degree in chemical engineering in 2014, both from the University of Rome.

Offshore pipelines design in the Energy Transition

New $\rm H_2$ and $\rm CO_2$ transport operating scenarios, technological challenges and innovation strategies

Elvira Aloigi, Technical Manager of H₂ & CO₂ Offshore Pipelines R&D Projects, Offshore Engineering **Giorgio Arcangeletti**, R&D Engineering Dept. Manager, Asset-Based Business Line **Benedetto Orselli**, Design and repurposing of offshore pipelines **Andrea Mercuri**, Senior Technical Safety Specialist Saipern S.p.A.

he new energy production and distribution scenarios include Renewable Energies, Hydrogen as energy vector and the application of Carbon Capture, Utilization and Storage (CCUS) technologies. According to the International Energy Agency, pipelines, as part of the transport infrastructure, are key enablers of the transition to a decarbonized energy system making it more viable economically especially when repurposing existing oil and gas pipelines. Considering Hydrogen transport, in Europe, 1.600 km hydrogen pipelines were identified in 2016 all onshore whilst today the European gas transport associations, within Gas for Climate, foresees 8 times more including repurposing of the existing gas grid and offshore lines.

The topic of repurposing is another key element and presumes that the energy transition should be based on a circular economy approach maximizing re-use without compromising safety.

In 2021 a study was commissioned by important associations to assess the feasibility of repurposing the European gas and oil infrastructure to transport hydrogen or CO_{2} (**Picture 2**).

Some results applicable to offshore pipelines are shown in **Table 1**.

The challenge for the pipeline designer is that no hydrogen pipelines offshore exist today, very few are the CO_2 ones, repurposing activities are mostly limited to life extension of existing pipeline without changing significatively the type of fluid transported.







Picture 2 – Re-stream (2021), a Study on the reuse of oil and gas infrastructure for hydrogen and CCS in Europe, by Carbon Limits and DNV (Det Norske Veritas) for IOGP (International Association of Oil & Gas Producers), Entsog (European Network of Transmission System Operators for Gas), Concawe, GIE (Gas Infrastructure Europe).

Offshore Pipeline Material	90%: API 5L X65 or X60	
Maximum Allowable Operating	150 bar (average - oil pipelines)	
Pressure	160 bar (average - gas pipelines)	
Size - Oil offshore pipelines	Outside Diameter range 12"- 36"	
Size - Gas Pipelines (long export gas pipelines)	Outside Diameter > 24"	

Table 1 – Data on Existing Offshore Pipelines in North Europe eligible for repurposing to H_2 and CO_2 Transport (ref. Re-Stream study)

In 2021 a study, Re-stream, commissioned by important 0&G associations, analysed the feasibility of repurposing the European gas and oil infrastructure to transport Hydrogen or CO₂

In addition, the new scenarios oblige to a transformation in the design approach that should primarily consider that some of the new molecules to be transported have an interaction with the integrity of the pipe material itself. Therefore, as part of the change, it is to be considered the testing of material properties under various conditions, to support and provide a strong scientific base to the standardization process of the design.

Advancing the innovation process in technology

After a preliminary state of art review, it was recognized that there were gaps to be filled from a technological point of view and a roadmap was established to fill them. All engineering disciplines of offshore pipeline design were involved in this process considering both JIP adjoining and experimental test campaigns. The intent was to be methodical and pragmatic, with a learning by doing approach.

The innovation plan was organized in three phases (**Picture 3**), each including various work packages.

The first phase was dedicated to deepening knowledge on the two fluids and identify the gaps where additional R&D effort was required. The second phase was focused to design and start filling the gaps. Some case studies were selected for new or repurposed offshore pipelines to transport H₂ or H₂/NG or CO₂. The study cases for pure hydrogen considered a new pipeline transporting hydrogen from an offshore electrolyser to shore, while for hydrogen blended with natural gas it was analysed the re-use of an existing offshore pipeline in the Mediterranean sea. The study case for CO₂ considered the reuse of an existing flowline system between two platforms and the shore, reversing the flow direction to transfer captured CO₂ from land industrial sources to subsea injection and storage. The **Table 2** below presents the main characteristics of all the case studied within the research program.

To fill some knowledge and technological gaps and to conduct experimental test campaign, a cooperation with research entities and laboratories, like Politecnico di Milano and RINA, was started including the active participation to an important Joint Industry Project, DNV (Det Norske Veritas) JIPH2Pipe (Joint Industry Project on Hydrogen Pipelines).

The third phase is ongoing with the ultimate objective to provide data and information to the engineering disciplines involved in pipeline design, to develop recommendations and guidelines or procedures and fit for purpose design tools, to consolidate a network of suppliers ready for the new scenarios, to elaborate and





Study Case	Service	Location of Production Facilities	Pipeline State	Main Characteristics
#1	H ₂ /NG Blend	Onshore - Green/Blue Hydrogen	Existing	Repurposing sealines, database from recent inspections available
# 2	H ₂ /NG Blend	Onshore - Green/Blue Hydrogen	New	Large diameter, long distance sealines
# 3	H ₂	Offshore – Green Hydrogen	New	Small size, limited distance sealines
#4	CO2	Onshore – CO2 Captured by Industrial Port areas	Existing	Repurposing flowlines for gaseous and dense phase CO ₂ transport to storage

Table 2 – Summary of Study Cases Data used within the R&D Research Program by Saipem

conduct experimental tests for the qualification of Saipem offshore pipeline systems for the new transport conditions and scenarios.

Know your partners: Hydrogen and CO,

The two fluids have some peculiar properties quite relevant to pipeline transport (**Picture 4**).

They are both gases at standard conditions, however CO_2 in the typical transport conditions of a gas pipeline, can be very close to a phase change from gas to liquid or to a supercritical state depending on the selected operating pressure and temperature.

Saipem Offshore Engineering Team promoted first and then joined the JIP H2Pipe by DNV to write a Guideline on design, construction and operation of hydrogen pipelines that supplement the standard DNV-ST-F101 on submarine pipeline systems

This behaviour is magnified if the CO_2 includes impurities because it behaves like a mixture. Picture 5 groups and directly compares in one graph the phase envelopes for pure methane, a typical natural gas composition, pure CO_2 and some CO_2 mixtures making it clear how CO_2 liquid, supercritical or 2-phases protrude in the typical transport region for gas pipelines. It is to be noted that exceeding the critical point CO_2 has the density of a liquid and the viscosity of a gas which is an advantage from a transport point of view.

If CO_2 is 1.5 heavier than air, Hydrogen is much lighter. It has the highest energy content per unit mass, so, much more than the most common fuels, however it







Picture 5 – CO_2 phase diagram (pure and with impurities) vs. pure methane and natural gas phase diagram (from DNV-RP-F-104, 2021)

has a very low energy density which is a drawback as it is transported via pipeline in gaseous form, even if compressed. Another peculiar aspect of Hydrogen is its ability to migrate into the structure of other materials. In metals as well, causing the deterioration of some properties and this is generally referred to as material embrittlement.

Hydrogen Pipelines Offshore

The offshore pipeline Oil and Gas industry designed using a stress-based approaches till the 90's when a dedicated R&D project - SUPERB JIP - introduced in DNV-ST-F101 (former DNV '96) the "limit state" design approach. Since then, the design by failure mode is the basis for the offshore pipeline design and relevant safety factors are calibrated through structural reliability theory based on acceptable target failure rates. The transportation of H_a, or H_a/NG through existing or on purpose designed pipelines can cause additional failure modes or important changes on the failure modes mechanisms with respect to the typical occurring to submarine pipelines according to DNV-ST-F101. It is, therefore, required that a combined assessment is done, and cross correlation(s) established among failure modes, material properties, usual and typical loads of the new energy scenarios and the specific fluid (e.g. H₂ or H₂/NG) environment (Torselletti et al., OMC-2021).

Hydrogen presents some unique "degradation mechanisms" to be considered during design. It has an interaction with typical offshore high strength line pipe materials (e.g. API 5L X60, X65, X70) and pipe welds, affecting key properties such as ductility, toughness and fatigue performance. A dedicated Saipem Offshore Engineering Team analyzed these issues considering all typical failure modes applicable to an offshore pipeline. Analysing the different failure modes, the one related to circumferential stress is ruling the sizing of the offshore pipelines in shallow and medium water depth (up to approx. 800 m, ASME B31.12 Option A) while in deep or very deep water (above 800 m and up to 2000 m) the wall thickness sizing is determined to fulfil the criteria of collapse for external pressure, or the



Picture 6 – Example of Sizing Criteria applicable to hydrogen offshore pipeline design as a function of water depth

minimum required specific gravity (Picture 6).

As far as the occurrence of cyclic loads for offshore pipelines, the high longitudinal stress and strain due to the installation phase (**Picture 7**), to the sea bottom unevenness and to the environmental loads need to be verified against the impact of the presence of Hydrogen on the resistance of pipe materials and welds to fatigue.

Fatigue damage is accumulated since the installation phase because of weather condition and depending on dynamic response of the pipe-vessel system. Also, the fatigue in operating conditions is caused by environmental loads originating bending stress cycles with frequencies of the order of less than one hertz joined with long cycles temperature and pressure variations.



Picture 7 – Complexity of interactions pipe vessel and sea environment in different pipe laying modes

In fact, an important reference code such as ASME B31.12 2019 does not include a specific approach for offshore pipelines or and for their girth welds that are part of the offshore pipeline fabrication process (**Picture 8**).

Based on these considerations it was decided to go through steps starting from the analysis of how hydrogen affects failure modes, elaborating a test matrix for materials and welds in hydrogen environment to consolidate or cover areas of uncertainties and work on a methodology for qualification of new and existing offshore pipelines to be re-purposed.

The years 2021-2022 have seen the dedicated Saipem Offshore Engineering Team promoting first and then joining in the JIP H2Pipe (started with 5 industry participants, it reached more than 30) by DNV to write a Guideline on design, construction and operation of hydrogen pipelines (offshore steel pipelines) to supplement the standard DNV-ST-F101 on submarine pipeline systems. JIPH2Pipe is developing not only a



Picture 8 - Saipem Pipe Laying Vessel Castorone

guideline but also performing an important test campaign in hydrogen environment to support the guideline contents.

In parallel Saipem is conducting, in RINA-CSM laboratories in Rome and Cosenza, an experimental test campaign to qualify a typical material for long and high-pressure pipelines and the girth welds performed onboard Saipem Vessels. New tests are also planned in 2023 for coating and field joint coatings applied to offshore pipelines.

Saipem is part of EPRG (European Pipeline Research Group) where the Hydrogen Topic group is working at an important test campaign in H₂ environment.

ASME B31.12, currently the main reference code on Hydrogen piping and pipelines, could be complemented and modified with additional considerations on material and welding properties in gaseous hydrogen environment and for offshore pipeline design. In this regard, Saipem is represented in ASME Europe International Working Group B31.12 and will work together with the other members to complement the code as required by the new energy transport scenarios.

CO₂ Pipelines Offshore

For submarine pipelines, the effort by Saipem is focused on the understanding of the thermodynamic behavior of CO_2 streams with impurities, the related flow assurance issues (phase control), the running ductile fracture phenomena, the readiness of in-line equipment and the safety aspects relevant to the development of a risk assessment methodology for CO_2 Leakages.

The DNV-RP-F104 for CO_2 pipelines is already aligned with the failure modes approach and advanced in terms of specific requirements such as dealing with impurities. It has also a tested approach for specific failures mode such as the running ductile fracture in the 2021 edition with the contribution of the CO2SafeArrest Joint industry project.

The effort by Saipem is focused on the areas relevant to offshore application still requiring further advancement such as the validation of tools for calculating the thermodynamic behavior of CO_2 mixtures and in particular the decompression curves in case of pipeline ruptures (for those cases not fully covered by the current state of art). The work done on

 CO_2 was focused mostly on predictive models for CO_2 with impurities with the objective to guarantee operating flexibility and safety. In fact impurities may cause side reactions, modify the extension of the two phase region and have an effect increasing the saturation pressure which is the driving force in the running shear fracture of a pipeline transporting liquid / supercritical CO_2 .

The R&D gap analysis on the running ductile fracture for subsea lines transporting CO, mixtures has led to the

Saipem is part of EPRG (European Pipeline Research Group) where the Hydrogen Topic group is working at an important test campaign in H2 environment

development of an internal guideline to design new or to verify repurposed lines and to identify that it would be desirable to reinforce some assumptions with experimental burst tests for medium diameters subsea lines possibly in a new JIP on this specific subject.

Safety Aspects and Loss Prevention

Safety aspects of Hydrogen, H_2/NG and CO_2 pipelines are of paramount importance. The Major Accidental Hazards associated to H_2/NG and CO_2 offshore pipeline systems are related to loss of containment events.

In case of a subsea release from an offshore CO_2 pipeline system, an underwater plume is produced which can impact the local flora and fauna due to pH changing close to plume. If the plume reaches the sea surface, it produces a bubble zone which can affect passing ships impacting on their buoyancy. Through the bubble zone, the CO_2 gas disperses in atmosphere producing a cloud of asphyxiant/ toxic gas: pure CO_2 is an asphyxiant gas and the content of impurities from CCS process, such as H_2S , CO_2 , can increase its toxicity. The cloud of asphyxiant/toxic gas can affect people on board of passing ships, or in the offshore installations or at shore causing injury from minor to severe and potentially loss of life depending on toxic substances concentration and exposure time.

In case of a subsea release from a hydrogen or H_2/NG pipeline, an underwater plume is produced as well. The impact for underwater environment is less severe than CO_2 case while the atmospheric dispersion can produce an environmental impact from moderate to high or very high depending on the inventory released. In addition, since Hydrogen is a flammable gas, easy to ignite, the likelihood of a flash fire or explosion is higher than for natural gas case. The thermal effects of a flash fire due to hydrogen ignition as well as overpressure



Picture 9 – CFD Plume from a subsea pipeline rupture transporting CO_2 at high pressure in dense phase due to vapor cloud explosion produce harm to people from severe to loss of life.

To reduce risks of pipeline system operation at as low as reasonably practicable levels, a formal and rigorous risk assessment process is required from the early stage of engineering phase. In particular, the risk assessment process can allow a design which considers the safety and environmental aspects and identifies the proper risk reduction measures where necessary. The risk assessment main steps have been analyzed by Saipem Team to identify the gaps with respect to H₂/CO₂ transport. One gap is in the identification of hazards and threats of the frequencies of loss of containment events and consists in the poor or totally missing data about offshore CO₂ and H₂ Pipelines. The other is related to the consequences of loss of containment events and in particular the lack of a good number of validation mid or full-scale experimental tests for the simulations model of ruptures and underwater gas dispersion.

To estimate the frequencies of loss of containment events Saipem developed its own methodology. It is valid for all type of steel pipelines, flexible lines, risers, and it includes the onshore pipeline connecting sections. The methodology foresees to estimate the loss of containment frequencies starting from the database of release frequencies for other hydrocarbon pipelines. It foresees that a team of representative leaders and specialists of each project discipline (e.g. corrosion, material selection, pipeline design, flow assurance, safety) is involved in a brainstorming workshop. The purpose of the workshop is to evaluate the threats related to CO₂ or H₂ transportation for the specific project under analysis and to associate a specific penalty factor to the loss of containment frequency coming from the hydrocarbon database. The evaluation of penalty factors is based on the severity of consequences of each threat.

Once the frequencies of occurrence of CO_2 or H_2 loss of containment are evaluated, then the consequences

of each loss of containment event need to be evaluated. The assessment of the consequences is usually carried out by means of advanced simulation tools.

Saipem owns an integral model, called POLPLUME for the simulation of subsea hydrocarbon releases. It was developed, in the past, in cooperation with "Politecnico di Milano", Department of Chemistry, Materials, Chemical Engineering "G. Natta", in Italy. Therefore, the same department has been involved in 2021 to adapt the model for different type of fluids like CO_2 and Hydrogen.

In addition to POLPLUME upgrade works, Saipem Team developed an internal computational fluid dynamic model to assess the subsea behavior of underwater plume for the most complex scenarios of a CO₂ release (gas and dense phase at various water depths).

In summary, the assessment of the consequences of subsea releases can be carried out with an approach based on integral models for simple cases of subsea loss of containment events or adopting a computational fluid dynamic model for more complex cases. The integral models present the advantage to be fast and suitable for risk assessment of relatively simple cases. The CFD models are useful for complex analysis but present the disadvantage of being time consuming, have high computational cost and they need the specific knowledge of CFD specialists.

The next step is the validation of these models with relevant mid or full-scale experiments on subsea releases of CO_2 or H_2 that do not exist at the moment. Therefore, Saipem joined safe C02 JIP with major oil and gas companies led by SINTEF to validate those models based on full-scale tests.

The full-scale experiments are planned in the next years, and they will be executed at sea and at various water depths.

In conclusion, Saipem has developed a methodology and a path to efficiently carry out Quantitative Risk Assessment for CO_2 and H_2/NG offshore pipeline systems reducing the uncertainty of the analysis.

Final Considerations and Way Forward: the value of R&D in the Industrial Energy Transition

The energy transition requires that offshore pipeline transport is economically convenient and able to provide large capacity and long-distance transport at highest HSE standards. The intersection of technological gaps and needs allowed the identification of the values that an R&D effort could bring.

Therefore, starting from mechanical design, the effort has been and will be:

- 1. on standardization, construction, welding and installation methods;
- for Material Technologies on studies and tests on materials. This includes development of methodology and predictive models for Structural Integrity and Running Shear Fracture, cooperation within JIPH2Pipe, EPRG and with other research entities for the experimental activities;
- for Safety, on how to assess the frequencies of loss of containment, underwater dispersion modelling of leaks & ruptures and their validation, third party interaction for hydrogen transport;
- for Flow Assurance, on the effects of impurities or of blended compositions on transient scenarios

including those leading to low temperatures and the risk of hydrates/solid formation and therefore blockages and potential ruptures for the pipelines.

Cooperation for experimental programs on materials and on the consequences of loss of containment events in the new offshore transport scenarios is a commitment that cannot be failed by all key actors in the energy business.

What above demonstrate how Saipem, as Contractor and Service Provider in the energy sector, reassessed its own technological portfolio to meet the demand of new energy sources and vectors by keeping at the top level the attention to safety, design and execution of new challenging projects.



Elvira Aloigi

Elvira Alogi has a M.Sc. in Chemical Engineering (Politecnico di Milano) and thirty years' experience with Snamprogetti/Saipem in the Oil & Gas sector. She worked in Environmental, Process, Flow Assurance departments reaching the role of Unconventional Technologies Process Manager. Following 5 years' international experience in Canada, from 2015 to 2020 she worked in Saipem Offshore Division Subsea Field Development. In 2020 she joined the Saipem Innovation Factory for a project on Circular Economy presented to Saipem CEO. She is currently engaged in Offshore Engineering as Technical Manager of H₂ & CO₂ Offshore Pipelines R&D Projects and she is Chair of ASME B31.12 EU IWG (Europe International Working Group).



Giorgio Arcangeletti

Giorgio Arcangeletti, after the achievement of a master's degree in Mechanical Engineering on 2005, joined Saipem S.p.A. on 2009 as System Engineer. Mainly involved on Subsea Equipment engineering for several executive projects, on 2016 started working as Technical Manager for Innovation Projects and development activities also for external Clients. Since 2020 Giorgio is Offshore R&D Engineering Dept. Manager within the Asset Based Business Line of Saipem S.p.A.



Benedetto Orselli

Benedetto Orselli has a M.Sc. in Civil Engineering (University of Ancona). He has forty years' experience in offshore pipeline design as structural engineer. He is senior engineer for the design of pipelines characterized by uneven sea bottom, deep and very deep water, narrow passage, installation issues and landfalls performed with special technologies such as the trunk lines across the Mediterranean Sea Italian shore, the Black Sea and the North Sea toward Norwegian coast. Involved in the studies for the design and repurposing of offshore pipelines from HCs to H₂ and CO₂.



Andrea Mercuri

Andrea has a M.Sc. in Mechanical Engineering (University of Calabria). He has twenty years' experience as loss prevention and HSE specialist in the Oil & Gas sector. He is a senior technical safety specialist, chairman for HAZID/ HAZOP and SIL assessments, TUV certified engineer for functional engineering (IEC 61508 and IEC 61511). His competences include qualitative and quantitative risk assessments for operational and installation phases, third party frequency interaction (fishing and shipping) with subsea facilities, dropped object studies, reliability assessments, Risk Assessment for Fire&Explosion and Escape&Evacuation, Emergency Survivability System Assessment, Hazardous Area Classification, Safety for Venting and Flaring systems, application of SEVESO directive.

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