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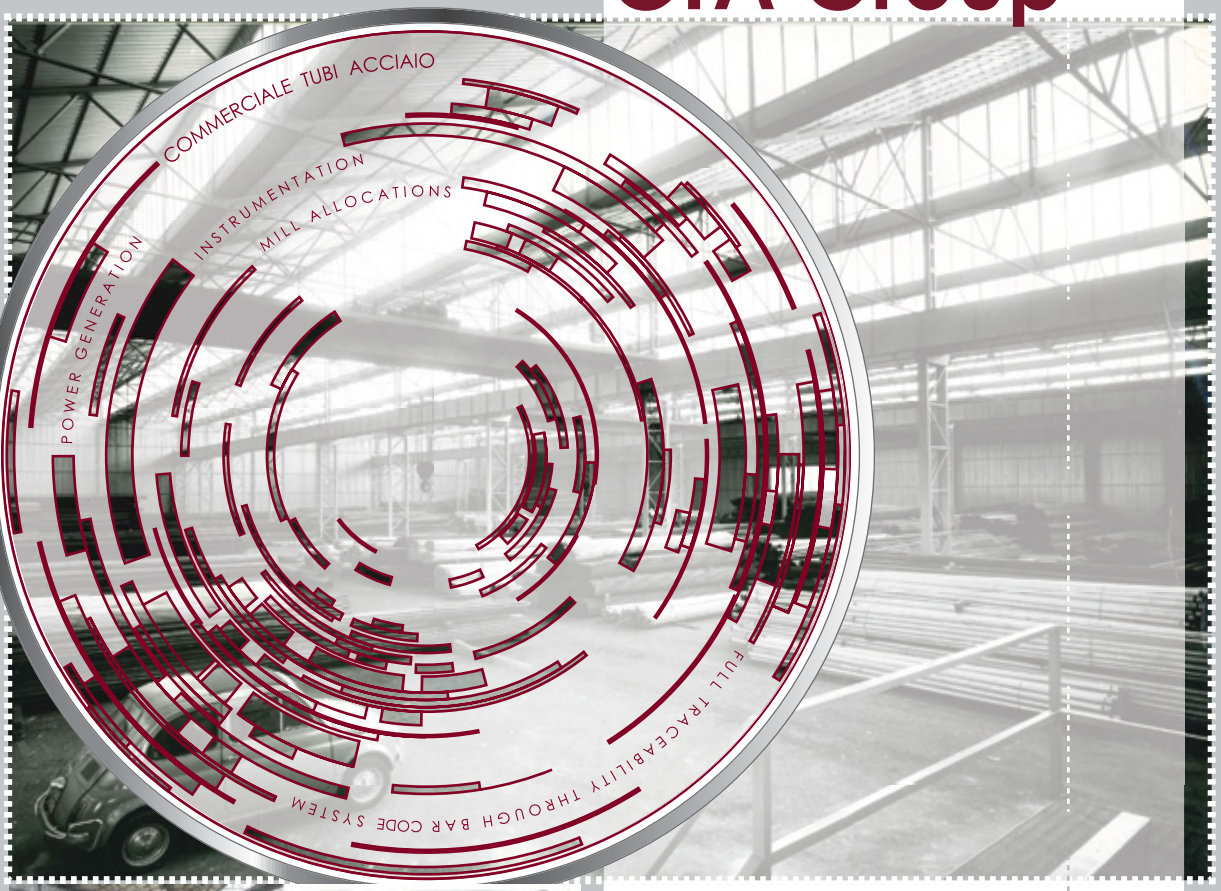

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Editorial

The New World: Opportunities and Uncertainties

Antonio Careddu
ANIMP President

Just as we started the optimism started to resurface in the hoped-for post-pandemic era, with the new war situation we now have a major additional source of complexity and uncertainty in our industrial world.

At the time that this magazine goes into press, it is way too early to assess the extent of this upheaval, particularly to our energy industry, not only in the countries directly involved, but even more broadly in the entire world. Most likely, there will be a major change and realignment in the direction and location of the global investments and a sizeable modification in the flow of goods and energy sources. We may be facing a totally new world order in the ways in which the energy and related products are produced, transported, delivered, utilized.

In this context, I am pleased to introduce the latest number of *Industrial Plants*, the yearly publication for international audiences of ANIMP, the Italian Association of Industrial Plant Engineering Companies, which 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, for over 50 years ANIMP has strived to develop a world-class supply chain, competitive globally in any industrial plant market, in order to promote growth, development, innovation and international cooperation.

Following our tradition, the current issue shows a selection of our industry's recently completed projects or of those under execution, with special emphasis on energy projects.

In this highly uncertain context, ANIMP underscores perhaps the most important single factor of the competitiveness of the Italian industry: while maintaining a top-of-the-line technological and execution capabilities in most world markets, overall the Italian industry has an unparalleled reputation for flexibility, imagination, capacity to react positively to sudden crises and changes in global markets.

> **"While maintaining a top-of-the-line technological and execution capabilities in most world markets, the Italian industry has an unparalleled reputation for flexibility, imagination and capacity to react positively to sudden crises and changes in global markets**

We are therefore following the evolution of the current crisis, ready to serve our customers in the new needs, as they arise.

In addition, ANIMP continues to work on programs we have embarked upon in recent years:

1. Collaborative digital solutions and the rationalization of the global supply chains, in the belief that cooperation among partners and the putting aside of natural suspicions are key factors of success in all our initiatives;
2. Decarbonization, the emphasis on the energy tran-

"ANIMP has emphasized decarbonisation, circular economy projects, the increasingly widespread adoption of ESG concepts and the preparation of many 'green' projects

sition projects, following commitments and pledges from the recent COP 26 symposium, which offer considerable hope that the global warming can be limited – but which will require significant investments in the 'new' energy industry;
Our Italian plant industry has firmly embraced the opportunities posed by these new trends, as witnessed by our general activities globally - and by the articles in this edition of our magazine;

3 Top attention to new industry investment programs, which are appearing on the drawing boards of Government and Energy companies alike, even in the more traditional energy fields, in order to fight the shortages, present and on the horizon: e.g. new gas plants, new pipelines, new LNG production and regasification plants, etc.

4 The structured and collaborative JIP (Joint Industry Program) among many players, large and small, for the creation of industry-shared guidelines on quantitative metrics to assess the environmental, social and governance (ESG) sustainability of the supply chains in our plant engineering sectors, with particular attention to equipment suppliers and suppliers' services, including subcontractors and international financial institutions This is an increasingly mandatory framework in large project tendering around the world.

Naturally, all these transformations cannot be implemented overnight, so we need patience and resilience. ANIMP continues to try to put together all these pieces of this new and ever-changing puzzle, to ensure that all industrial sectors of our supply chain can provide new, valid and competitive solutions.

In addition to putting together the technical and human resources and experiences among all our players in order to satisfy the future needs of our Clients', ANIMP can also leverage on the financial resources which our stake holders and institutions such as CDP, SACE and SIMEST can make available to stimulate the innovation and reduce the risk for new products and services in support of the Italian businesses.

"ANIMP has started to put together all the pieces of the new decarbonization puzzle, to ensure that all industrial sectors of our supply chain provide new and competitive solutions

Therefore, in spite of the current difficulties, risk and uncertainties, we look at this 'new future' with considerable 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.
We are therefore ready for new challenges. In ANIMP, we also remain always grateful to the Italian and other partner industries for their strong and continuing support.

Antonio Careddu

Antonio Careddu

Antonio Careddu graduated at Politecnico di Milano University and joined Saipem as an electrical engineer.
From 1991 to 1998 he was assigned various roles in Saudi Arabia, Mexico, Malaysia, Republic of South Korea, Oman. In 1999 he came back to Italy to take the responsibility as Department Manager and later as Project Director.
In 2010 he became Country Manager and CEO of Saipem Contracting Algérie and in 2012 Chairman and CEO of Saipem France.
In 2013 he returned to Italy and was appointed Director of the Saipem's Innovation, Systems and Corporate Marketing Unit.
In August 2018 he was appointed Head of Onshore Business Development, Commercial and Tendering.
ANIMP President since mid-2018

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NextChem's technologies for the production of low-carbon and renewable hydrogen: Electric Blue Hydrogen™, Circular Hydrogen™, Green Hydrogen

Application of a unique business model to meet the needs of the new developing hydrogen market, as project developer, co-investor, industrializer and integrator of innovative technologies, and as an EPC general contractor

Alberto Litta Modigliani, VP Hydrogen
NextChem, a subsidiary of MaireTecnimont Group

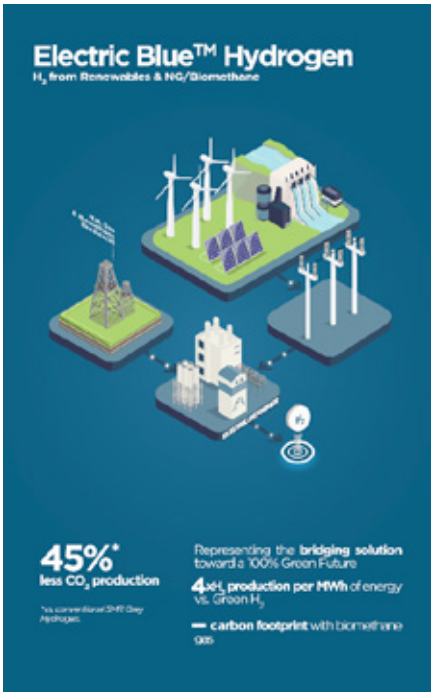
Hydrogen is establishing itself as a key element for the energy transition. Its characteristics make hydrogen a fundamental energy carrier: it can be used as a fuel and as a feedstock in many industrial processes, it is storable and transportable over long distances.

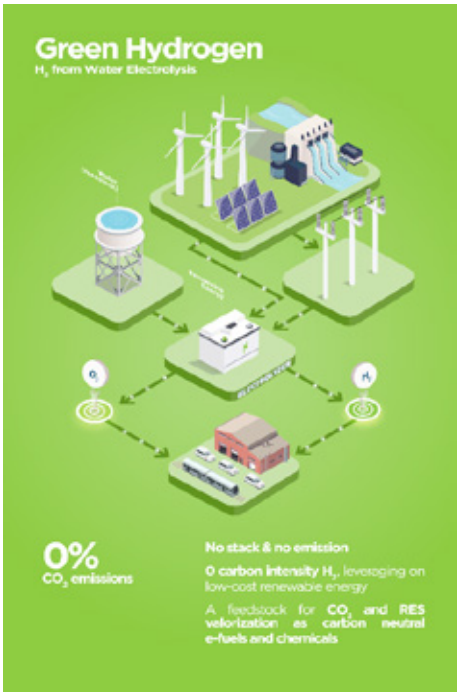
> "Hydrogen is a fundamental energy carrier: it can be used as a fuel and as a feedstock in many industrial processes, it is storable and transportable over long distances

According to the forecasts published in November 2021 by the Hydrogen Council, by 2050 the demand for renewable or low-carbon hydrogen could reach about 660 million tons, constituting 22% of the final energy demand at global level. Hydrogen will play a key role in the decarbonization process. It can be used in the transport sector, as a raw material in several industrial sectors such as steel or chemical, or as a building block to produce different products, such as fertilizers.

> "By 2050 the demand for renewable or low-carbon hydrogen could reach about 660 million tons, constituting 22% of the final energy demand at global level

To face up to the global challenges of the industry's decarbonization through hydrogen, NextChem has adopted a unique business model able to meet the needs of the new developing hydrogen market. Thanks to the capabilities of Maire Tecnimont Group, NextChem is positioned both as a project developer and co-investor in the project development, as industrializer and integrator of innovative technologies, and finally as an EPC contractor in the realization steps. Maire Tecnimont, with its strong technical expertise as a leading engineering company, represents the ideal link between the world of renewables and the world of the process industry, and is positioned through NextChem as the optimal partner for any type of end-to-end project related to the decarbonization of industrial processes. NextChem can supply three technologies to produce three different types of low carbon and renewable hydrogen, which allow a significant emissions' reduction: Electric Blue Hydrogen™, Circular





"NextChem can supply three technologies to produce three different types of low-carbon and renewable hydrogen, with significant emissions' reduction: Electric Blue Hydrogen™, Circular Hydrogen™ and Green Hydrogen

Hydrogen™ and Green Hydrogen.

The first is ElectricBlue Hydrogen™. This is based on traditional know-how, but it involves the use of electricity to feed the endothermic reactions of steam methane reforming. ElectricBlue Hydrogen™ has similar architecture to that of the steam reformer, with two innovations: CO_2 capture; and the electrification of the process, which allows for the use of energy from renewable sources to provide the heat for the reaction. ElectricBlue Hydrogen™ can reduce the amount of CO_2 emitted by the 45% compared to the traditional process. In addition, thanks to an effective process of capturing CO_2, carried out with a higher partial pressure, it is possible to achieve a further reduction of the CO_2 emitted, and the energy required for the process is lower.

Green Hydrogen is produced via water electrolysis using renewable sources and it is the only zero-carbon option. NextChem has access to all the production chain technologies available on the market and is able to optimize their integration in any type of chemical and petrochemical process. The electrolysis of water is an electrochemical process that allows plants to transform electrical energy into chemical energy. Costs of energy supply from RES and electrolyzers are decreasing over time, although the use of energy from RES and its supply discontinuity have a direct effect on production costs, still high compared to the production costs of grey hydrogen production. However, the interest in this technology is growing. Green hydrogen competes with both fossil fuels and other shades of hydrogen, because it is the most sustainable version. For a widespread application of hydrogen, it is important to produce a sufficient volume to meet the demands of industry, using sectoral synergies, investing in the size of costs and providing flexibility to the energy system. It is important that EPC contractors are involved starting from the early stages of a project development, because of their capacity of integrating the technologies functional to the process.

"Circular Hydrogen™ can help to solve the problem of non-recyclable waste, currently sent to incineration or disposed in landfill while the production costs are competitive compared to traditional hydrogen

Lastly, NextChem has also developed the technology to produce Circular Hydrogen™. Circular Hydrogen™ is produced by syngas, obtained by the chemical conversion of carbon and hydrogen contained in non-recyclable plastic and dry waste, such as Refuse Derived Fuel, dry fraction of urban solid waste, non-recyclable plastic materials, or waste materials from recycling operations. Circular Hydrogen™ can help to solve the problem of non-recyclable waste, currently sent to incineration or disposed in landfill. Beyond the environmental benefits, the production costs are

competitive compared to traditional hydrogen. The synergy between the two sectors, that of waste management and disposal and that of the chemical industry, is translated into a very promising technology. This technology fits the principles of the circular economy and allows its users to achieve a high overall reduction of the environmental impact, when compared to the traditional approach of waste incineration and conventional synthesis of chemicals from fossil fuel raw materials. Plants to produce circular hydrogen could be located in traditional energy-intensive industrial sites, such as refineries, where they can contribute to their decarbonization, or close to waste sorting plants where they would optimize logistical processes and reducing carbon footprint also in transport.

Alberto Litta Modigliani

Nuclear engineer by education, Alberto is a senior executive, with 25 years of international experience in the energy sector.
Passionate about the challenges of the energy transformation, Alberto has spent 4 years as Head of Technology and Design at Engie's BU Hydrogen in Paris. Since July 2021 he has been appointed VP Hydrogen at NextChem, Maire Tecnimont's company for Green Chemistry and Energy Transition.

Smart Storage to support renewables

Digitally smart, within a proactive regulatory system and with the option of long duration, energy storage can really support renewables to achieve ‘Net Zero’ emissions

Antonio Zingales, Director, Corporate Development & Innovation
SAET

1 MW/0.5 MWh Energy Storage plant in Wien (Austria) for VERBUND Hydro Power GmbH

The world has agreed to a set of shared targets on climate change. Those targets require deep decarbonization, relatively quickly. This transition to a low-carbon sustainable future with Renewables development involves Energy Storage, because Energy Storage is becoming the critical enabler, given its ability to level the variability of electricity production, which in turn can increase grid reliability and stability and therefore great prospects for Storage are expected (see **Fig. 2**). While Storage technologies are still nascent, deployment could accelerate rapidly in the next few years.

To increase RES means to provide the relevant flexibility

The new must is to limit the rise in global temperature to 1.5° Celsius by reducing emissions: to achieve this commitment, great efforts must be made to reduce emissions and the power electricity sector will be central to global decarbonization. It is known that deep decarbonization is going to involve an enormous amount of electrification. As we push carbon out of the electricity sector, we pull other energy services like transportation and heating into it. As a result, innovative solutions will be essential to meet three critical challenges for the power sector (**tab. 1**):

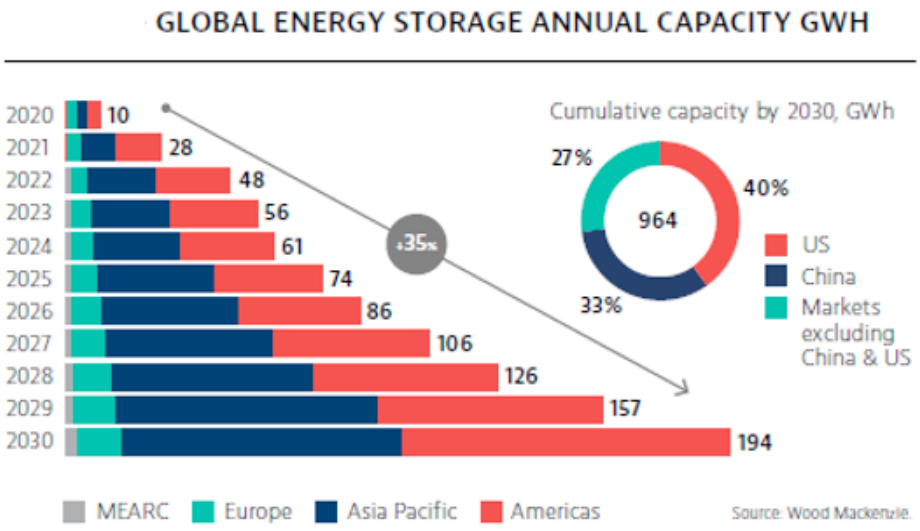


Fig. 2 - Global Energy Storage annual capacity and Cumulative capacity

Fig 3 - Energy Storage system used for primary regulation 2.5MW-3.2MWh in Prottes (Wien - Austria)

There is a general consensus that electrification of large parts of the economy is essential to reach long-term climate goals: Electricity becomes the core of the energy system and Energy Storage the key technology because of flexibility. Flexibility- according to USEF, 2018, p. 4f - is the ability to purposely deviate from a planned / normal generation or consumption pattern. This ability can be deployed either directly, by an external signal, or indirectly as a response to a financial incentive such as energy prices and tariffs.

The rapid integration of large Renewable capacity with their inherent variability creates large challenges for the power system, including potential imbalances in supply and demand, changes in transmission flow patterns, and the potential for greater system instability as the built-in inertia provided by fossil generation is removed. All of these call for new solutions to create flexibility in electricity supply and demand over different durations. Batteries provide the ability to adjust supply and demand to balance the system. They also provide a wide range of

- **to increase the electrical energy** to be produced because of the rising of electric consumption (i.e. electric vehicles and residential heating),
- **to transform the power system from f ossil-powered generation to renewables,**
- **to meet the economic sustainability** of the energy transition.

EoE	Electrification of Everything
FtR	Fossil to Renewables
E S	Economic Sustainability

Tab. 1

additional services needed to maintain grid stability, managing frequency, voltage, and short circuit levels. Batteries enable renewables to deploy at scale by adding the final, key ingredient to zero-carbon energy systems: the SECURITY OF SUPPLY. The energy storage technologies have been highlighted as a fundamental technology for the resilience of the grid and for the continuity of electricity supply.

> "The energy storage technologies are fundamental for the resilience of the grid and for the continuity of electricity supply

Another important aspect is that Storage solutions have relatively low lead times compared to upgrading of transmission and distribution (T&D) grids. As a result, there is increasing investment interest in these technologies. Several applications that energy storage can fulfil can also be performed by alternative infrastructure, such as demand response, power plant retrofits, smart-grid measures that enhance power networks and other technologies that improve grid flexibility.
In any case Storage is one of the main tools for Flexibility.

Digital Smart Storage is the solution for many applications

In terms of Energy Storage, Batteries have dominated the market, because of flexibility, reducing costs and the speed at which they can respond to operational signals. The applications of batteries in wide range of key services are shown in **Fig 4**. Services can be stacked together to provide multi-value streams for battery storage. Storage systems with suitable digital controller are fundamental for the energy transition (for energy efficiency and security point), since they can provide:

- Power-Intensive services: short discharging cycles (seconds, minutes) that can ensure security and inertia to the power system, contributing to rapid frequency regulation (Fast Frequency Reserve).
- Energy-Intensive services: long discharging cycles (hours) leading to load shifting (supporting the high residual load) and reduction of grid congestions.

Both applications result important: the first one to cope with the progressive loss of inertia in the system, the second one to manage the increasing fluctuations as a function of weather conditions. Regarding the energy-intensive services, their contribution to the electrical system will become more and more important with the increasing renewable capacity, that, in some hours during certain days, already exceeds the actual electricity demand (i.e. mid day PV over-generation). As a matter of fact, where suitable storage systems are not available "in the bottle neck of congestion", the

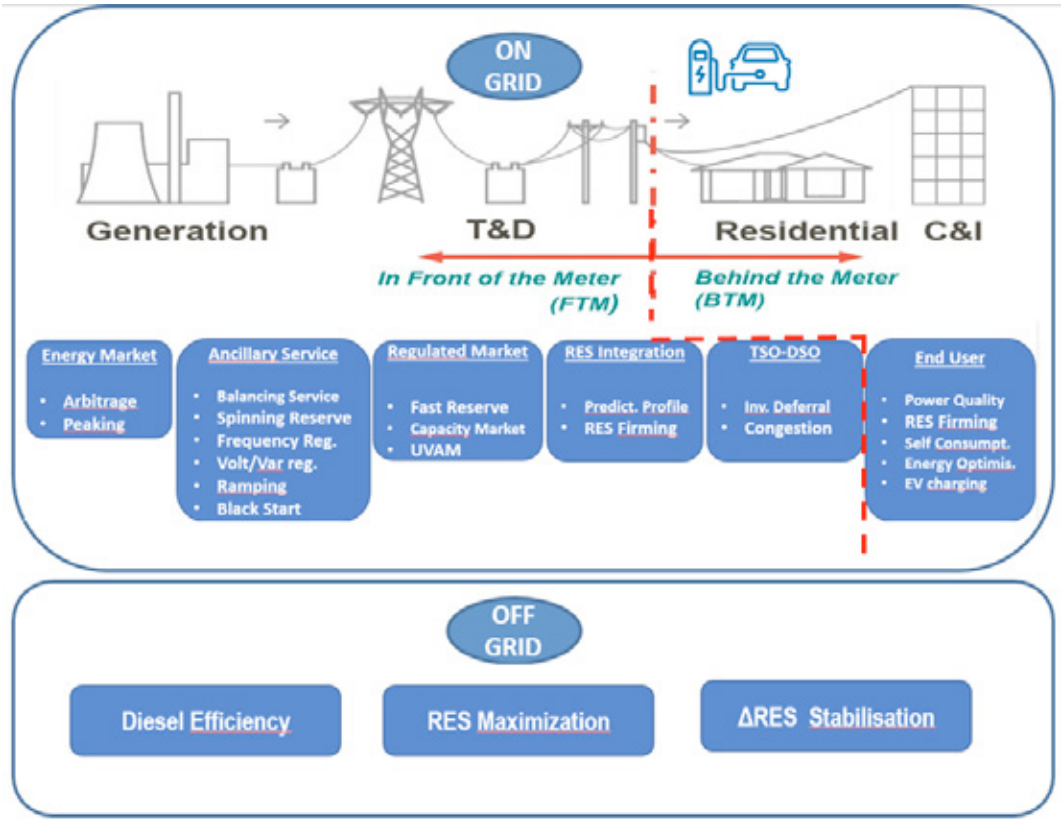


Fig 4 - View of the most key services provided by Storage ON-GRID and OFF -GRID

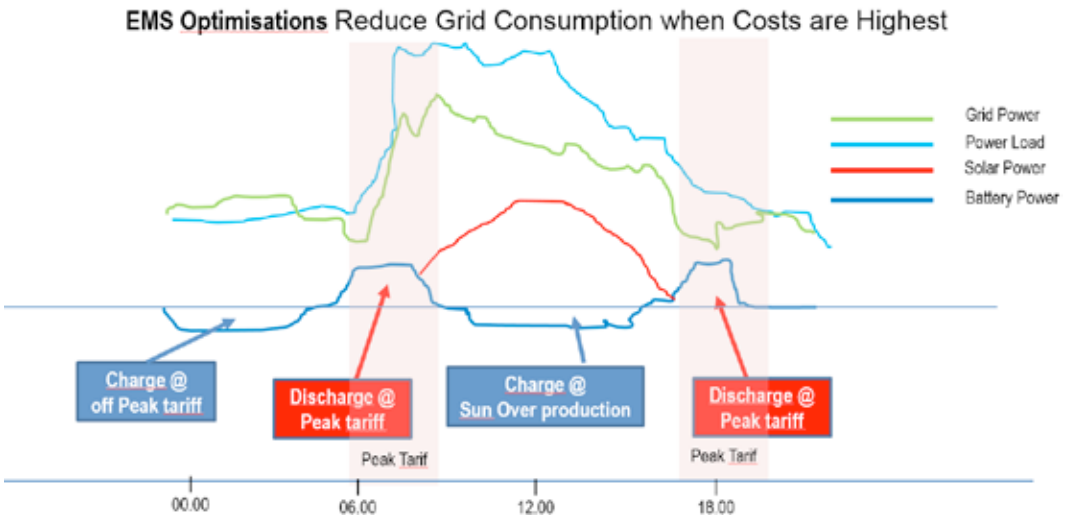


Fig 5 - Storage Energy Optimization with off Peak and Peak Tariff

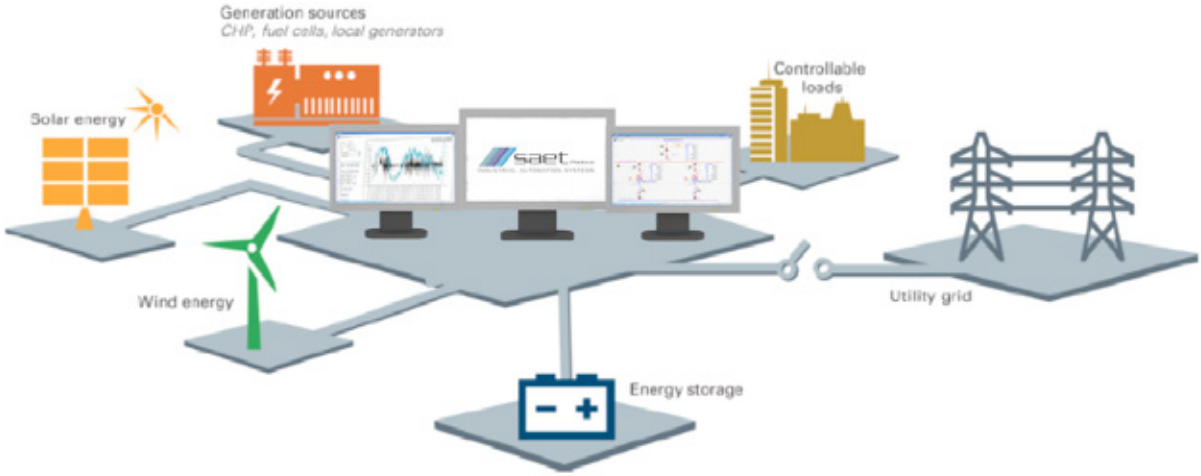


Fig 6- Energy Management System allows the digital smart control of Storage Systems

TSO is forced sometimes to curtail big quantities of clean and cheap wind and solar energy. The managing of Energy Optimization (considering peak tariff and off Peak tariff is something that a Smart Controller (Energy Management System) is able to provide (see **Fig 5**), comprehensive digital strategies to support system optimization at the lowest cost. Battery energy storage systems can be defined "Digitally Smart" when they have an intelligent software at the power level using algorithms to coordinate energy production, while there is a "decision maker" computerized control system used to decide when to keep the energy to provide reserves or release it to the grid: i.e. Energy is released during times of peak demand, keeping costs down and electricity flowing.

Most of the applications on grid-scale are front-of-the-meter (FTM) however, the behind-the-meter (BTM) market is also important, particularly as corporates seek to reduce their own emissions to achieve their sustainability goals. BTM installations includes customer stationary storage systems for commercial, residential and industrial self-use of stored energy. It is expected that these BTM installations will become more than one half of global storage capacity by 2030.

Another "smart feature" of the Storage is the resilient characteristic "Grid Forming" of inverter control. Most of inverter-based sources are Grid Following Inverters (the voltage angle of the grid is used to control their output). But BESS using grid-following inverters are not resilient to grid disturbances. They typically shut down until the disturbance has passed, and require the grid to reestablish after a blackout before reestablishing themselves (no black start). On

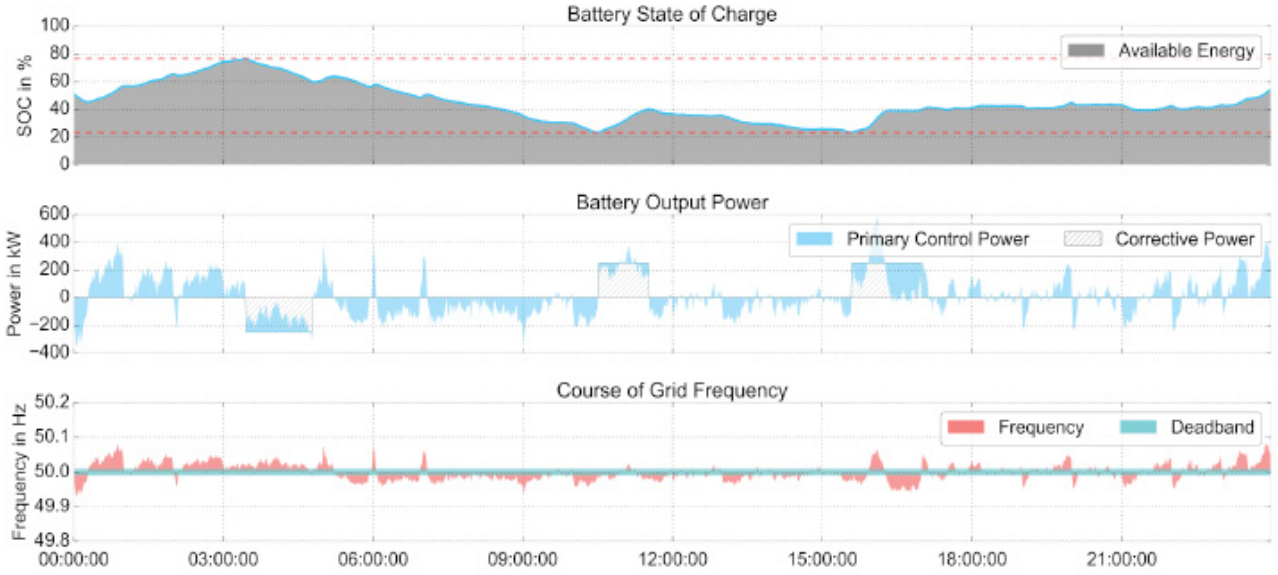


Fig 7 - The frequency adjustment function

the contrary Grid-forming inverter with an independent internal frequency can establish grids and strengthen operating grids. This contributes to the Smart Digital Storage suitable for large RES accommodation.

Frequency Regulation to support the grid

With RES penetration Storage is an essential tool for respecting the quality of the service (frequency, voltage) guaranteeing inertia and short-circuit power: SAET had an important experience of this type (see **Fig. 7**) in Austria with EVN and Verbund.

The regulation is used to reconcile the instantaneous differences caused by fluctuations in generation and loads. Adjustment is used to smooth this difference. In the event of an imbalance between generation and load, there is a variation in the frequency at which the speed regulators of the generators react and with greater speed the storage systems for this purpose. This function is even more important with a weak grid or in off grid applications because the rapid change of sun and or wind could cause unacceptable output variations of the power supply.

Integrated Minigrid

Microgrids are electricity distribution systems containing loads and distributed energy resources, (such as distributed generators, storage devices, or

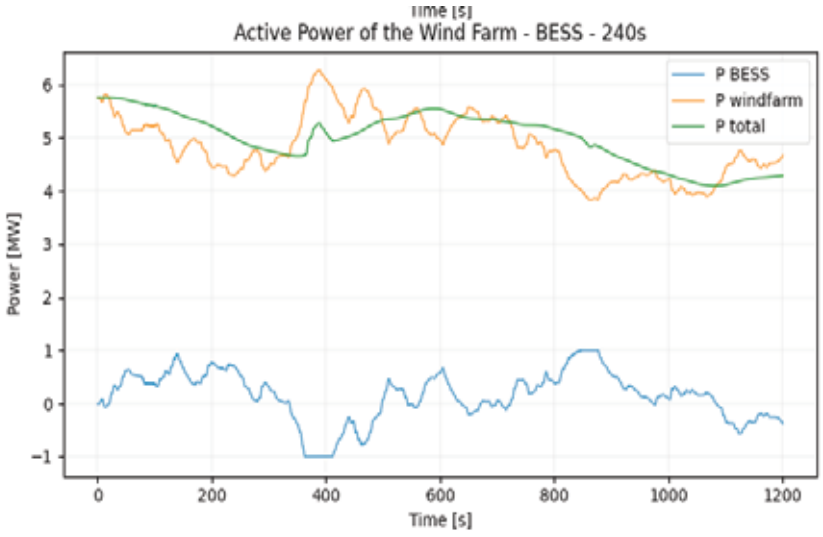


Fig 8 The frequency adjustment function

The function Grid Firming is implemented in the application of **Fig 8** as described below:

1. the EMS measures the real-time power output of the wind farm
2. From this value the EMS calculates the correction power output of the BESS to smoothen the total output
3. A dead band is set in order to avoid BESS active power exchange caused by minimal fluctuations of the wind production

The total output (green) is significantly smoothed. Without BESS the output would have been the one of the wind farm (orange).

Fig 9 - Energy Storage System provided by SAET to Electra in Cabo Verde

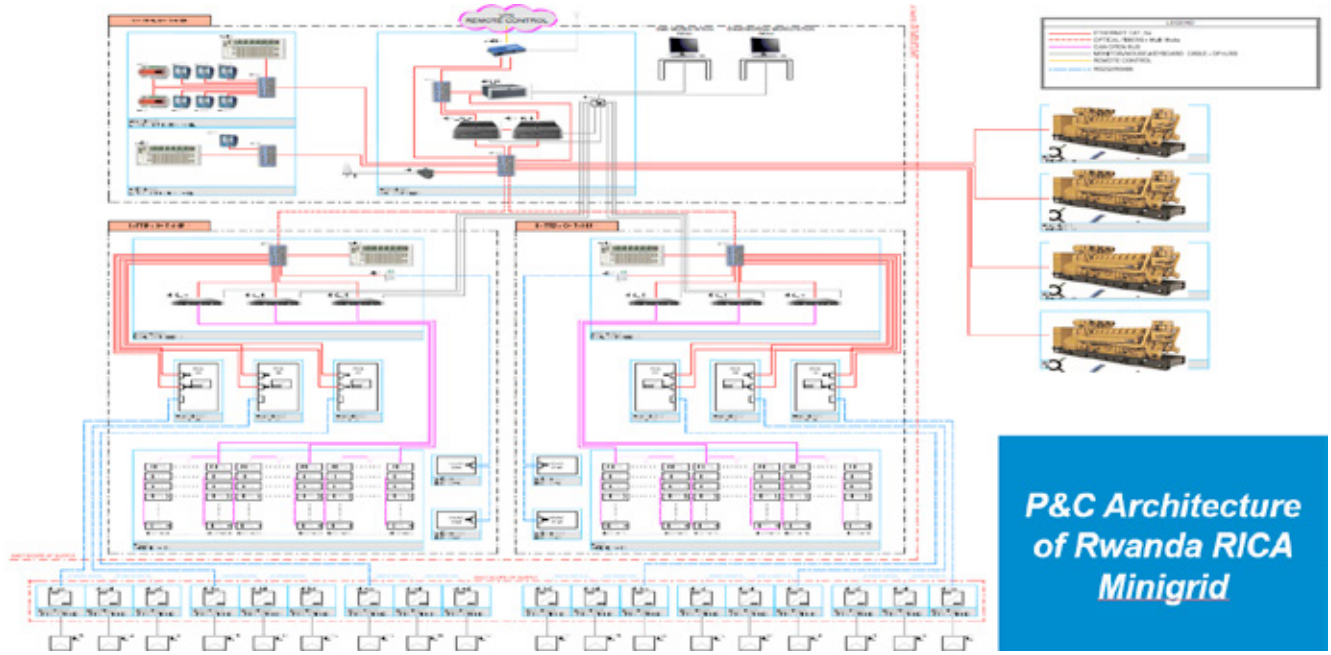


Fig 10 - Rwanda Minigrid : Diesel System 1600 kW, PV 1800 kW, Batt . 3000 kWh locality Kigali (Rwanda), Photo of the system and Architecture of the Control System

controllable loads) that can be operated in a controlled, coordinated way either while connected to the main power network or while islanded.

A growing role of “mini-grids” (or “micro-grids”) is mainly associated with developing nations with smaller networks and limited renewable generation. Saet had important experiences of minigrids in Capo Verde for Electra and in Rwanda for Rica.

But the minigrid solution is increasing also in developed countries for discrete or remote areas (i.e. small islands) or in critical infrastructures (so called Microgrid Communities: Military sites. Hospitals, Outlets, Research centers, Data centers) in which more than a simple back up of generators it is

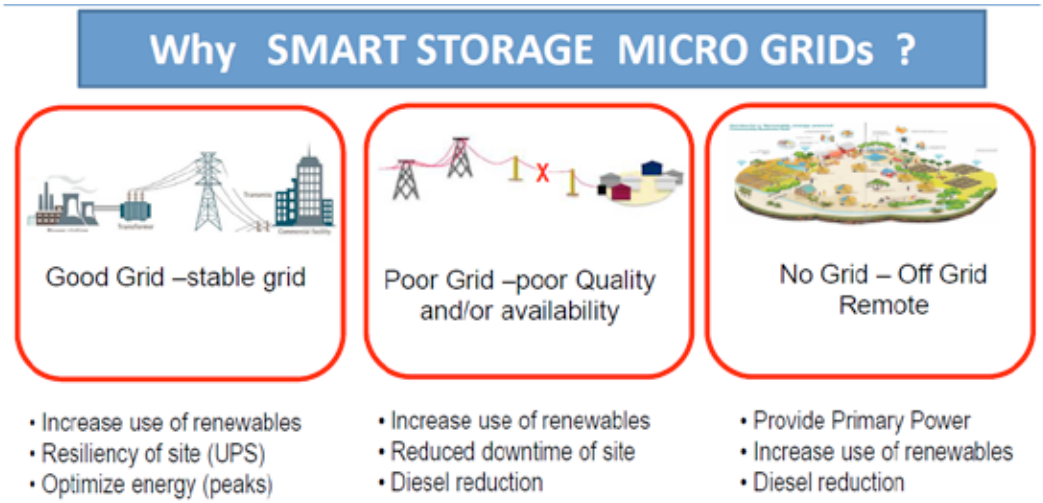


Fig 11 - Microgrid Philosophy.

necessary , because the smart management of multi-resources and consumption can support to optimize Energy, to increase reliability of the power supply, to reduce carbon emission, to reduce operating costs.

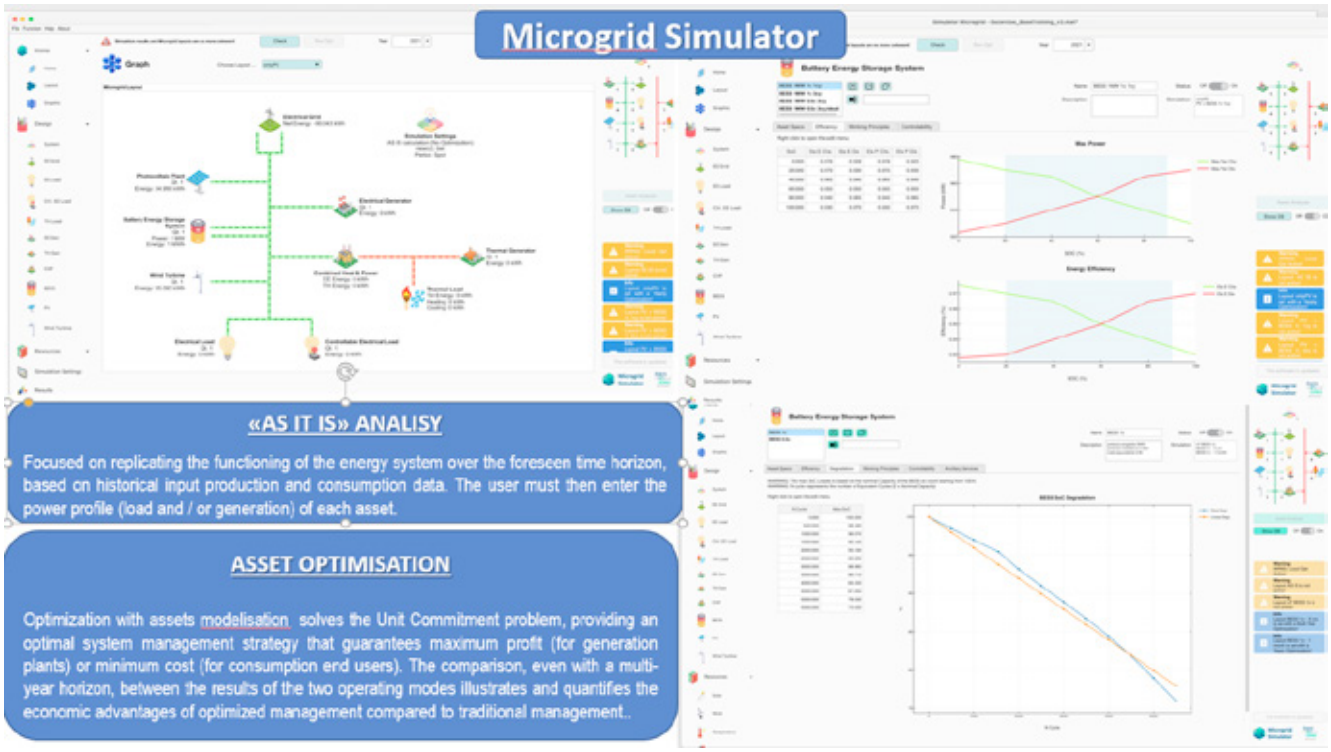
Searching Revenues for Investors: depending on regulatory system

Storage systems can solve or mitigate grid problems, but they must also constitute a source of remuneration for investors (a factor highly dependent on the local regulatory system). In principle, the revenues of an investment can come from the energy trading (Arbitrage), from the restricted market (Ancillary) for dispatching services and from the regulated market (remuneration for the availability of a defined service such Fast Reserve , UVAM or Capacity Market).

From the Revenues analysis we got often that storage plants are not economically sustainable only with energy trading, but it is necessary to access the various ancillary services markets to find the opportunity to invest in storage: this means they are depending on regulatory plan.

For this purpose, government action will be required to help lower costs, mobilize the necessary investment and create market signals enabling investors to make an attractive return on Storage. An enabling governmental ecosystem would include the implementation of (i) long-term system planning, (ii) early compensation mechanisms that reduce uncertainty for investors while the market is still nascent, and (iii) supportive policies, regulations, and market designs.

Fig 12 - MICROGRID SIMULATOR made by Falck Renewables Next Solutions



Long Duration Energy Storage (LDES) the last step to net zero

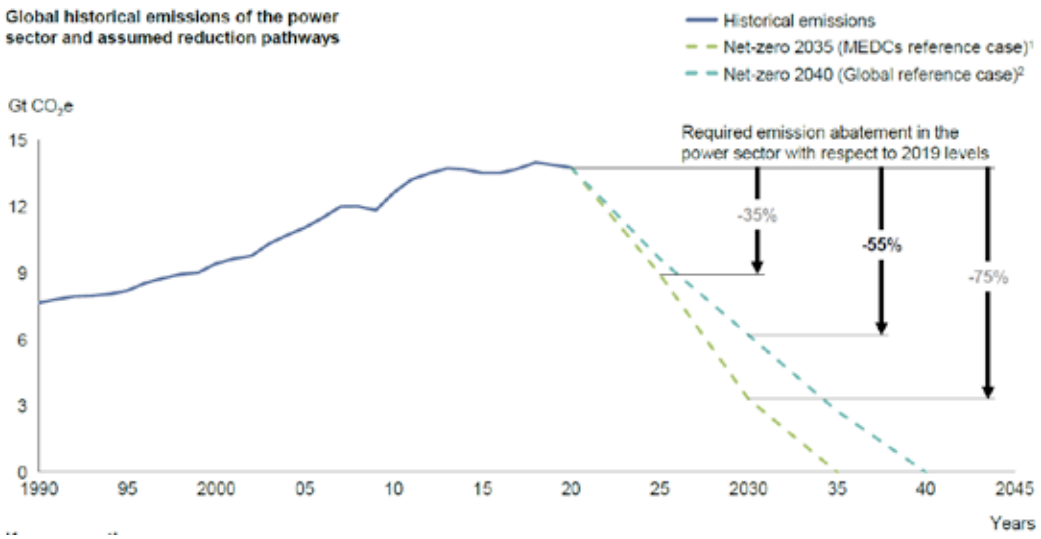


Fig. 13 - Energy Power sector emission reduction pathways, and the rate to abate to reach net zero (McKinsey LDES)

Long-term system planning, including clear RE targets, are critical to creating investor confidence. Targeted support for early deployments and scale-up would help kick-start the market and trigger the learning curve on costs. Finally, supportive market designs such as capacity mechanisms and policies that capture the full value of Storage would enable investors to monetize their outlays. Together, these measures will ultimately help ensure that the energy transition is achieved at the lowest societal costs. Effective policy should look for ways to create additional flexibility for different types of assets, including storage, to participate in the market and work to simplify and standardize permitting and deployment regulations. Such efforts could significantly boost creating the appropriate supporting conditions to accelerate storage adoption and deployment.

It is therefore interesting to have a simulator to enhance the various sources of revenue. SAET is using *Microgrid Simulator* made by Falck Renewables Next Solutions (See **sheet 11**) to support customers in evaluating the various configurations in the feasibility study phase.

After the historical emission of power sector with great increase in the last decades up to nowadays, a reduction pathway is assumed which can have different slopes (rate to abate) and different net zero time (see **Fig 13**). The European Union has committed to cut greenhouse gas emission by 55% compared to 2019 by 2030, a key milestone in reaching climate neutrality in 2035 rather than 2050. While in the beginning of emission reduction, the Power Intensive Storage was the most effective for the electrical system (frequency regulation, virtual inertia. Power reserve), in the further reduction, Energy Intensive Storage will become more relevant and LDES (Long Duration Energy Storage) will be necessary for the last step. The last step to net zero is the most difficult to reach with evolving energy roles of STORAGE, of LDES, of HYDROGEN,

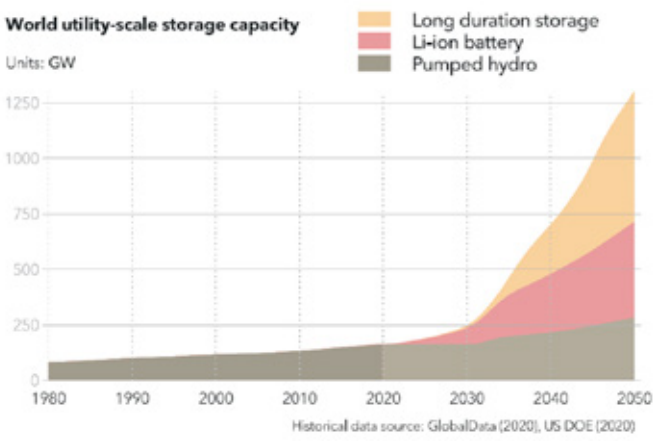


Fig. 14 Expected utility scale storage capacity

Fig. 15 SAET experience with NaS Battery (6h duration) 10.5MW-72MWh BESS in Scampitella (BN - Italy)

"The rising penetration of renewable energy will require not just increasing amounts of energy storage but also developing long-duration storage solutions

complementing direct electrification and helping to address harder to abate sectors: let say that storage needs remain relatively low up to a share of around 80% renewables, but increase substantially toward 100% renewables, with a growing importance of long-term storage for seasonal balancing.

The rising penetration of renewable energy will require not just increasing amounts of energy storage but long-duration storage depending on the country and the characteristics of its energy market.
In order to accommodate large amounts of renewable energy new flexibility challenges across different timing are to be considered:

- "Medium" duration :4h-8h for intraday flexibility;
- "Large duration: 12h-60h for multiday flexibility
- "Extra Large duration": months for seasonal flexibility

To date, much of the focus has been on short-duration batteries of up to four hours, on the contrary more research and development and industrialization design will be needed to support longer-duration storage options. Practically there is the need to develop energy storage technologies that can be cost-effectively deployed for much longer durations than lithium-ion batteries.

"Medium" duration generally involves providing grid stability services and peak-shifting and Lithium-ion batteries are currently the cheapest zero-emissions option for providing balancing services of less than 4 hours. LDES (with different emerging technologies), can provide duration for days and even weeks, with resilience to an electric grid ready to distribute solar and wind power on a large scale. This extension to periods lasting days or weeks is the need of imbalanced RE output or potential outages caused by transmission constraints. LDES technologies are a promising zero-carbon solution for these long-duration flexibility needs, especially those lasting several days.

Finally, the need for seasonal flexibility is due to the natural variability of solar irradiation, wind speed, temperature, and rainfall over weeks and months, and also to extreme weather events.

Some LDES overview and the HYDROGEN solution

One of the first LDES is flow-batteries.
Flow-batteries are liquid -based batteries that use tanks of liquid electrolyte. The electrolyte runs through electrodes to charge and then run in reverse to discharge. The possibility of reaching long duration is mainly due to the fact that doubling the capacity is only to double the tank; the design is easily scalable, and has a long life cycle and effectively unlimited capacity. However, flow batteries have lower energy density than lithium-ion and are not currently cost competitive, but they are the most consistent electro-chemical solution for LDES.
Vanadium is currently the preferred electrolyte for flow batteries due to its stability, although the metal faces supply issues which, may in turn, affect costs (**Fig. 16**).

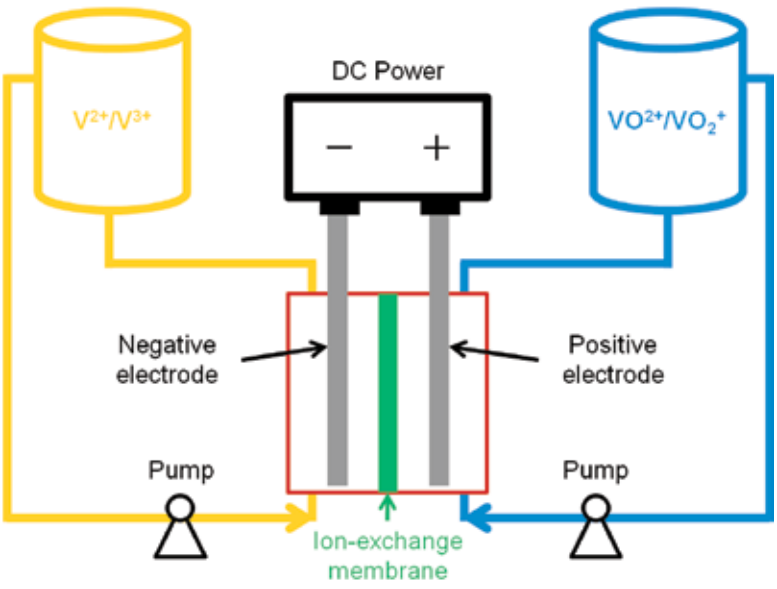


Fig. 16 - Redox Vanadium Batteries basic scheme

Hydrogen technology is often considered to have the highest long-term potential for LDES, with great flexibility also because can be the key of a storage solution rather than a transportation solution. Many countries are considering hydrogen as a key part of their emission reduction pathway even if the technology to convert power to hydrogen and back to power has a round-trip efficiency only around 30% .
However, while producing renewable hydrogen via renewable energy-driven water electrolysis is globally growing, it still represents a small fraction of total global hydrogen production and is far away from being cost competitive. Research and development into hydrogen storage for use as energy storage is also at relatively early stages, but some conclusions are already available:
Sustainable production of hydrogen is a key element of the LDES energy transition agenda, especially for

Fig. 17 - SAET experience with VANADIUM BASED energy storage system -450kW/1440kWh in Ciminna (PA-Italy)

Company Info

SAET is an Italian company operating internationally that offers solutions for high-voltage electrical grid, electrochemical storage systems and custom solutions (Operation & Maintenance, after-sales service, automation, weighing systems). It has always operated in the name of technological diversification and a strong commitment to innovation, thanks also to the prestigious collaboration with the University of Padua.

Our business unit

Grid Solutions (GS) with a focus on HV stations designed to connect production plants from renewable and other sources to the National Grid, construction of renewable plants and other activities relating to the construction of grid-connected plants and portions of the grid itself

Business lines:

· ELECTRICAL STATION - TRANSMISSION
· ELECTRICAL STATION - USER
· TECHNICAL ADVISOR
· ELECTROMECHANICAL ASSEMBLY
· PROTECTION & CONTROL

Energy Storage (ES) with a focus on the construction of electrochemical storage systems, stand alone or associated with other plants (renewable, industrial, etc.)

Business lines:

· ENERGY STORAGE ≤ 1 MW
· ENERGY STORAGE ≤ 10 MW
· ENERGY STORAGE > 10 MW

Custom Solutions (CS) with focus on O&M services for the management and maintenance of plants, automation and special industrial systems or exploratory systems for Saet

Business lines:

· AUTOMATION
· WEIGHING SYSTEM
· OPERATION&MAINTENANCE
· SPARE PARTS
· AFTER SALES SERVICE

seasonal and mobile energy storage purposes.
The technology is about to enter the market, as the economy of the solution has considerably improved over the years.
The water electrolyser (WE) as a key element of such hydrogen production can offer its high operational flexibility for grid services (operation under partial loads, quick response, system operation for providing reserve and frequency response services).

The objective of the next H2 projects is to deploy and monitor improved electrolyser systems configured to attract revenues from grid services and leveraging timely power price opportunities, in addition to providing hydrogen (and potentially oxygen) for high value markets.

The penetration of intermittent renewable electricity based on solar and wind energy increases the need to match supply and demand for power. Electrolysis is a means to convert excess electricity into hydrogen that can be stored and re-electrified at a later time, or used for other energy consuming or industrial processes. As a flexible load the electrolyser can also offer grid balancing services provided that it is of sufficient capacity and responsiveness to participate in the power industry's balancing markets.

Conclusions

With growing shares of variable renewable energy

sources, electricity storage plays an increasing role in the renewable energy transition.

An important feature is the Storage with Digitally Smart control, another point is the proactive regulatory system to provide market signals enabling investors to make an attractive return.

But there is no definite answer to the question of how much storage will be required at which renewable penetration to reach Net Zero. Yet there is a broad consensus in the literature that system-wide storage needs remain moderate up to fairly high shares of variable renewables.

"Digitally smart storage, within a proactive regulatory system and with the option of long duration, can really support the roll-out of renewable energy forms to achieve Net Zero emissions

When the penetration of variable renewable energy sources approaches very high levels, the main driver for electricity storage seems the capacity to react to renewable surplus integration even with long cycle time (big energy shifting): therefore, Long-term electricity storage technologies remain an important option.

Our conclusion is that Digitally smart, within a proactive regulatory system and with the option of long duration, STORAGE can really support Renewables up to Net Zero Emission.

Antonio Zingales

Antonio Zingales graduated with honors in Electrical Engineering from the University of Padua. After a short university collaboration, he joined Passoni & Villa in Milan in a technical position and contributed to the creation of a business unit dedicated to High Voltage test equipment. Master in Economics and Business Organization in 1987 at SDA Bocconi in Milan. Since 1990 he has been involved in Industrial Robots for the Japanese STAR group in the position of commercial director with responsibility for Italy and Europe. In SAET since 2000 as commercial director he contributed to the EPC role of electrical protection systems, then of turnkey HV stations, and finally of Energy Storage Systems. He then took part in the sale of the majority stake to Falck Renewables in the SAET board of directors . From 2022 with the entry of the Falck Renewables group he became Corporate Development & Innovation Director.

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SAET is an Italian company active on an **international scale** offering solutions for **high voltage electrical grids, electrochemical storage systems** and custom solutions (**Operation and Maintenance**, after sales service, automation, weighing systems).

Always SAET works with particular attention to **diversification and technological innovation**.

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Geophysical survey of the offshore microtunnel route in Delimara Peninsula (Malta)

Assessing the seafloor integrity and the possible deteriorations that might arise from the bedrock collapse during the nearshore microtunnelling, and identifying and avoiding cavities during the work

Vanessa Barcaglioni, Giuseppe Canna, Giuseppe Vecchio
Techfem S.p.A.
Maurizio Ponte, *Università della Calabria*
Giuseppe Ferraro, *Geofisica Misure s.n.c.*

This paper reports the main result of the geophysical survey performed in the Delimara peninsula (Malta) along the offshore route of the microtunnel realized for the shore approach of the 22" Melita Transgas Pipeline. The main goals of the survey were to assess the seafloor integrity and the possible deteriorations that might arise from the bedrock collapse during the nearshore microtunnelling, and then to identify and avoid cavities during the work.

The preliminary geognostic investigations carried out on this segment through several boreholes highlighted the presence of fractured limestone and possible cavities. A following tomographic analysis (Electrical Resistivity Tomography) allowed the detailed reconstruction of the lithostratigraphic and geomechanics characteristic of the entire corridor. The geoelectric prospect also allowed to verify and evaluate the risk of intercepting cavities along the corridor during the drilling phase.

The installation of seven multielectrode lines were performed: one of them was longitudinal to the microtunnel pathway, two parallel and the rest transversal to it. Six of them were installed on the seabed, with the help of divers, to better mitigate the effects of the marine depth. The post-processing of the data, optimized through the precise knowledge of the electrode positions and the resistivity values of the seawater, led to the definition of a two-dimensional and a three-dimensional predicting model, able to work up to 50 m depth from the seabed. Such models link the values of the resistivity measured and the lithologies of the seabed (known from the stratigraphic logs) to its stratigraphy, allowing to exclude the presence of cavities along the pathway analysed and, thus, to distinguish the karst lithologies (limestone and marly limestone) from the non-karst ones (marls and clays).

Introduction

The geophysical investigations aim to support the design of a gas pipeline (Melita Transgas Pipeline) in the section interested by the microtunnelling technology. The microtunnel crosses under the Delimara peninsula for 600 m and extends under the seabed for other 600 m. The purpose of the investigations was reconstructing the lithostratigraphic structure of this nearshore section, up to a depth of 50-60 m from the seabed, also assessing the fracturing conditions and any karst processes that affect the lithological formation present.

> "The geophysical investigations aim to support the design of the Melita Transgas Pipeline in the section interested by the microtunnelling technology

The activities are subsequent to a first phase of investigations carried out "on the land" (drilling, refraction seismic and geoelectric tomography prospecting). In the nearshore area, two continuous drilling operations and a morpho-bathymetric survey of the seabed have already been carried out, the latter used as a support for the programming and processing activities carried out in this phase. Just starting from the acquired data, it was possible to evaluate the most suitable geophysical methodology for the achievement of the expected objectives. The seabed is featured by a very variable depth between the coast and the outermost part, which

reaches 40 m of water depth. It was, therefore, preferred to use the geoelectric resistivity method with tomographic processing (ERT). In addition, considering the need to maintain a high resolution capacity, as well as the considerable depths involved in the outermost area, it was decided to lay the electrode cables for the execution of the measurements directly on the seabed. This entailed the need to use specifically made cable, with an extension of 50 m with respect to the position of the first electrode lying on the bottom.

Geological and geomorphological features

The site has been investigated along a line approximately WNW to ESE of about 1200 m. The elevation above mean sea level varies from about 30 metres at the western and decreasing to about -42.0 m, below mean sea level, at the eastern shoreline.

The geological strata (making up the Delimara Peninsula) include the Upper and the Middle members of the Globigerina Limestone formation as shown in **Figure 1.**

The sedimentary sequence is composed of alternating calcareous marls and marly limestones with subordinated prominent bioturbated indurated limestone's that were deposited in a pelagic environment. The stratigraphic sequence is composed by an alternating nature chancing between relatively hard and soft strata of very limited thickness, which may be, in part, the result of selective cementation and neomorphism.

The Upper Globigerina Limestone of Delimara is of a uniform grey colour, lacking the yellow-grey-yellow division that is elsewhere diagnostic of the Member.

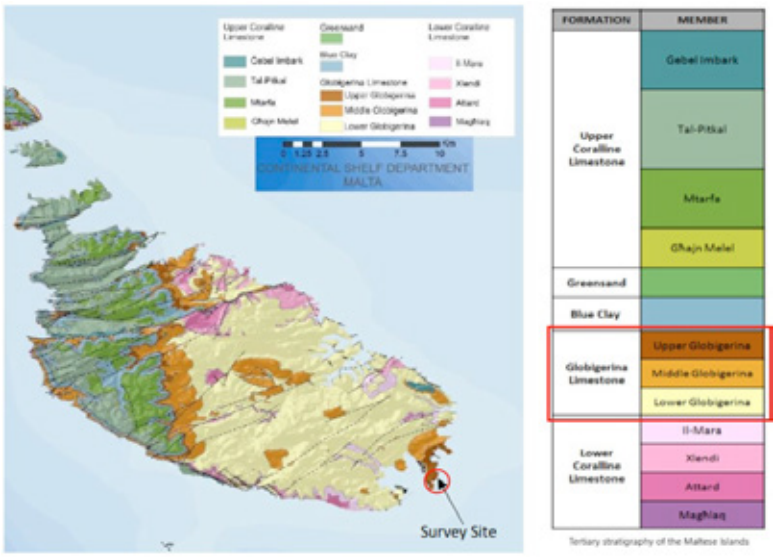


Fig. 1 - Geological map of Malta (from Continental shelf department) and survey site.

This correlates with a lack of disseminated iron usually characteristic of the lowermost and topmost Beds. This lack of disseminated iron in turn correlates with an increase in the amount of clay within the Member at this locality. It is atypical concentration of clay minerals that may well be responsible for the formation of the preferential diagenesis within this member as a whole at Delimara. Neomorphism of the lime mud is particularly prominent in the carbonate zones and essentially absent from the marly horizons. As a result, the carbonate zones are more lithified than the marly horizons.

The division between the Upper and the Middle Globigerina Limestone is marked by the presence of a conglomerate phosphate-rich bed named C2 (Pedley 1975) in which most of the pebble material is extensively perforated or pitted and infilled with glauconite.

The Middle Globigerina Limestone is classified as a clayey biomicrite rich in planktonic foraminifera. This member is generally characterised by compact, light grey calcareous marls occasionally altering with massive-bedded marly limestone's layers and dispersed phosphate particles and pebbles.

From a structural system, the area assumes a monoclinal structure, with a slight slope (2-4°) of the bedding planes in the ESE direction. Tectonic dislocations with an outstretched character affect the monoclinal generally very limited shifting, but such as to determine a certain degree of fracturing, resulting in geomechanical degradation and increase of secondary permeability (by fracturing) of the rock mass.

From the geological survey carried out in the surface, the correlation of bibliographic data and what has been identified from the results of the geophysical images on land and sea, the presence of a fault system oriented south-west north-east is presumed for the site of interest, with direction of immersion southeast. This fault system is probably constituted by a series of fault planes, sub-parallel to each other, which extend towards the southeast. For this reason, the Microtunnel path, will intercept these structures, crossing areas of high fracturing, with probable presence of fine sediment and sea water that have the fractured void.

Additionally, the study area is characterized by eroded cliffs and coves along the coastline in the Delimara peninsula. The geomorphological structures are associated with presence to terraces, paleoshore platforms and shoreline. The terraces are characterized by a concave break of slope at their landward limit that occurs at a regular bathymetric depth. Their landwards limit occurs at three different depths, in the study area: 28-30 m, 35-37 m and 42 m.

These terraces are interpreted as coastal platform formed by subaerial atmospheric agents during the exposure at the bottom and the erosion of the waves (hydraulic pressure and abrasion) that guided the coast towards the ground during the post-glacial sea level rise. As a consequence, the ground edge of these platforms, known as the corner of the coast, provides an indicator of the maximum sea level at the time of formation of the platform. The shallower paleoshoreline, on the other hand, correspond to the notches identified by divers at depths of 25-30 m and 33-40 m, in the study area.

Electrical Resistivity Tomography (ERT)

The electrical resistivity tomography (ERT) surveys aims to determine the subsurface resistivity distribution through measurements on the ground surface. The ground resistivity is related to various geological parameters, such as the mineral and fluid contents, porosity and degree of water saturation in the rock. Electrical resistivity surveys have been used for many decades in hydrogeological, mining and geotechnical investigations. The fundamental physical law used in resistivity is Ohm's Law that governs the flow of current in the ground. The equation for Ohm's Law in vector form for current flow in a continuous medium is given by: $J = \delta * E$.
Where δ is the conductivity of the medium, J is the current density and E is the electric field intensity. In practice, what is measured on field the electric field potential. We note that in geophysical surveys the medium resistivity ρ, which is equals to the reciprocal of the conductivity ($\rho = 1/\delta$), is more commonly used.
The resistivity values are largely dependent on the porosity of the rocks and the salinity of the contained water. Unconsolidated sediments generally show even lower resistivity values than sedimentary rocks, with values ranging from about 10 to less than 1000 Ωxm. The resistivity value is dependent on the porosity (assuming all the pores are saturated) as well as the clay content. Clayey soil normally has a lower resistivity value than sandy soil. However, an overlap in the resistivity values of the different classes of rocks and soils can be observed, as the resistivity of a particular rock or soil sample depends on a number of factors such as the porosity, the degree of water saturation and the concentration of dissolved salts. The resistivity of groundwater varies from 10 to 100 Ωxm depending on the concentration of dissolved salts. The low resistivity (about 0.2 Ωxm) of seawater due to the relatively high salt content. For this reason, the resistivity method can be considered as an ideal technique for mapping the saline and fresh water interface in coastal areas.
The apparent resistivity measurements in the field have been carried out using an eight-channel georesistivimeter with galvanic isolation (ABEM Terrameter LS2 System) for resistivity, induced polarization and spontaneous potential, with the following characteristics: Automatic or manual selection of the current input from 0.20 to 2500 mA; Energization with max voltage 600 V (1200 V peak-peak); Maximum power to 250 W; Current transmission accuracy to 0.4 %; Current pulse length 0.1%; Impedance 30 MΩ min; Resolution 3 nV; dV/I accuracy to 0.2 % and dV/I accuracy to 0.1%.
To perform the measurements in multielectrode configuration, the system is equipped with an automatic selector, capable of managing 64 electrodes simultaneously. The electrodes were placed manually on the seabed, then connected to the selector via multicore cables. For sea operations, a boat with a length of 12 m was used, engine power of 340 KW ("Simo" dive boat).

Delimara ERT Survey

Seven ERT surveys were carried out using a multielectrode method. Three of these were carried out in parallel with the pipeline design route, for a length of about 630 m. In particular, one along the pipeline axis (TR02) and the other two at a distance of 10 m from each side. Other four ERT were carried out in the transverse direction, approximately NE-SW for a length of 315 m each one. One of them was executed on land (TR00), it develops between the altitudes of 10 and 13 s.l.m. The other three have been realized offshore, so as to interest transversely the track plan of the microtunnel path and the valley submerged valley present north of the pipeline track. The longitudinal measurement lines (TR01, TR02 and TR03), were carried out by laying 4 cables with 32 x 5.0m-spaced electrodes, for a length of 155 m each. The measurements were carried out at the centre of each pair of cables (simultaneous acquisition on 64 electrodes 315m in length), proceeding from offshore to the mainland, with a roll-along procedure, providing an overlap of 155 m, equal to the length of a single cable. In this way, for each line, three stations will be required (acquisition step).
The acquisition points, coinciding with the central terminations of the cable pairs, have been materialized on the surface by buoys positioned using a GPS-RTK (GR-3 - RTK GPS System from Topcon), anchored to the seabed with special ballasts ("dead bodies"). Both the positioning of the buoys and their anchorage, and the laying of the

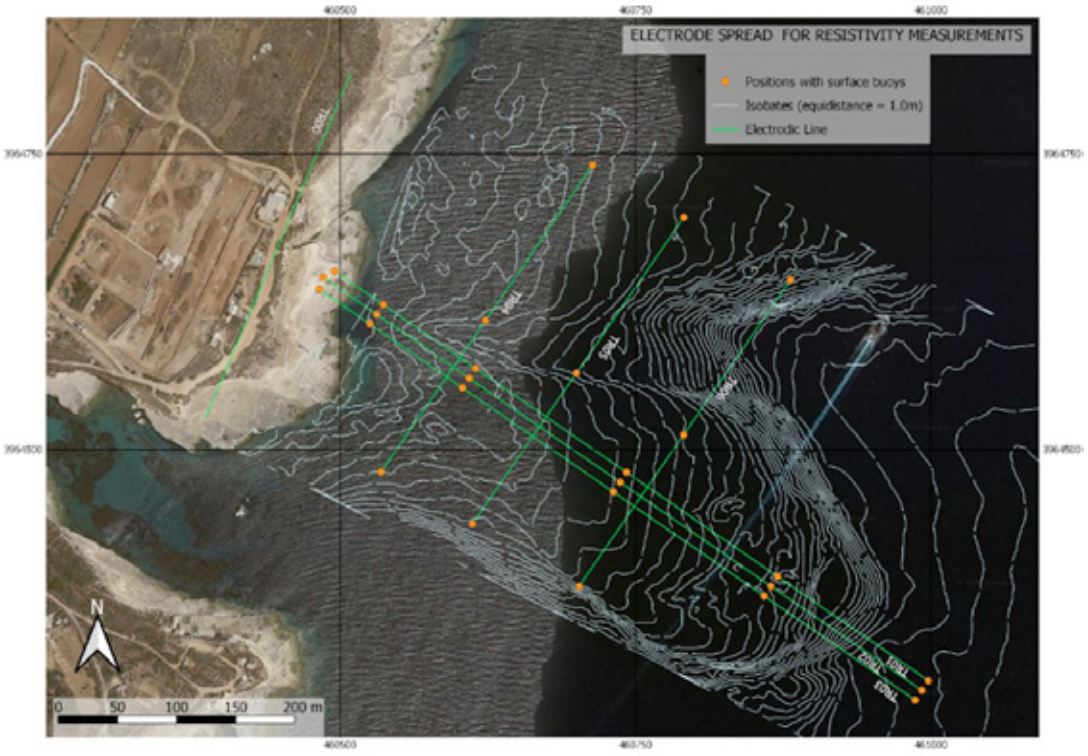


Fig. 2 - Map of electrode lines realized

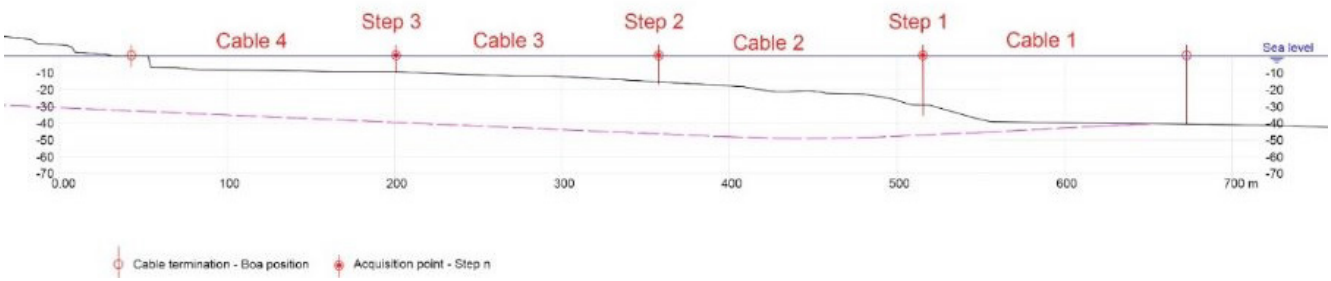


Fig. 3 - Acquisition scheme for longitudinal lines

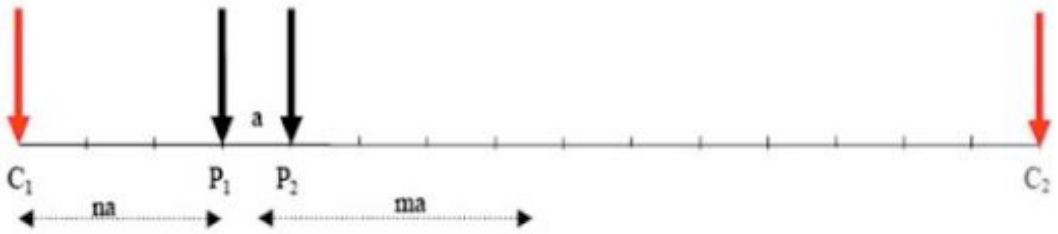


Fig. 4 - Multigradient array (C: Current electrode; P: potential electrode)

cables on the bottom, have been performed under control of specialized personnel (divers), see **Figure 2** and **Figure 3**.

In our case, the survey was aimed to the reconstruction of the lithological variations of the sector of interest, and, in particular, to the identification of the calcareous substrate and to identify any cavities and highly karsted areas. An electrode spacing of 5.0 m and a depth of investigation of 55-60 m have been planned. With an electrode spacing of 5.0 m, using 64 electrodes, results in an investigative depth of 55-60 m under the seabed. In order to have as high a resolution of the survey as possible and also increase the depth of investigation, the multicore cables will be laid to the seabed, with the help of geologist's divers. In the measurements a multigradient array was used, which has a good sensitivity compromise between the perception of vertical and lateral variations of underground resistivity. In addition, this array allows the acquisition of multiple measurements simultaneously (up to eight), allowing

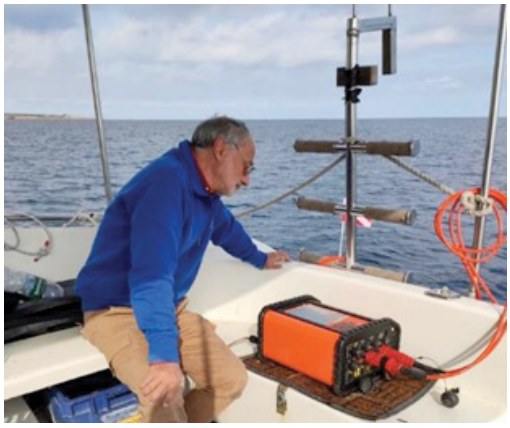


Fig. 5 - Laying of the cables, arrangement of the electrodes on the seabed and data acquisition

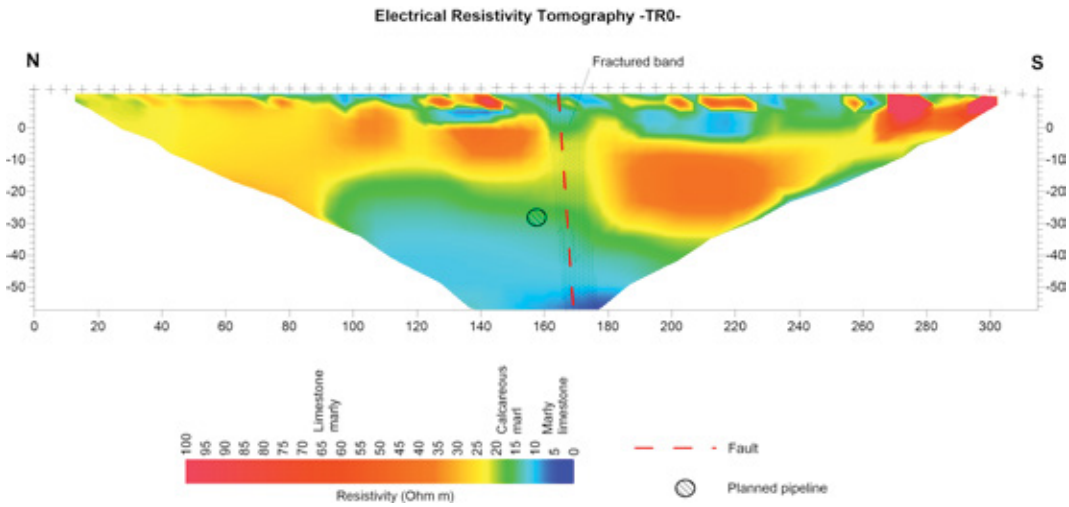
faster data acquisition. **See Figure 4.**

For each of the longitudinal lines, 635 m long, 4167 measurements were made, while in the transverse ones, with a length of 315 m, the measurements were 1565. The spatial resolution of the survey depends not only on the spacing of the electrodes and the number of measures, but on a series of factors in a system to be considered complex. In correspondence of possible cavities, being filled with water, there is to expect lower values of electrical resistivity than the carbonate rock in which they are contained. The possibility of solving them is linked to their dimensions in relation to their depth, as well as to the contrast of resistivity between rock and the filling marine water. At a depth of 20-25 m from the seabed, a resolution (ability to detect a cavity) of 4-6 m can be assumed; below this size the electrical anomaly produced, is considered too weak to be perceived by measurements performed on the seabed. **See Figure 5: (fig. 5a, 5b, 5c, 5d)**

Water depth and resistivity: In order to obtain useful estimates of resistivity in soil and rock, it has been necessary to integrate the water depth and the resistivity of the water in the interpretation model. Errors in water depth or resistivity lead to artefacts in the model, as the inversion program compensates for surplus or deficit in conductance in the water model by the corresponding increase or decrease in the resistivity. In this case, the bottom topography varies greatly; hence, it is of utmost importance to measure both bottom topography for each survey line to avoid misleading results. The water depth in the study area was mapped using multibeam sonar, already carried out in a previous survey; the data acquired by this measure are of good overall quality, with their degradation in the area close to the shore line. This situation has created some problems of elaboration in proximity of the coast. The value of the resistivity of sea water was measured in a laboratory on a taken sample (0.19 Ωm at 15°C).

Processing and Interpretation

The TR00 survey was carried out on the land, with a length of 315 m, between the elevation of 10 and 13



Electrical Resistivity Tomography – TR00.

Fig. 7 - TR00 prospecting (on land) and fault position

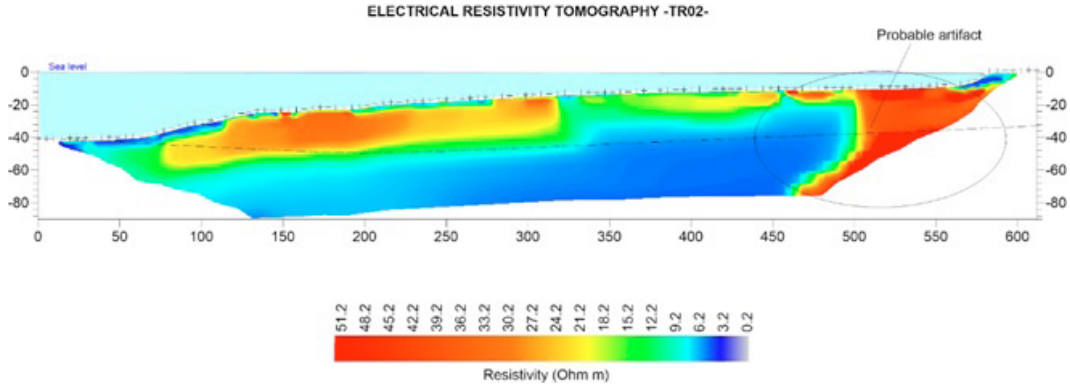


Fig. 8 - Electrical resistivity tomography – TR02

s.l.m. It falls within the outcrop areas of the Upper Globigerina Limestone Member. The purpose of this prospection was to verify the response from the electrical point of view, of the substrate surfacing as a whole up to depths of over 50 m. Furthermore, as the electrode line passes through a tectonic dislocation (**Figure 6**), it has been possible to verify the response, from a geoelectric point of view, of the fracturing band associated with it. The inversion was carried out by providing for gradual variations in resistivity (*L2 norm - smoothness-constrained least squares method*), to better highlight the lithological variations and the fracturing state (residual 2.5%).

The resulting model shows a discrete lateral continuity of the electrical horizons, characterized by low resistivity bands (5-20 Ωm), alternated with higher resistivity horizons (20-60 Ωm). The low values can be correlated to the presence of a pelitic component (marl and marly limestone), while where it tends to increase, it can be attributed to the prevalence of the coarse and calcareous component (limestone marly). The effect of the fault is visible both in the displacement of the electrical/lithological horizons, and in the definition of a slightly less resistive sub vertical band, about eight meters wide, which can be correlated with the fracturing band. See **Figure 7**.

The three ERT surveys parallel to the pipeline (TR01, TR02 and TR03), are laid on the seabed, for a length of 630 m. The numerical modelling was performed by adopting the electrical resistivity of the sea water as determined in the laboratory, with a value of 0.19 Ωm at 15°C; while for the depth of the seabed, and of the electrodes, reference was made to the data of the existing bathymetric survey. The numerical inversion was always carried out using the Res2DInv64 software, *L1 norm inversion method* (robust). Despite the relatively low residual error values (6-7%), the inversion produced artefacts (see **Figure 8**) in the area closest to the coast, presumably due to the incorrect estimate of the depth of the seabed near the shore line.

For this reason, it was decided to "cut" the length of the longitudinal prospections to 560 m, excluding in the elaboration the section close to the shore line and that on land. The results thus obtained are more reliable and consistent with the local lithological context. The inversion was carried out always providing for abrupt changes in resistivity (L1 norm - robust) and the models obtained have residual between 7% and 8%.

The three resistivity 2D models, parallel to each other and spaced 10 m laterally, show good lateral continuity of the electric horizons. A first horizon, slightly inclined

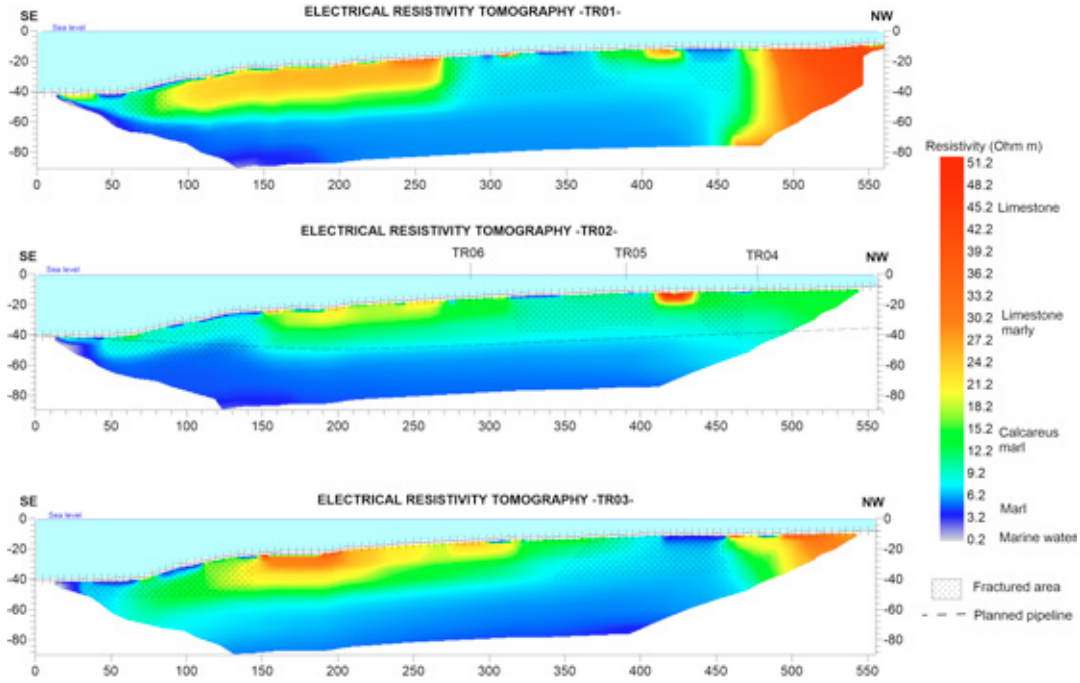


Fig. 9 - Electrical resistivity tomography – TR01-TR02-TR03

in the SE direction, has a thickness of 20-22 m and a resistivity between 20 and 40 Ωm, correlated with the lithologies of the Upper Globigerina Limestone Member, as found in coring, consisting of limestone, weak to very weak, with grey marly. An underlying horizon, whose base is located at about 35 m depth, shows a reduction in the value of electrical resistivity, which is between 12 and 18 Ωm, attributable to the increase in marly intercalations.
Below 35-38 m of depth, there is a sharp decrease in resistivity values, between 2 and 6 Ωm, which can be attributed to a lithological variation, where pelites (marls and clayey marls) are prevalent, such as also found in coring.

Regarding the evaluation of the state of fracture and of karst forms that may affect subsoil sectors, it must be considered that the increase in the state of fracture and karst have the effect of increasing the porosity of the rock mass. This condition determines, from the electrical point of view, a sudden reduction in the resistivity values, as the conduction of the electric current is made easier by the interstitial water, even more so if it is high in salt content, being sea water. This condition will be particularly evident when the lithology is of higher resistivity (limestones), in which the contrast with the fractured bands and, even more, in the karst areas filled with water, is higher. In particular, the detectable cavities will be characterized by particularly low resistivity values, close to those of sea water (<0.5 Ωm). In this perspective, therefore, the lateral variations of low resistivity within the electric/lithological horizons, can be interpreted as more fractured and possibly karst areas.

In the attached models, some areas with lower resistivity are observed within the limestone horizons, which can therefore be interpreted as more fractured. One of them coincides with the escarpment between the platform and the underlying bottom, from 10 m up to the progressive 150 m where the limestone mass is probably more disarticulated due to the morphological condition. Other areas where the resistivity decreases are between the progressive 260 m and 450 m, in which the rock mass is presumably affected by fracture due to tectonic causes. There are no localized sectors with resistivity lower than 0.5 Ωm, so there is no indication of detectable cavities.

For the purpose of further evaluations on the geometric distribution of the values of the real electrical resistivity of the sector investigated with the longitudinal ERT (TR01, TR02 and TR03 (See **Fig 9**:)), the data of the three survey lines have been merged into a volume (3D) included between the bottom of the sea where the electrode lines fall to a depth of about 60 m from the seabed. The geoelectric data thus placed in space have been subject to 3D inversion through the use of the Res3DInv64 software. The inversion parameters have remained the same as those used in the 2D inversion (L1 norm robust and 0.19 Ωm for sea water resistivity).

As seen also in 2D models, and presumably for the same reasons, an artifact near the coast is produced in the calculation. This is characterized by an area, between progressive 450 and 500 m, with an abrupt lateral passage between a low-resistive and a high-resistive side by side, with unrealistic values and distribution not consistent with the local lithostratigraphic

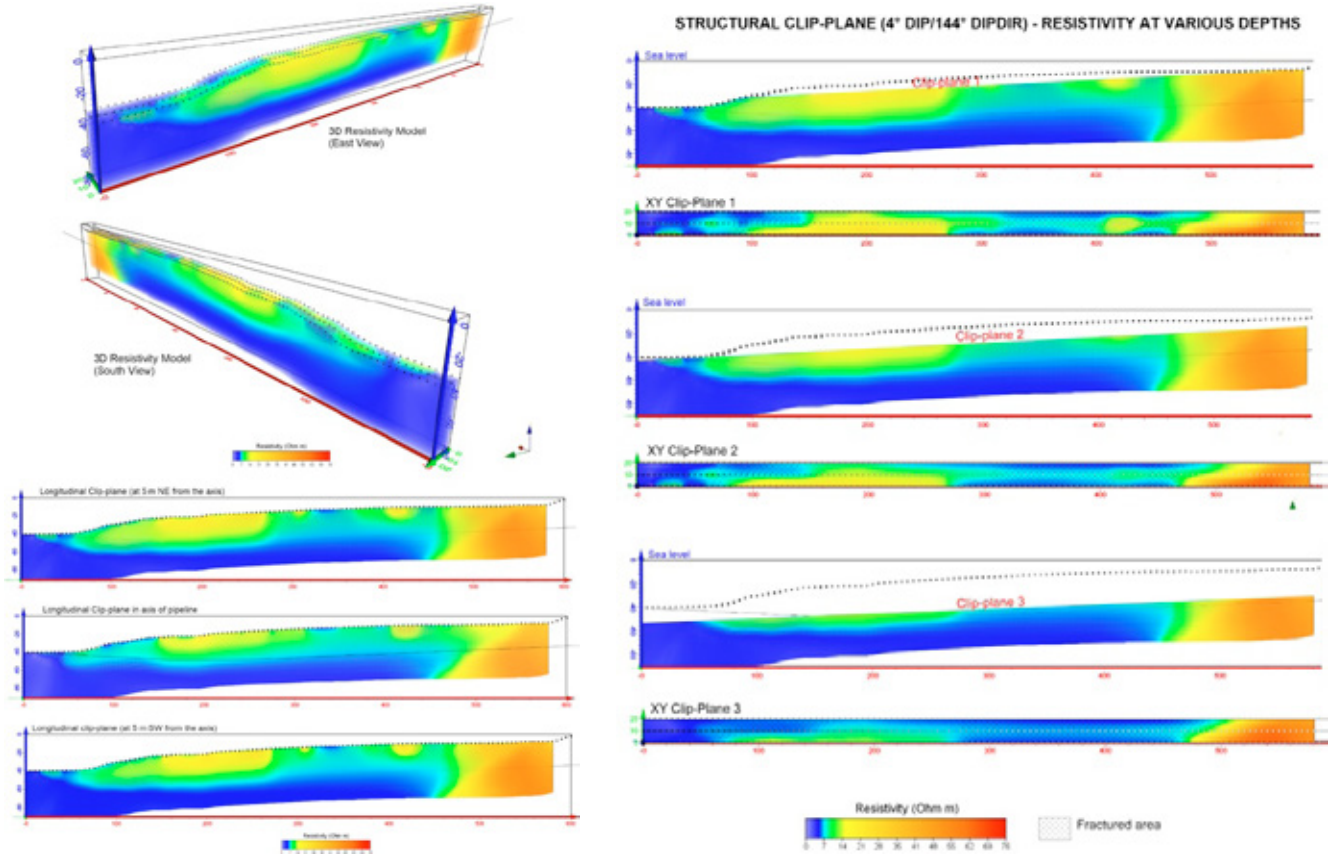


Fig. 10 - 3D Resistivity model and structural clip-plane (4°DIP/144° DIPDIR) – Resistivity at various depths

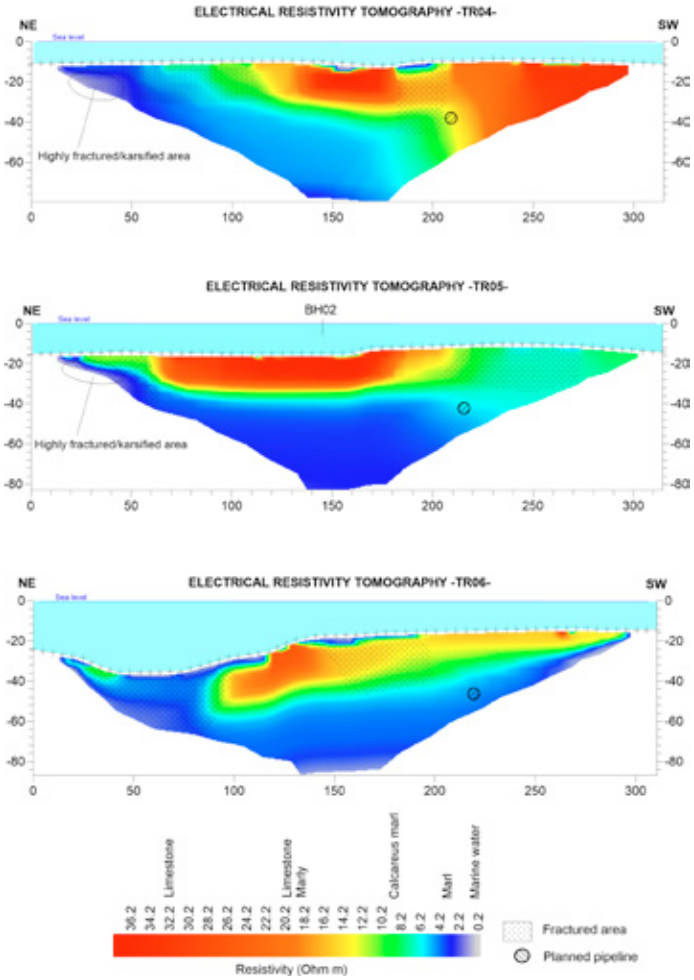


Fig. 11 - Electrical resistivity tomography – TR04-TR05-TR06

context. In the remaining parts of the model the result obtained is similar to that seen in the 2D lines. The values of the electrical resistivity are presented by volumes in transparency, with perspective views (from the East and South); in vertical slices (clip-planes), one of which is aligned with the pipeline, one located 5.0 m towards the NE and the other 5.0 m towards the SW. Finally, in order to have a perception of the variation of the resistivity values within the homogeneous lithological/electrical horizons, clip plane of a structural plane was used, with geometry similar to that of the outcropping Formation (DIP/DIPDIR - 04°/144°), at various depths. (See **Figure 10**).

The three geoelectric prospections transversal to the direction of the pipeline axis (TR04, TR05 and TR06 (See **Figure 11**)), cover the entire area of the submerged morphological platform and the valley present in the north side. The models, always elaborated with the same boundary conditions used for the longitudinal models, show a distribution of the resistivity values similar to those already described, therefore consistent with a sub-horizontal monoclinal structure of the lithologies. An electrically relatively higher resistive first horizon (>10 Ωm) is always observed, laterally affected by slightly more conductive/fractured bands.

Two particularly low-resistive cores are present in the

initial part of the TR04 and TR05 models, with resistivity values lower than 1.0 Ωm, attributable to highly fractured and karst areas. As also observed in the longitudinal models, in depth (25-27 m in the platform area) there is a marked decrease in the resistivity values, correlated with the increase in the frequency of the marly intercalations.

Conclusions

Geophysical surveys through geoelectric resistivity method (ERT) have been carried out in the nearshore area of the Delimara Peninsula, where a microtunnel is planned to be realized for the offshore approach of the 22" (Melita Transgas Pipeline).

The measurements were carried out in extreme conditions, from a technical point of view: the presence of significant water depths, with high electrical conductivity, limits the resolution capability of the methods due to short circuiting in the water layer. However, these difficulties have, at least in part, been avoided thanks to adequate equipment, careful planning, and attention to details (precise positioning on the seabed and measurement of sea water resistivity). The electrical resistivity models obtained have a good quality level (residual 7-8%) and are consistent with the lithostratigraphic context of the investigation area.

The correlation of the electrical resistivity values of the 2D and 3D models with the lithologies, as reconstructed also in the executed coring, allowed to hypothesize the geometric arrangement of the lithologies up to depths that reach 50-60 from the seabed. In the offshore area, the lithological structure is characterized by the presence of a horizon with relatively high resistivity, attributable to the predominantly calcareous and marly limestone lithologies (Upper Globigerina Limestone Member), with a thickness varying between about 22 and 30 m, in which a gradual decrease is observed of the resistivity values in its lower portion, attributable to the presence of more frequent pelitic intercalations (marly). Even deeper, resistivity values are observed to decrease further, a condition attributable to a lithological change (marls and clayey marls - Middle Globigerina Limestone Member).

For the identification of the fractured and karst areas in the rock mass, it was considered that they led to an increase in porosity, and that in the presence of sea water there was a reduction in the electrical resistivity values. This condition is extreme in the presence of cavities filled with sea water, in which calculated resistivity values lower than 0.5 Ωm are to be expected. These values are not found in the resistivity models, except for two small nuclei present in the ERT TR04 and TR05, in their initial portions, attributable to areas of strong fracture and karst.

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Graduated with honors in Construction Engineering at the "Politecnico delle Marche" in March 2002, she started working for services companies operating in the Offshore Oil & Gas field in Fano. She carried out tasks of structural engineering of subsea pipelines for basic and detailed projects, becoming over the years the project coordinator for engineering activities. She held the role of Deputy Project Engineering Manager for multidisciplinary projects in Oil & Gas.
She has been part of international Task Forces for EPC (Engineering Procurement and Construction) projects following the engineering phase and the procurement of materials along with the technical alignment of shore approaches construction service providers.

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He graduated with honors in Geological Sciences in 2014 at UNICAL - the University of Calabria (Italy). After his graduation he attended the master "Sistema di Gestione Integrata per l'Erosione Costiera". Giuseppe started his career as a freelance and in October 2014 he moved to the energy industry starting his collaboration with Techfem. Employed as a junior geologist, he is now a senior geologist specialised in geological and hydrological analysis, seismic studies and application of "no-dig technology". Joining Techfem allowed him to consolidate and his knowledge in the geological field for both onshore and offshore project. During his career, he's been involved in many projects, related to feasibility studies, FEED and EPCI for Snam, Eni, S.G.I. and many other companies, bringing his competences in different geological, hydrogeological and seismic aspects.

Giuseppe Vecchio

He graduated in Geological Sciences in 1989 and he consolidated his scientific knowledge through collaborations with the Department of Earth Science of UNICAL - the University of Calabria (Italy).
From 1992 to 2002 he collaborated with the Experimental Institute for Soil Study and Defense based in Florence, through scholarships, research grants and several contracts. The research activities were aimed at surveying and mapping soils and their thematic maps.
He has been working with Techfem S.p.A since 2002 coordinating geological, hydrogeological and seismic activities applied to pipeline design.

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Giuseppe Ferraro received his MS in geology cum laude from University of Rome "La Sapienza" and then engaged professional path in applied disciplines focused on near surface geophysics, geognostics and analysis of environmental systems. He then began his geophysical career as a technical manager at Geofisica Misure snc gaining extensive experience in project management as well as technical services in the planning, acquisition and modeling of refraction and reflection seismic prospecting. Furthermore, he developed extensive experiences in multi data-integration chiefly magnetic, electromagnetic and geoelectric data, modeling the subsurface both in 2D and 3D onland and offshore. Over the years, the activities have concerned geological and geotechnical modeling of subsurface, hydrogeological basin characterization and geo-archeological research.

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Paolo Macchi, Managing Director - Trillium Pumps Italy
Edoardo Garibotti, Managing Director - Termomeccanica Pompe

Mid-April, Trillium Flow Technologies finalized the acquisition of Termomeccanica Pompe. Trillium Flow Technologies' objective is clear: bringing together under its Italian umbrella the historical La Spezia company and its existing Gabbioneta pumps legacy brand to further assert its position as a global player in the engineered pump market.

Trillium Flow Technologies is a global designer, manufacturer, and aftermarket services provider of engineered pumps and valves used in mission critical applications. Its established portfolio of brands serves customers in the water and wastewater, power generation, oil and gas, mining, nuclear, and general process industries. The existing Trillium Flow Technologies pump portfolio includes not only Gabbioneta, but also Begemann, Floway, WEMCO[1], WSP, and Roto-Jet Pump brands (visit www.trilliumflow.com).

"Mid April, Trillium Flow Technologies added Termomeccanica Pompe to its brand portfolio. Its goal is clear: to unite the two historic Italian brands - Gabbioneta and Termomeccanica Pompe - under its leadership to further affirm its position as a global player on the engineered pump market

Paolo Macchi, Managing Director of Trillium Pumps Italy, firmly believes that the Termomeccanica Pompe's acquisition will create a much larger Italian engineered pump manufacturer by combining two strong legacy brands with a highly complementary product portfolio, installed base, and service capabilities. The joint entity will be uniquely positioned to support our local and international

Termomeccanica Pompe La Spezia HQ

Termomeccanica Pompe API 610 BB5-type pump for water injection service at onshore oil extraction plant under final performance test at La Spezia in-house test center

Termomeccanica Pompe API 610 VS1-type pump for sea water supply service at LNG regasification terminal

customers in a more comprehensive and impactful way.

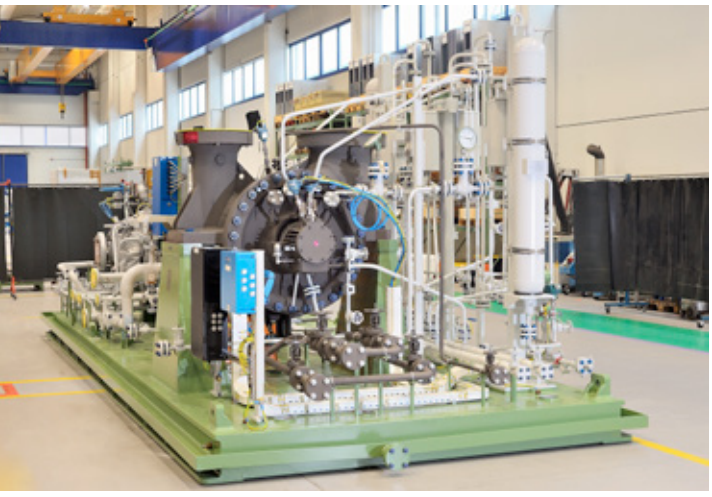
Termomeccanica Pompe supplies design-to-order packages and engineered-to-order pumps focused on large vertical and horizontal pumps while Trillium Flow Technologies Gabbioneta brand provides engineered-to-order packages and configure-to-order pumps, with a focus on smaller to medium horizontal pumps. Trillium Flow Technologies Italy & Termomeccanica Pompe's teams will be able to work together collectively and present one unified product package to Trillium Flow Technologies' customers, including the wide range of products from the entire family of pump brands.

Together, the two companies will also cover the industrial market in a more comprehensive way since the Gabbioneta pumps brand focuses mostly on serving the oil & gas market while the Termomeccanica Pompe brand predominantly serves the water, desalination, and power markets as well as segments of the oil & gas market complementary to Gabbioneta. At supply chain level, strategy, footprint, and spend will be leveraged between both organizations, thus creating a leaner and more efficient model.

In this article, Paolo Macchi, CEO of Trillium Pumps Italy and Edoardo Garibotti, CEO of Termomeccanica Pompe, explain how the two excellences of the Italian industry together will allow Trillium Flow Technologies to provide its global clientele with a wide range of complementary products, with related engineering and after-sales services

Manufacturing will also see efficiency gains related to the strategic placement of orders between Trillium's existing Gabbioneta, and now Termomeccanica Pompe brands, bringing strong benefits to Trillium Flow Technologies' customer base as the new combined organization will allow us to offer products with shorter lead-times at a more competitive price. A strong point for both Trillium Pumps Italy, and Termomeccanica Pompe's manufacturing facilities are their relative test centers. Trillium Pumps Italy boasts one of the most advanced test centers for API 610 pumps that allows customers to witness their pumps' tests remotely. In its test center, which ranks amongst the largest in Europe, Termomeccanica Pompe not only conducts full-scale performance testing of all its pumps, but also its contractual model tests as well as the validation of new hydraulics for product development. Termomeccanica Pompe's test center, like Trillium Pumps Italy, allows both in-person and remote witness testing.

Edoardo Garibotti, Managing Director of Termomeccanica Pompe, shares that adding value to customers' projects is in Termomeccanica Pompe's



GABBIONETA API 610 BB2-type pump for atmospheric residue product at crude distillation unit

GABBIONETA API 610 VS6-type pump for booster service in the Oil &Gas upstream sector

DNA. Their entire organization revolves around developing and providing engineered pump solutions related to both products and services tailored to our customers' specific projects requirements. This is a value we completely share with Trillium Flow Technologies, who, with its global reach, will allow Termomeccanica Pompe to further strengthen its legacy.

By joining the Trillium Flow Technologies, a First Reserve portfolio company, Termomeccanica Pompe will benefit from the financial solidity First Reserve offers its portfolio companies, a key factor that the global engineered pumps market demands. This solidity will also allow us to maintain the investments in our strong innovation and customization culture in terms of technology and quality improvement related to products, services, processes, manufacturing, and people.

Finally, Termomeccanica Pompe adds that they are particularly proud of the contribution Termomeccanica Pompe will be able to make to Trillium Flow Technologies' after-sales and development. Indeed, the company's strong central and local service organization, especially in the MENA area, will enable Trillium Flow Technologies to expand its service capabilities and to better serve its current installed base across all Trillium Flow Technologies pump brands.

As David Paradis, CEO of Trillium Flow Technologies, shared in a previous press release: "...The addition of Termomeccanica Pompe to our portfolio better positions us as a global supplier of high-performance vertical turbine and split case pumps. More specifically, Termomeccanica Pompe expands our offering into water and other critical infrastructure applications. Termomeccanica Pompe's highly engineered product range, strong supply chain, world-class manufacturing, extensive test capabilities, and wide-ranging aftermarket service organization combined with the same from our Gabbioneta and Floway brands will allow us to present one united and complete product offering to customers around the world."

Paolo Macchi

Paolo Macchi has an MSc degree in Mechanical Engineering from Politecnico di Milano. He began his career at USAG Utensilerie (Gemonio) where he was co-author of a patent on mechanical extractors. He was later Head of the CAD / CAM Office and then Production Manager at ILMA Plastica (Gavirate), a world leader in the construction of injection molds for plastic materials for the automotive sector, before becoming COO in Signal Lux, an Italian-French company active in the design and production of components for household appliances with factories in Italy, France and Tunisia. After earning his EMBA degree at the School of Management of Politecnico di Milano, in 2005, he joined Tyco, where he held the position of CEO of Biffi, Raimondi, and Fasani and subsequently became VP Actuation & Controls, a group of Tyco Valves & Controls, a world leader in the construction of actuators and controls that includes the Biffi, Westlock, and Morin brands. After the acquisition of Tyco Valves & Controls by Pentair he also becomes CEO of all the Italian operations of the Valves & Controls group which in addition to the previous brands also includes the Vanessa brand. In August 2016, he joined the Weir group then Trillium, where he became CEO of Gabbioneta (Nova Milanese).

Edoardo Garibotti

Edoardo Garibotti graduated in Mechanical Engineering (MSc) from the University of Genoa in 1984. He joined state-owned Termomeccanica in 1987. Over the years, he held a series of positions, amongst which After-Sales Business Unit Manager and Pump Product Line Sales & Marketing Manager after privatization in 1995. He was successively promoted Managing Director of Termomeccanica Pompe upon the company's inception in 1999. Under his 20-year leadership, Termomeccanica Pompe has asserted its position as an international leading designer and manufacturer of engineered pumps for applications in the fields of water transmission, desalination, power generation and oil & gas. Edoardo Garibotti also holds a series of offices inside as well as outside Termomeccanica Pompe, which currently include, amongst others:

- Managing Director of Termomeccanica Romania (Bucharest)
- Member of the Board of Termomeccanica Saudia Co. Ltd (Riyadh) and of Termomeccanica Pumps Services LLC (Abu Dhabi)
- Member of the Scientific & Technical Committee of La Spezia Superior Technical Institute's Foundation
- ANIMP's International Business Section Head

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Ansaldo Energia and Energy Dome for innovative energy storage solutions

With this agreement, Ansaldo Energia enters into a strategic segment of the energy supply chain: a crucial operation in the era of "ecological transition"

Alice Pesenti, Product Manager, Energy Storage
Alessandro Giacchino, Head of BOP Engineering Department
Ansaldo GreenTech

Claudio Spadacini, Energy Dome CEO and Founder, Daniela Gentile, Ansaldo GreenTech CEO and Giuseppe Marino, Ansaldo Energia CEO after the signature of the license agreement that allows Ansaldo Energia to use the Energy Dome proprietary energy storage technology based on the compression and expansion of CO_2.

Last april Ansaldo Energia and its subsidiary Ansaldo Green Tech signed a license agreement that allows the Company to use the Energy Dome proprietary energy storage technology based on the compression and expansion of CO_2. The agreement also provides for the marketing license of Energy Transition Combined Cycle (ETCC) technology in combination with gas turbines. The license agreement follows the Memorandum of Understanding signed last year and the due diligence carried out by Ansaldo Energia on the Energy Dome technology, which confirmed the TRL (Technology Readiness Level), performance and costs, as well as its potential in the energy storage market. Ansaldo Energia thus enters a strategic segment of the energy supply chain: a crucial operation in the era of ecological transition and a fundamental step for guaranteeing reliability in the distribution of energy produced from renewable sources.

"Ansaldo Energia and its subsidiary Ansaldo Green Tech signed a license agreement that allows the Company to use the Energy Dome proprietary energy storage technology based on the compression and expansion of CO_2

The innovative storage system called CO_2 Battery, owned by Energy Dome, is based on a thermodynamic cycle which, using carbon dioxide (CO_2) as a working fluid in a closed cycle and transforming it between its gaseous and liquid phases, allows an efficient and economical energy storage, using only components already available on the market from leading national and international suppliers. The process involves a

charging mode, in which the CO_2 is taken from an inflatable atmospheric gasometer, the Dome, compressed and then stored under pressure at ambient temperature in the liquid state, while the heat deriving from the compression is recovered in a thermal storage system.

When energy needs to be released into the grid, liquid CO_2 is transformed into gaseous, heated using heat from the thermal storage system, and expanded in a turbine driving a generator. The electricity generated is thus fed back into the grid and the CO_2 returned to the atmospheric gasometer, ready for the next charging cycle, in a process producing no emissions into the atmosphere. CO_2-based energy storage is proposed as a valid alternative to electrochemical batteries, due to its large storage size and, therefore, to the stabilization of electrical networks integrating significant quantities of renewable sources, overcoming several limitations such as those, among others, relating to difficulties in procuring raw materials and in disposal.

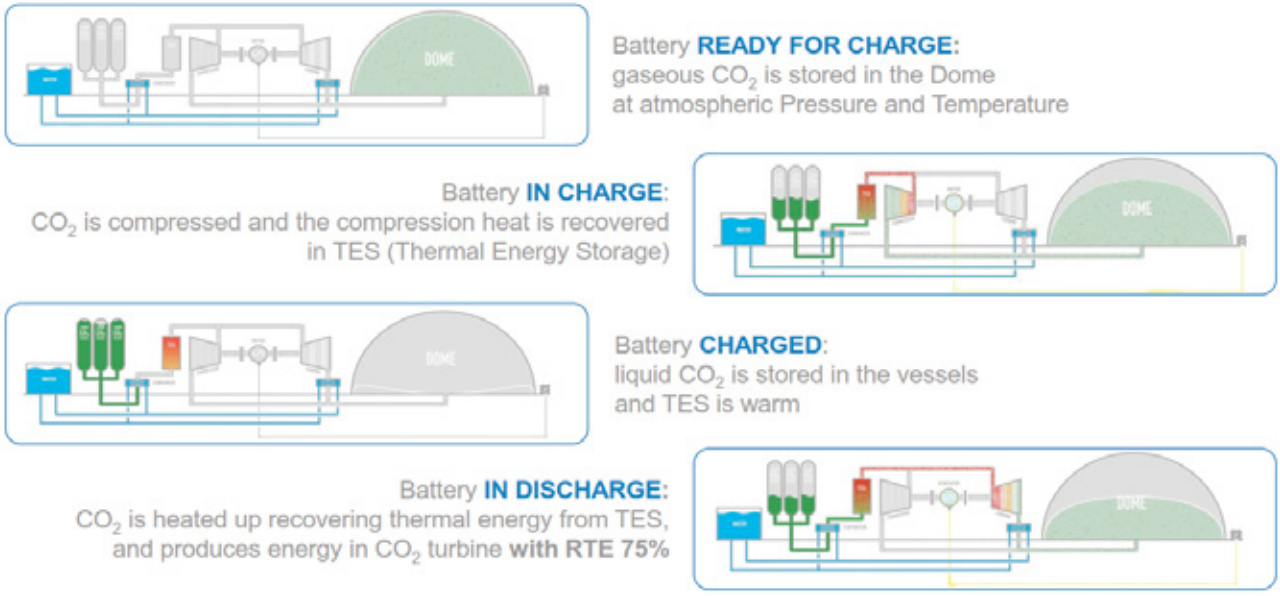
Ansaldo Green Tech is a subsidiary fully owned by Ansaldo Energia, established in June 2021 to address the sensitive moment of the energy transition through an important business diversification. A spin-off dedicated to defining new technologies and products for the energy transition, guaranteeing an adequate approach to the market, backed by the expertise and tradition of Ansaldo Energia, with its nearly 170 years of experience.

"At a time when a strong growth in energy produced from renewable sources is expected - with their intermittent characteristics - the storage issue definitely becomes crucial", says Daniela Gentile, CEO of Ansaldo Green Tech. "This is why the agreement reached with Energy Dome is a source of great satisfaction and a really important step for the energy strategies of the next few years, that will be a strong point of our offer".

"At a time when a strong growth in energy produced from renewable sources is expected - with their intermittent characteristics - the storage issue definitely becomes crucial

CO_2 Battery is an innovative system, based on a process not particularly complex and suitable for three main applications: stand-alone system for arbitrage purposes; plant integrated with renewables (solar, wind) for time-shifting purposes; finally integrated into must-run power generation systems, with the aim of modulating electricity generation independently of the industrial process where they operate.

ETCC is a functionally more complex product that

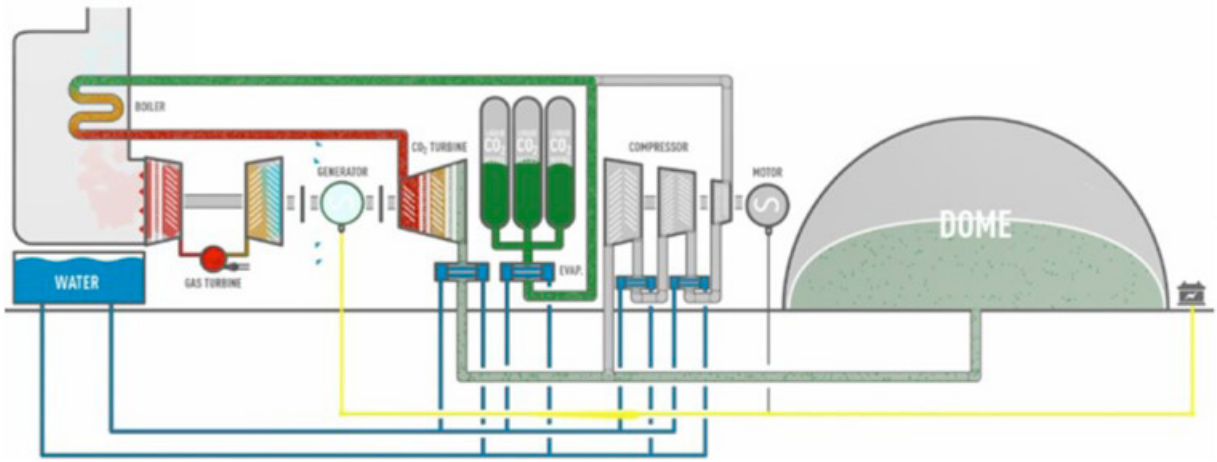


enhances the peaker capabilities of gas turbines by substantially expanding their operating range, thanks to the integration of a CO_2 bottoming cycle combined with a storage system. The hybrid configuration of a gas turbine integrated with an energy storage solution allows the resulting combined cycle to be operated both with peaker functionality and for arbitrage purposes, supporting the electricity grid in compensating the volatility of renewable energy generation or resolving grid congestion.

The ETCC configuration is also available as add-on, applicable to existing gas turbines in an open cycle configuration: the upgrade makes it possible to increase traditional operating efficiency without impacting start-up times, and to integrate the possibility of arbitrage, as an additional service.

Both CO_2 Battery and ETCC have a plant configuration that integrates a power train consisting of rotating machines with a part of the plant aimed at the efficient management of storage systems, combining in an innovative way some typical power generation components with other specific elements, to ensure maximum operational flexibility and full process reversibility.

This functional separation reflects in the possibility of sizing the system power independently of the operating duration of the storage system, thus allowing the



creation of the most suitable system configuration through a "brick" approach to meet the customer's specific needs; in particular, the duration of the storage system can be sized at will, overcoming the technological limits typical of electrochemical storage systems.

Finally, with reference to electrochemical storage technologies, a further advantage of the CO_2 Battery is its 25-year lifespan, during which no degradation in performance is detected, even in the case of a high number of charge and discharge cycles. During the 20 years of service-life, it will not be necessary to replace the main components of the system, and at the end no issues relating to disposal arise, as no critical raw material is used in this technology.

"A further advantage of the CO_2 Battery system is its 25-year lifespan, during which no degradation in performance is detected, even in the case of a high number of charge and discharge cycles

Alice Pesenti

In Ansaldo Energia since 2006, initially Process Manager at Ansaldo Ricerche, later in R&D for Ansaldo Energia with the role of Combustion specialist, in particular for Validation activities on Rig and later on Turbogas. Team Leader for Combustor body always within R&D, subsequently Deputy Global Combustor department. From 2020 in Innovation in the Energy Storage field, today in Ansaldo Greentech as Product Manager for Energy Storage.

Alessandro Giacchino

In Ansaldo Energia since 2007, holds a Bachelor's degree in Environmental Engineering and a Master Degree in Advanced Engineering for the Design and Management of Power Plants. During his career covered the roles of Mechanical Plant Engineer, Senior Engineer specialized in industrial noise control, Lead Engineer for Hybrid Applications and Project Engineer, acquiring broad competencies in power plant design, optimization and testing, and also additional skills in product development and management. Since 2022 is Head of BOP Engineering Department in Ansaldo GreenTech.

BTS Biogas, intelligent management of organic waste

The transformation of waste- and by-products into a valuable resource creates value for the Community and Environment

Franco Lusuriello, CEO
BTS Biogas

Anaerobic digestion systems represent an economically and environmentally sustainable solution capable of transforming waste into renewable energy. Thanks to a highly experienced team and 29 international patents, BTS Biogas transforms by-products into a valuable resource that that returns to the production cycle. Through its 250 plants worldwide, the company contributes to the energy transition process by producing biogas, biomethane for transport, electricity and heat, soil fertilisers and carbon dioxide for food use. Some of the most important projects developed by BTS Biogas are plants fuelled by olive pomace, OFMSW (Organic Fraction of Municipal Solid Waste), farm effluents and biological waste from food companies.

BTS Biogas is an Italian company that has established itself on the domestic market and internationally as a technological leader in the field of anaerobic digestion. The Group has been involved in the development, engineering, construction and maintenance of over 250 biogas plants in Europe, North America and East Asia for more than 25 years. Thanks to a highly experienced team and 29 international patents, today the company provides consultancy and customised technological solutions for the design, construction, commissioning, maintenance and assistance of systems, which are recognised by the market for their high levels of reliability and for the continuous production of energy.

"BTS Biogas provides consultancy and customised technological solutions for the design, construction,

commissioning, maintenance and assistance of anaerobic digestion systems

BTS Biogas believes that the "smart" management of organic waste and the generation of clean energy are crucial to building a sustainable future for local and global communities. Under this perspective, anaerobic digestion systems represent an economically and environmentally sustainable alternative to the current waste management system: indeed, organic residues are transformed into renewable energy allowing communities and companies to achieve the goal of "zero waste" and increase decarbonisation more quickly.

Indeed, anaerobic digestion unites two fundamental components of our society - the food system and the production of energy - in a closed system in which the by-products of one become the raw materials of the other and are transformed into a precious resource for the community. The natural gas created by the anaerobic digestion process comes from organic waste, a source that is continuously replenished by man, which, if not used in this system, would in part increase climate-altering emissions. Unlike other energy sources, the combustion of biogas does not contribute to increasing the atmospheric concentrations of CO2 of fossil origin and is therefore one of the best sources of energy.

BTS Biogas operations are managed by over 100 employees, located at the Italian headquarters in Affi (Verona) and in Brunico (Bolzano) and the offices abroad in France, the United Kingdom and the USA, which were inaugurated in 2021. Through its plants, the company contributes to the process of energy transition towards a circular economy with the production of biomethane for transport and the network, electrical and thermal energy, soil fertilisers and carbon dioxide for industrial use. Some of the most significant projects for the type of by-products used are represented by plants powered by olive pomace, OFMSW, the effluents of farms or biological waste from food companies.

Agroenergy among the first plants in Europe powered by olive pomace

The Agoenergy biogas plant, built by BTS Biogas in 2019 in Andria, Apulia (Italy), is owned by the Agresti family, which also owns the Agrolio company that has been producing extra virgin olive oil for three generations. The Agresti family has been able to make use of olive pomace for anaerobic digestion with significant advantages for the environmental impact and economic balance sheet of the company, combining tradition and local values with innovative circular economy models.

Indeed, Agroenergy is one of the first plants in Europe to be powered 100% by pitted biphasic olive pomace, which was previously stored in stainless steel silos. This source of power can also be supplemented by other by-products of the agricultural supply chains on the territory.

With the biogas produced, the cogeneration module generates 500 kW of electricity and 500 kW of thermal energy, while the digestate is part of the plant cycle of olive production, helping to improve its quality and quantity. The efficiency and functionality of Agroenergy are guaranteed by careful, continuous biological support: the process is mesophilic (35° - 48°C) and involves a preliminary digestion phase in a hydrolysis pre-tank. Two storage tanks with floating covers and a separator were built downstream of the fermenter.

AMIU, the plant in the metropolitan city of Bari powered by OFMSW

Owned by AMIU, the municipalised urban hygiene company that manages the waste collection, processing and disposal activities in the city of Bari (Apulia, Italy), the plant built by BTS Biogas in 2020 has an installed power of 1,200 kW_{el}. The site, powered by OFMSW (Organic Fraction of Municipal Solid Waste) mixed with other compostable waste fractions such as pruning cuttings, is able to produce electrical and thermal energy and soil fertilisers. It is one of the few plants constructed for the processing of organic waste in a metropolitan city, built to utilise organic waste and make a virtuous and sustainable waste disposal system available to citizens.
The project involves AMIU collecting and transporting waste to the plant's delivery areas, where the quality of the biomass is assessed: that which is not considered suitable is discarded. The plant is able to produce electricity or heat for self-consumption, with the surplus being sent into the network.

Demeter Energies, the French plant powered by farm effluents

The Mauzé-sur-le-Mignon plant (France) was built by BTS Biogas in 2016 for Demeter Energies, the capital of which is held by local dairy cattle, beef cattle and goat breeders and cooperatives and Sergies, the energy union which holds 20%. This initiative was in response to the demand that requires French farmers to reconsider their production methods and diversify them to keep the sector alive.
The plant, with a capacity of 499 kW_{el}, is able of processing the effluents of 12 farms located within a radius of less than 8 km, converting them into electricity, heat and natural fertiliser.
The surplus, which corresponds to 1,500 MWh, is channelled into the heating network built by Demeter Energies in Mauzé-sur-le-Mignone and used by public buildings, saving the equivalent of 15 tonnes of gas for the René Caillié secondary school, 115,800 litres of fuel for the swimming pool and municipal buildings and 135,000 litres of fuel for the corn and alfalfa dryers. The electricity produced meets the domestic needs of around 1,300 people. Mauzé-sur-le-Mignon was one of the first French cities with fewer than 10,000 inhabitants to produce heat and energy from renewable sources.

Equimeth produces biogas from the biological waste of the Fontainebleau region

The plant, built by BTS Biogas in 2021, produces 25 GW/year of electricity and 250 Nm^3/h of biomethane. This project represents one of the most important biological waste recovery units in the Moret-Loing-et-Orvanne area (France) because it produces biogas from wastewater, biological agricultural and food industry waste. The Fontainebleau region, where it was built, is known for its equestrian traditions. Historically, manure from horse farms was used to fertilise mushrooms grown on nearby farms, but their relocation forced a rethink on alternative forms of recovery of this biomass, which has become the focus of the Equimeth project. This site, which uses 25,000 tonnes of organic matter every year, provides up to 15% of the gas consumed by the inhabitants of the municipalities of Moret-Loing-et-Orvanne, Fontainebleau, Saint-Mammès, Avon, Thomery or Champagne-sur-Sein and allows the majority of local biological waste to be processed using pasteurisation. The biomethane produced by the plant corresponds to the annual gas consumption of 4,000 families and avoids the emission of nearly 7,200 tonnes of carbon dioxide per year. Every year, 1,300 hectares of agricultural land are fertilised using the digestate produced. Digestate is an easier fertiliser to process than manure as it is more concentrated, and nutrients are more easily assimilated by crops.

In France, organic waste accounts for one third of residual household waste and can be a source of pollution if incinerated or landfilled. Equimeth makes it possible to recover and optimise these elements, transforming them into a valuable resource for the community. The presence in Ile-de-France of large volumes of organic matter from agriculture and the food industry, together with quality transport infrastructure, are factors that promote the development of biogas in the region.
The construction of this plant marks an important step towards the energy autonomy of Ile-de-France and contributes to achieving the energy objectives of the region, which envisage the use of 40% of energy from renewable sources by 2030 and 100% by 2050.

The Jessup plant, one of the latest generation projects developed in the United States

Located in the Maryland Food Center, home to one of the largest agri-food logistics districts in the region, the Jessup plant is one of the latest generation projects developed by BTS Biogas in the United States in 2021. The plant will produce 1,600 m^3/h of biogas and 1.2 MW_{el} per year and will use over 125,000 tonnes of waste from the processing of fruit and vegetables, meat, baked goods, oil and fats, which will generate around 800 cubic metres of biomethane an hour, resulting in a quantity that is equivalent to the needs of 4,800 homes. The biomethane produced will be channelled into the network and used for transport, while the thermal energy generated will be used to heat the digesters and the surplus will be sold to third parties. A semi-permeable membrane technology also allows nitrogen to be recovered and water to be purified, which is then partially reused in industrial processes.

Two pre-processing systems have also been included in the plant, to eliminate any impurities from the incoming material, as well as a "Waste Water Treatment" post-processing system, capable of purifying the digestate by dividing the liquid component from the solid one. The solid fraction is used as fertiliser in agriculture, while the liquid fraction is recycled during pre-processing and is partly sanitised. The project allows the exploitation of food waste by transforming it into electricity and thermal energy with significant benefits for the environment. This site is part of a series of new plants that BTS Biogas is developing in the United States, a market with policies that promote the generation of energy from renewable sources, such as biogas.

The South Milford agro-industrial plant

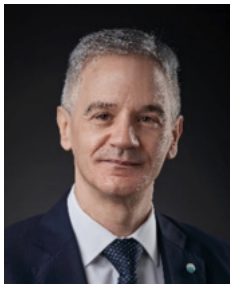
The plant, owned by AB Agri, a company specialising in the production of feed and data services for the agri-food industry, was built by BTS Biogas in 2016 in South Milford (North Yorkshire), in the United Kingdom. With a capacity of 500 kW_{el}/h of biogas and 550 Sm^3/h of biomethane, the site is capable of receiving up to 100,000 tonnes per year of organic waste from industrial food processing and green waste, which is used to produce about 4.2 million Sm^3 of biomethane and 4.2 million kWh of electricity. Thanks to a membrane purification system, in addition to producing electricity, the plant is able to transform biogas into biomethane and channel it directly into the national gas network, minimising CO_2 emissions. The heath, on the other hand, is used to heat the fermentation tanks, the upgrading units and the pasteurisation system. In the meantime, the digestate obtained is used to produce 50,000 t/y of pasteurised liquid fertiliser.

The plant uses the "Waste to Power" pre-treatment solution, designed to manage both packaged and bulk organic waste, including liquids, and can be suitably installed on BTS Biogas plants ranging from 500kW to over 1.5MW. Thanks to the flexibility of this system, it is possible to effectively process perishable organic raw materials at decentralised locations on a more appropriate and sustainable scale, without transporting them over considerable distances to centralised anaerobic digestion hubs, substantially reducing the carbon footprint of operators.

Municipal household waste, food production waste, hospitality, retail and public sector waste are then transported to the South Milford site. The plant uses 40,000-60,000 t/y of liquid food waste, 10,000-20,000 t/y of solid food waste and 10,000-20,000 t/y of green wastes that contribute to the production of biomethane.

"Today, BTS Biogas has a pipeline of projects around the world that will help increase the production of biogas by reducing climate-altering emissions

Today, BTS Biogas has a pipeline of projects around the world that will help increase the production of biogas by reducing climate-altering emissions. Biogas is also destined to play a leading role in the on-going effort for energy independence, which has become a central issue on both Italian and European political agendas.



Franco Lusuriello

Franco Lusuriello, born in Genoa, is the CEO of BTS Biogas, a technological leader in the development and construction of biogas and biomethane plants. The manager has a profound understanding of the energy sector and has spent a career spanning thirty years in the Power Plants, renewables and civil construction markets, as well as having consolidated experience in the management of strategic operations in highly competitive markets.
Lusuriello has been at the helm of BTS Biogas since 2020, the year in which he joined the company, after having worked at Building Energy as Managing Director E&C, with global responsibility for pipeline projects in solar, wind and biomass technology. He previously held the position of COO of Building Energy US and was responsible for the North and Central American market. From 2008 to 2013, he was the General Manager of Rizzani De Eccher, a company operating in the civil and industrial construction and infrastructure sector, in Azerbaijan. Earlier, he was an Executive VP of Danieli SpA, a multinational global leader in the development of steel plants, which he joined after twenty years working at Tecnimont, Shell and ABB. Lusuriello has a degree in Electrical Engineering from the University of Genoa.

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Edoardo Busato, Regional Sales & Service Manager, MENAT Region
De Pretto Industrie

De Pretto Industrie is an Italian turbomachinery manufacturer. The company was established in 1885 and for more than 80 years has been part of leading global organizations. De Pretto Industrie Is today an Independent company acting as an Original Equipment Manufacturer (OEM) for new steam turbine generator sets up to 50MW but also as an independent Service Provider (ISP) of any rotating equipment manufactured by any OEMs in the market, thanks to its reverse engineering capabilities and its technical dept of 30+ engineers covering all key domains (thermodynamic/ construction/instrumentation/system).

De Pretto Industrie has extensive engineering competence in repair and revamps of turbomachinery, developing customized solution for each product and make. One stop solution provider for any rotating equipment, repair in emergency situations, OEM-equivalent warranties as well as cost and lead time advantages are the main benefits we can provide our customers with. Innovative thinking is applied to manufacturing and upgrading of turbomachinery control systems according to the highest market standards, latest normatives and best practices.

"De Pretto Industrie applies a customized and tailor-made approach on all its projects, but at the same time making sure the resulting capital and operating expenditures are minimized for the end-users

Case study

A major refinery in the Middle East region was experiencing severe problems with 2 backpressure-extraction steam turbines used to feed the refinery steam utilities lines as well as to generate power. DPI proposed to the end-user to perform a complete engineering study with a root cause analysis to identify the possible causes of such limitations and a retrofit solution to increase power output, efficiency, reliability and availability.

The thrust bearing of those units had been the main source of concerns since the initial installation, leading to frequent failures due to overheating, high vibration levels and, as a result, partial load operation with impacts on steam and power production. Thermal efficiency and reliability of the units were also affecting

LOAD CASE N°			1	2
Period – Start time / End time			01/01/2020 00:00 10/04/2020 20:00	14/08/2020 13:00 07/11/2020 10:00
Intermediate stop 1 Start time / End time			11/03/2020 16:00 11/03/2020 17:00	16/08/2020 12:00 16/08/2020 15:00
Intermediate stop 2 Start time / End time				17/10/2020 13:00 19/10/2020 08:00
Live steam				
— pressure	PPI414	bar a	121,9	121,8
— temperature	PTI413	°C	515,0	518,7
— mass flow	PFI401	t/h	145,5	158,0
Wheel chamber				
— pressure	PPI427	bar a	72,0	77,2
— temperature	PTI423	°C	449,7	460,5
Extraction				
— pressure	PPI423	bar a	36,7	36,8
— temperature	PTI420	°C	366,3	370,0
— mass flow	PFI402	t/h	25,2	38,5
Exhaust-steam				
— pressure	PPI434	bar a	15,4	15,3
— temperature	PTI425	°C	285,2	286,7
— mass flow	PFI403	t/h	116,6	116,2
Turbine speed	PSI402	rpm	8.196	8.198
Power at generator terminals	PEI432	kW	13.080	14.064

the normal operation, after 40+ years from initial installation.

Engineering Study – Performance Analysis

Data acquisition for thermodynamic assessment

The performance calculations are based on process values given by the Refinery. Engineering studies and performance analysis were carried out with the aim to acquire data for an accurate thermodynamic evaluation.

Assessment of thrust forces

The Refinery is reporting severe problems with the steam turbine thrust bearing: frequent faults because of overheating, vibration levels. As a result, machine is operated at partial load (around 15MW) while nominal power output is 21,5MWe. Modified bearings have been installed without considerable improvements. A first visual evaluation of the steam turbine layout shows that the balancing pistons are well contributing to balance the HP and MP reaction stages (according to the rule of "same dP-same average diameter"). While the additional thrust generated by the HP and MP control stages were not taken into consideration in the original design of the steam turbine. The thermodynamic simulations indeed confirmed the above assumptions are correct. In fact, control stages show a reaction grade of 15% for HP control wheel and 10% for MP control wheel which lead to a delta pressure on each control wheel and a corresponding thrust force.

If we consider those thrusts forces, the residual thrusts acting on the thrust bearing at full load are in the order of 50 ÷ 60 kN, towards the steam flow direction.

The thrust bearing on the active side has an area of 10,620 mm2; the specific pressure is consequently ≈ 5 ÷ 6 MPa, a much higher value than the one indicated in the original thrust bearing drawing (max 3.3 MPa).

From De Pretto Industrie design experience, this type of thrust bearings should be able to work up to 3.5 ÷ 4.0 MPa of specific pressure, before reaching the temperature limit values. The optimal working range to target in the design phase is up to 2 MPa.

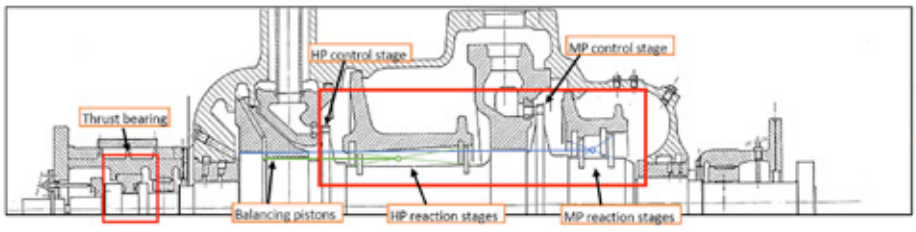
This confirms the historical temperature behavior of the thrust bearing, which rises with the load until it reaches the limit value of 110 ° C, resulting on partial load operation of the steam turbine around 15 MWe.

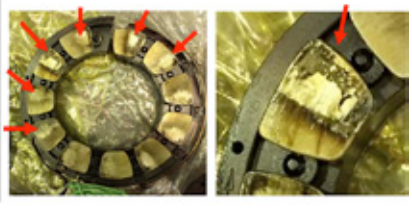
Engineering Study - Rotodynamics

Consistency of original design

Rotordynamic calculation is required to accurately predict the location of the high speed and low speed shaft line later critical speeds. De Pretto Industrie engineering standards impose critical speeds to be located either 10% below operational speed or 15% above operational speed to ensure a stable behavior of the rotating equipment. Journal bearing clearances and oil film as well as supports stiffness are also taken into consideration in the overall calculation.

Results shown steam turbine first critical speed is well below critical operating range and second critical speed is well above the same. Intermediate shaft first





critical speed is inside the critical operating range. This could lead to vibration issues if the shaft is not properly balanced or if the alignment is not properly done.
Lateral analysis turbine side (high-speed shaft line) with new turbine bearings having 1,2‰ clearance. Improvements are visible:

- Steam turbine first critical speed is still well below critical operating range, and second critical speed is still well above the same.
- Intermediate shaft first critical speed is now outside the critical operating range (above operating speed +15%)
- Generator first and second critical speeds are between the 1x and 2x operational speed and outside the critical operating range.
- Intermediate coupling first critical speed is above 2x operational speed and just outside critical operating range.

Advantages of the Retrofit Solution

Upgrades of performances

- DPI is able to design and customize a retrofit solution in order to increase the thermal efficiency of the unit.
- Retrofit with performance improvement includes the full redesign of the steam path using latest advanced blade profile technologies with the following new internal parts to be manufactured accordingly:

a) New rotor and new stator blade carriers

The new internals, having foot print design to fit the existing turbine casing axial and radial constraints, will avoid major modifications. The steam path will be redesigned as follows:

- HP control stage: new design to reduce reaction grade and thrust forces
- HP blading section: 9 stages as the existing configuration
- MP control stage: will not be installed as not required
- MP blading section: 5 stages instead of then existing 3 stages

b) New balancing piston

New balancing piston, designed to better compensate the thrust forces of the blading and reduce the axial forces on the thrust bearing. If possible with the actual space constraints, spring loaded sealing rings will be used as an upgrade to improve efficiency and reliability

c) New HP and LP gland bushes

New HP and LP gland bushes designed to ensure proper leakage ratio. If possible with the actual space constraints, spring loaded sealing rings will be used as an upgrade to improve efficiency and reliability

d) New HP and LP journal bearings

New HP and LP journal bearings with required reduced clearances according rotordynamic design (1,2‰ clearance), designed to improve stability and oil flow, having oil orifice inside the bearing housing.

e) New thrust bearing

New thrust bearing, designed to withstand the axial forces all over the operating range of the turbine, avoiding overheating or load limitation

The retrofit will allow to upgrade quite considerably the power output and thermal efficiency, given the same load conditions, in detail:

- Nominal 21,5MWe case: actual required inlet steam flow of 192,24 t/h (almost never reached during plant life time) **– retrofit solution 185,9 t/h**
- Load case 1: actual measured power 13.080 kW – **retrofit solution up to 14.415 kW (+10,2%)**
- Load case 2: actual measured power 14.064 kW – **retrofit solution up to 15.905 kW (+13,0%)**

LOAD POINT			NAMEPLATE INLET COND.	NOMINAL 21,5 MWe	1	2
Live steam						
– pressure	PPI414	bar a	122,6	122,6	121,9	121,8
– temperature	PTI413	°C	520,0	520,0	515,0	518,7
– mass flow	PFI401	t/h	180,0	190,7	145,5	158,0
Wheel chamber						
– pressure	PPI427	bar a	83,0	87,3	69,8	74,5
– temperature	PTI423	°C	470,0	475,5	449,7	456,3
Extraction						
– pressure	PPI423	bar a	36,48	36,54	36,7	36,8
– temperature	PTI420	°C	353,8	352,7	358,7	356,2
– mass flow	PFI402	t/h	40,0	40,0	25,2	38,5
Exhaust-steam						
– pressure	PPI434	bar a	15,2	15,2	15,4	15,3
– temperature	PTI425	°C	255,3	249,6	271,1	268,6
– mass flow	PFI403	t/h	139,3	150,0	119,6	118,8
Turbine speed	PSI402	rpm	8.196	8.196	8.196	8.196
Power at generator terminals	**PEI432**	**kW**	**19.635**	**21.500**	**14.415**	**15.905**

As a result of the study, the retrofit project showed the following main benefits for the end-user:

- **Higher Efficiency**

With rising fuel prices and consumption and considering the increasingly stringent environmental regulations, the improved thermal performance of a steam turbine is a key factor to reduce the carbon foot print of plants and their OPEX

- **Higher Power Output**

The increasing demand for power puts pressure to the existing plants to increase capacity. With this retrofit solution, we have been implementing the latest technologies allowing for more power output with the same steam input and output configuration.

- **Hligher Flexibility**

With the increased shares of renewable sources, existing thermal plants must operate with higher flexibility. Combining latest engineering technologies and digital control systems, a retrofitted turbine can respond to the power demand fluctuation with high efficiency and minimal stress.

- **Greater Reliability and Availability**

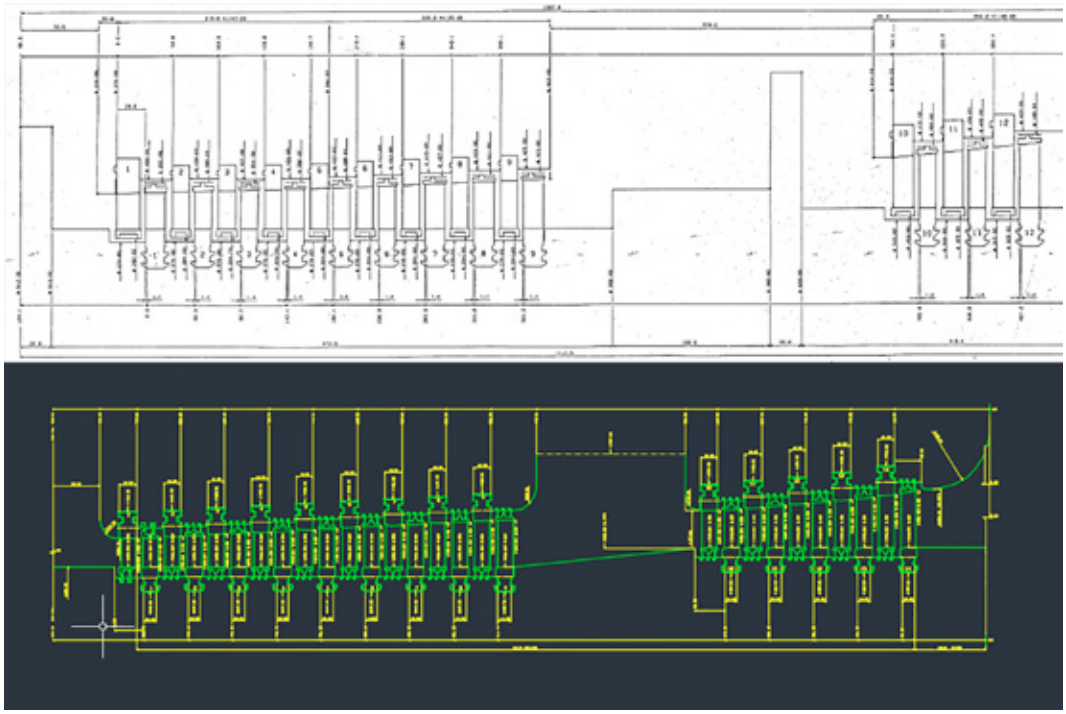
Operators are more and more looking to run their assets as long as possible avoiding/minimizing downtimes. By replacing old components with equivalent but more modern and robust ones, a retrofit not only reduces maintenance requirements and intervals but can also enhance the unit's lifetime.

- **Profitability**

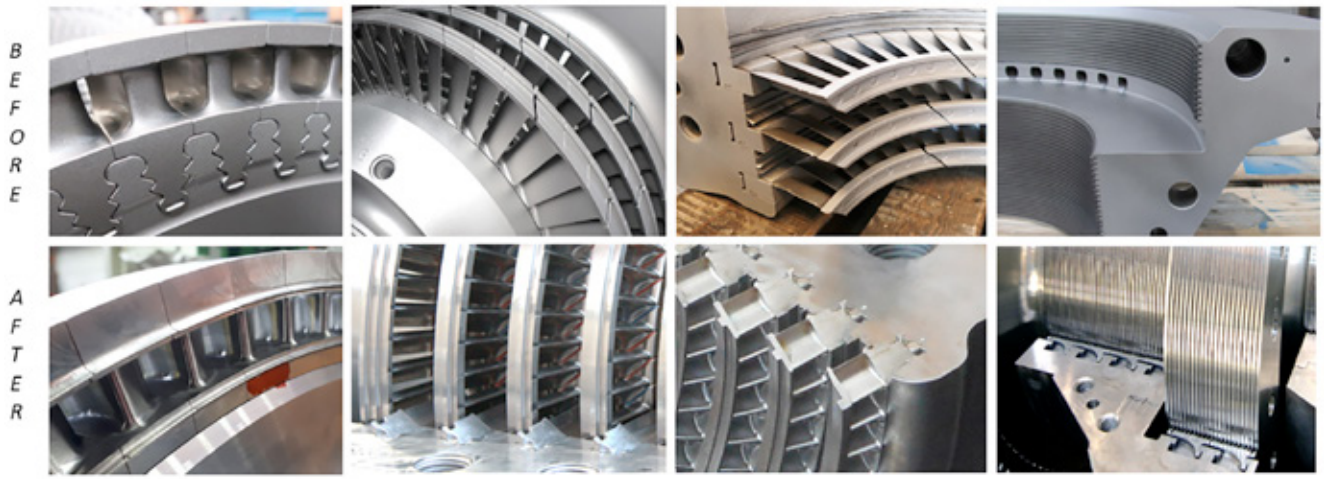
The economics of retrofitting compare favorably with the cost of a new plant and the lead time is much shorter. Our services range from technical direction to complete turnkey installation (typically executed within a scheduled outage period). Return on investments are achieved within a couple of years and performance guarantees are provided.

Highlights of the Retrofit Solution

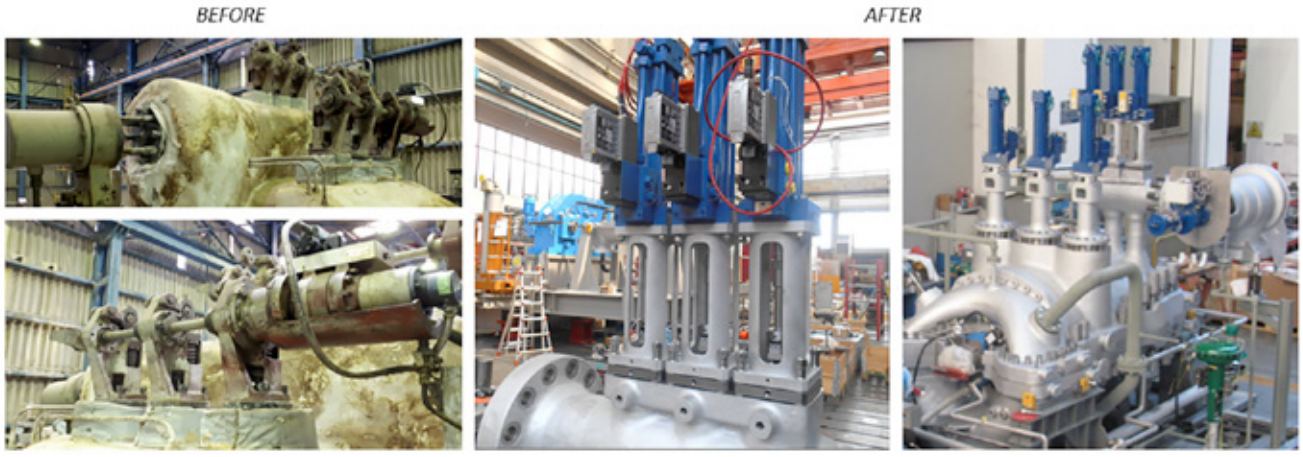
- Comparison between old steam path and new steam path



- Details of upgrades – blading and seals



- Details of upgrades – valves and servomotors



- Details of upgrades – control system

Edoardo Busato

Mr. Busato is the Regional Sales & Service Manager for De Pretto Industrie in charge of the MENAT region.
He has more than 12 years of experience in the turbomachinery industry, having acquired lots of knowledge in oil & gas and power generation field.
He started his carrier in the company as Service Engineer, with specialization in design, manufacturing, repairs, modifications and upgrades of rotating equipment. His responsibilities are now business development and project management, supporting customers all over the region with his team.

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ORF Onshore Receiving Facilities

Contribution to the execution phase of the 'First Oil' for the first foreign Oil&Gas company to produce oil since the approval of Energy Reform in Mexico (2013), as part of a new greenfield development project located in the Campeche Bay off the coast

Pino Gozzo, Engineering Manager
DG IMPIANTI INDUSTRIALI S.P.A.

The overall project development consists of an offshore platform, which delivers the production to the Onshore Receiving Facility (ORF) located in Sanchez Magallanes, through a multiphase sealine. After separation at ORF, production is directed to Pemex's San Ramón plant for treatment.

The project has been developed in a fast track approach. The production has started since two years and a half from the drilling of the first well in Area 1 and in less than one year since the approval of the development plan, totally fulfilling the expectations of the Mexican Government, aimed to increase the overall production in the country.

> "This project has been developed in a fast track approach

This early production phase (named PHASE 1) produces up to 15,000 barrels of oil per day, while the full field production (named PHASE 2) started in 2022 by means of an FPSO, will increase production up to 100,000 barrels of oil per day.

DG Impianti scope included engineering, procurement, construction, commissioning and start-up of ORF, including the tie ins with PEMEX areas in Bateria San Ramon and ECO San Ramon.

Phase 1 Project Detail

The plant consists of a process area, which includes pig trap area and separation unit, (with two separators, one slug catcher, seven measurement skids and the flaring system); utility area, (which includes the power generation, the compressed air system, the fuel gas skid, the nitrogen unit); building area (control and electrical room); telecommunication system and firefighting system.

The manifold unit, which include the manual choke valve, the HIPPS and the pressure transmitters for alarm and process shut down, receives the multiphase

stream from the pig trap unit and deliver it to separation unit.

The separation unit consists of one separator/slug catcher, rating 600lbs, designed to operate 1x100% during phase 1 and phase 2 and two separators, rating 150 lbs, designed to operate only during phase 1, when the operating pressure is set at 6 bara.
During Phase 1, the process separators and the separator/slug catcher receive the multiphase fluid in order to separate gas, oil and water streams, measure them, commingle oil & water in one stream and deliver separately gas and liquid phase to the Pemex plant named Bateria San Ramon.

Then, in Phase 2, the process separators / slug catcher receives the raw gas in order to separate gas and condensates, measure them and deliver both commingled to the Pemex plant named ECO San Ramon.
The flare, vent and blowdown system ensure the safe and reliable collection and disposal of the fluids relieved from the plant during upset scenarios, start up, maintenance and depressurization operations. The Unit is composed by:

- One sonic flare, designed to ensure smokeless flame under the most severe scenario (hot blow down of unit 200);
- One flare KO drum, designed to separate the liquid droplets above 600 microns from the gas, before it is relieved to the flare, with the capacity to hold the maximum amount of liquid, which can be relieved during an emergency;
- 2x100% flare KO drum pumps, designed to empty the drum in approximately two hours during phase 1.

The flare network system is designed with an unpocketed , sloped header draining to the KO drum.
The fuel gas is used to purge the main header, vent and blowdown system and to feed the flare pilot. The fuel gas is supplied by unit fuel gas: the main source of fuel gas comes from downstream of separation and upstream of measurement system. The fuel gas skid allows to reduce gas pressure, to remove any possible condensate from the fuel gas, to heat and condition the gas to reach the required values and to distribute the fuel gas liquid-free mixture to the various users at constant pressure (3 barg).

Another use of the fuel gas is to feed the main power generation unit, composed by two generators, designed for stand alone mode operation, with gas internal combustion engine.
Besides main power generation unit, the plant foresees an emergency generation unit, designed to provide power to selected critical users in case of a major malfunction of the main power generators or ESD (emergency shutdown). It also provides power to selected users on initial start up (black start), when fuel gas and other ancillary systems are not yet in operation.
The instrument and utility air is provided by unit “compressor air”, by means of three 50% air compressors. The compressors are controlled by an on-skid PLC based control system. Limited unit alarms and status inputs interface via hardwired connections to the PCS (process control system) for display on the HMI (human machine interface).
Project strategy aimed to optimize as much as possible the schedule, maximizing parallel execution of design, procurement and prefabrication, in Italy and Mexico, taking advantage of the support of the local content, for a time frame of 12 months from KOM (May 2018) to plant handover (May 2019).
All project execution phases have been carefully planned to minimize the risks. In particular, the logistic strategy has been set out through site surveys and feasibility studies to find the most suitable mean of transportation for each item, from ground to air freight, including the rental of a dedicated air charter (Antonov) for the shipment of the critical items.

“The project strategy optimized the schedule by maximizing parallel execution of design, procurement and prefabrication, in Italy and Mexico, taking advantage of the support of the local content, for a time frame of 12 months from KOM (May 2018) to plant handover (May 2019)

The construction involved 270,000 man-hours in four months – from January 2019 to May 2019, date of plant handover to client- for the installation of 137 tons of steel structures, 3720 dia inch of piping , 30,000 m of electrical and instrumentation cables, 1170 manual and automated valves, reaching the successful goal of zero LTI (Lost Time Injury).
Notwithstanding the difficulties of a harsh environment and the frequent hinders of the local communities, this performance was made possible by the flexible organization of DG IMPIANTI, which allowed the maximum integration with the stakeholders (client, local suppliers and subcontractors, communities) and the fast decision making process which enabled to carry out timely the most suitable solution.

Phase 2 Project Detail

The main objective (just concluded in March 2022) of the ORF transition from Phase 1 to Phase 2 is to convert the ORF plant as follows:

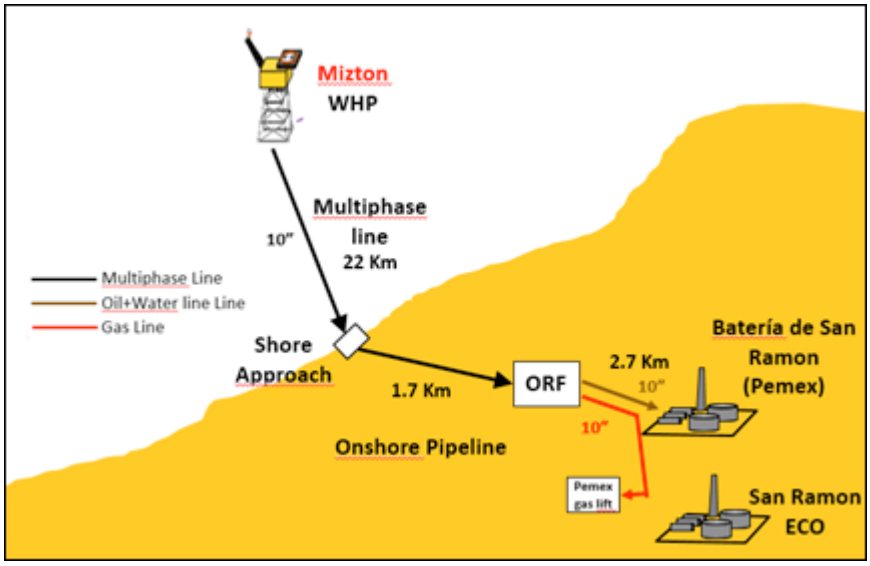

Figure 1 - Phase 1 - Early production

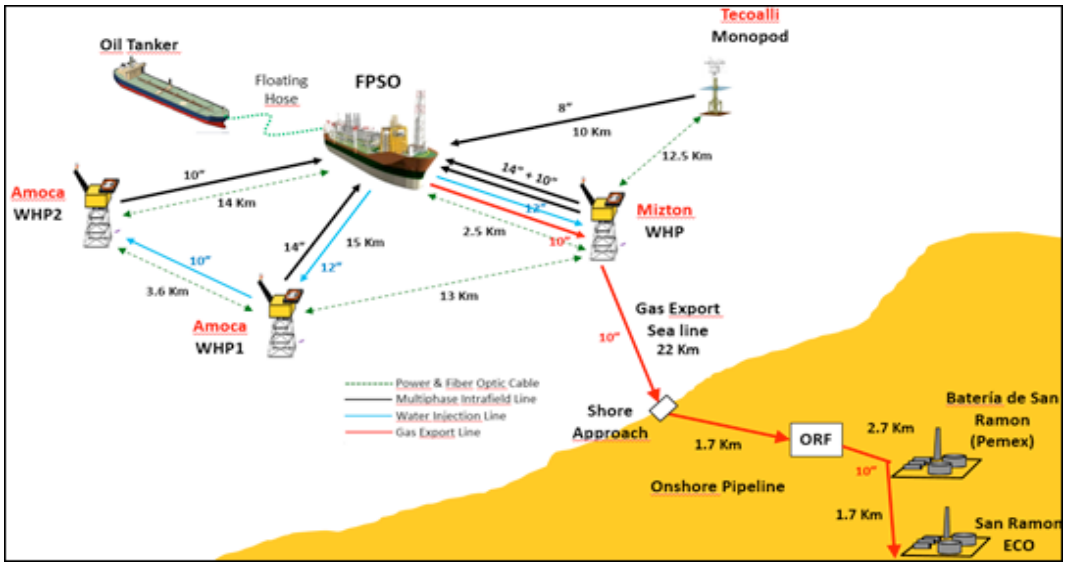

Figure 2 - Full field production Phase 2 (post FPSO installation)

- **Phase 1:** Phase 1: Mizton is a Well Head Platform, exporting multhipase product by means of a 10" subsea line to ORF as shown below (**figure. 1**)

- **Phase 2:** Mizton is a Well Head Platform, exporting multiphase product by means of 2x10"/14" subsea lines to the FPSO and exporting Gas to ORF with the same subsea line previous used for multiphase product (see **figure 2**).

The integration activities for the transition from Phase 1 to Phase 2 have been divided in work packages (WP) as below:

- WP2: Facilities upgrade before subsea cables installation;
- WP3: Integrated pre-check prior to FPSO arrival;
- WP4: Integrated commissioning.

All preparation activities that will not impact the platform production (spool fabrication, hydrotest, NDT, etc.) will be carried out before the FPSO arrival, meanwhile all the installation/conversion activities will be performed during a planned shutdown once the FPSO hookup activities will be completed

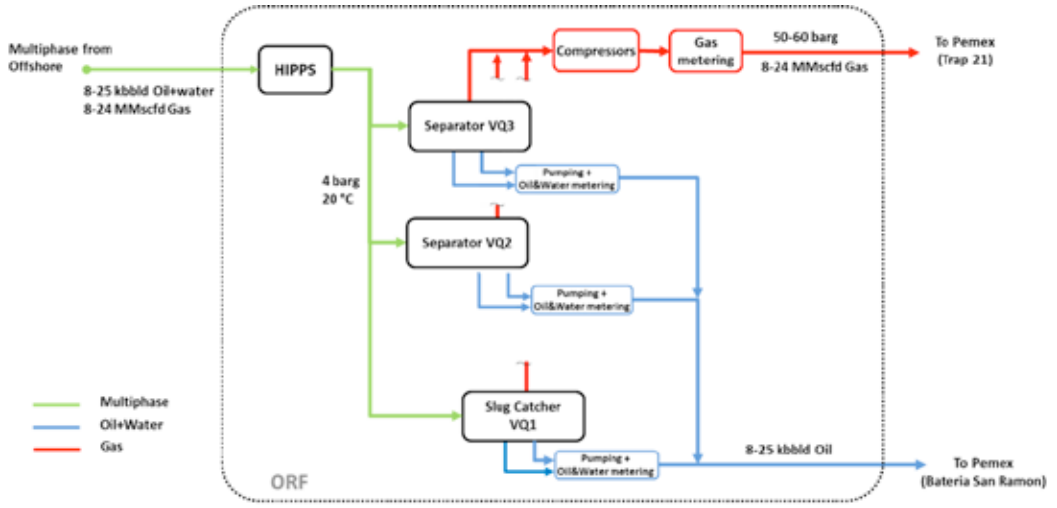

Figure 3 - ORF configuration for early production Phase 1

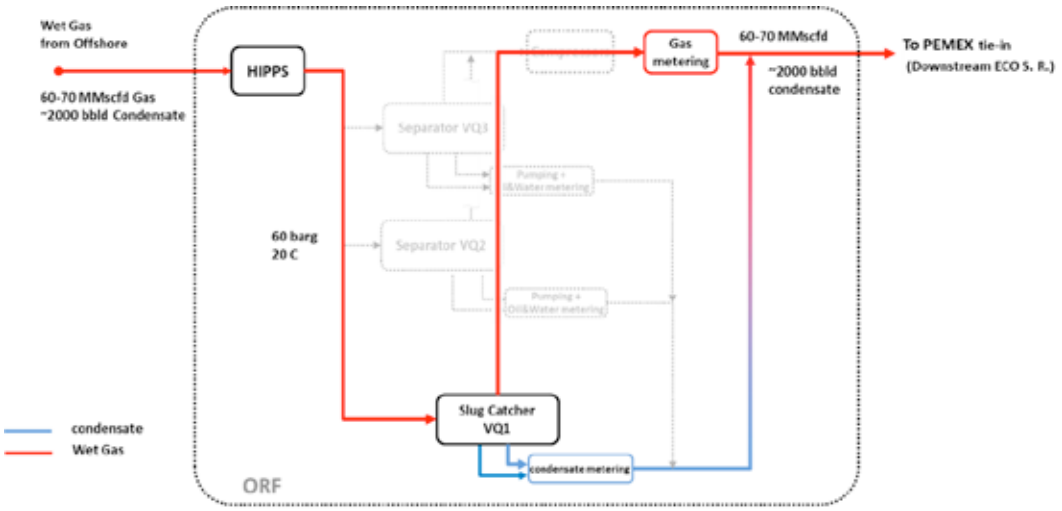

Figure 4 - ORF configuration for full field production Phase 2 (post FPSO installation)

ORF is actually configured in early production asset (phase 1), the multiphase product is sent to the ORF by a multiphase sea line. After the FPSO arrival and during the integrated commission activities it has been considered to convert in final asset the ORF receiving system (phase 2) as below:

- Phase 1: ORF is a multiphase receiving facilities, working with 3 separators in parallel at ~4 barg, measuring all streams, compressing gas up to 50-60 barg and finally exporting the 2 streams (see **Fig. 3**);
- Phase 2: ORF is gas + condensate receiving facility, working at ~60 barg with a single separator/slug catcher (VQ001), measuring gas and condensate streams and finally export them jointly in a single wet gas pipeline (see **Fig. 4**).

The work phases have been planned and scheduled in such a way as not to compromise mainly the health of the workers, the surrounding environment and compliance with execution times. The anti-Covid procedures prepared by DG IMPIANTI for all site personnel, have meant that the execution of the activities took place in total safety. A massive commitment of resources dedicated to this issue has made it possible to carry out the activities without infections.

In order to optimize the shutdown activities and avoid any delay for the start-up, the WP2 activities will be performed:

1. Multidisciplinary Site survey;
2. Material verification for company provided items;
3. Material preparation/storage for shutdown activities;
4. Piping and support metrology and pre-fabrication;
5. New cable routing (cable tray and cable pulling);
6. Scaffolding area identification and erection.

Before the preparation activities for the “shutdown” of the plant, the following activities were coordinated:

- Prefabrication of new pipes, supports, laying of cable trays;
- Mobilization of housing for the “camp”;
- Mounting of scaffolding, “Pigging” and sealine depressurization;
- Shutdown activities, field assembly of pipes / equipment, alignment of the instrumentation

towards the “loop ceck” control room;
- Post-shutdown activities, (scaffolding removal, cleaning, start-up assistance, camp demobilization).

The management of the DG IMPIANTI has demonstrated their commitment towards quality to all parties and personnel involved in the contract/project through development, approval and communication of the Project Quality Plan/Program, Quality Policy, Quality Objectives, Quality Key Performance Indicators and Quality Manual.
Management has also committed to ensuring that sufficient resources are made available for project quality management system.
The HSE plan main objectives can be described as per below:
- Ensure the safety and health of personnel involved in all activities;
- Protect assets and equipment to ensure the economic viability of each project;
- Maintain the natural environment at work sites;
- Ensure all activities comply to approve legislation and meeting Company’s HSE requirements;
- Provide guidelines to help Project Manager, Project Management Team (PMT) staff and Line;

- Supervisors in managing Safety and Health at work place.

We plan and act for the future.

Pino Gozzo

Pino Gozzo, engineering manager of DG IMPIANTI INDUSTRIALI S.P.A. has a broad deep experience in the Oil&Gas and energy sector, built in 30 years of activity and having held a variety of positions in various engineering companies. The skills acquired in the Syracusan petrochemical sector have contributed to professional training for shipyards in Mexico, Congo, India, Kuwait, Romania onshore and offshore. The planning of turnarounds within the refineries and the construction of new plants / platforms (EPC) complete his curriculum vitae. In particular, he is the Company reference point for problem solving.

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The role of the small-to-medium enterprise in the path towards the Energy Transition

The challenge of the energy transition is not an adherence to an environmental slogan, but represents a key element in the ability to understand the present, in order to build a solid future

Fabio Nardone, Business Development Manager
Fores Engineering s.r.l.

This is the principle guiding the path undertaken by Fores Engineering Srl, a subsidiary of Rosetti Marino Group, since 2017, when it began to design and industrialize solutions for the circular economy, through a development model that embraces environmental, ethic and social aspects, without prejudice to the economic sustainability of its business model.

The company, that this year celebrates 30 years of operations, has delivered in 40 different countries over 3,000 integrated solutions consisting of Analyzer Systems, Gas Measurement and Treatment, Fire & Gas safety systems and integrated Automation and Telecommunication systems, in a complex market with high quality and safety standards.

These skills in the engineering and delivery of advanced multidisciplinary solutions, even in harsh environments (Offshore, Desert, Arctic), characterize Fores as one of the trustable market leader for customized integrated solutions with high reliability and safety, and represent a strong reference also for the Energy Transition challenges, where industrial systems need to operate with high level of availability in harmony with the territory and strict environmental requirements.

In this context, for example, μsLNG solution has been designed to produce liquid biomethane as sustainable fuel, originated from the biogas generated by anaerobic digestion (agricultural / livestock waste, Organic Fraction Municipal Solid Waste) properly concentrated and refined through a specific technological process (Upgrading).

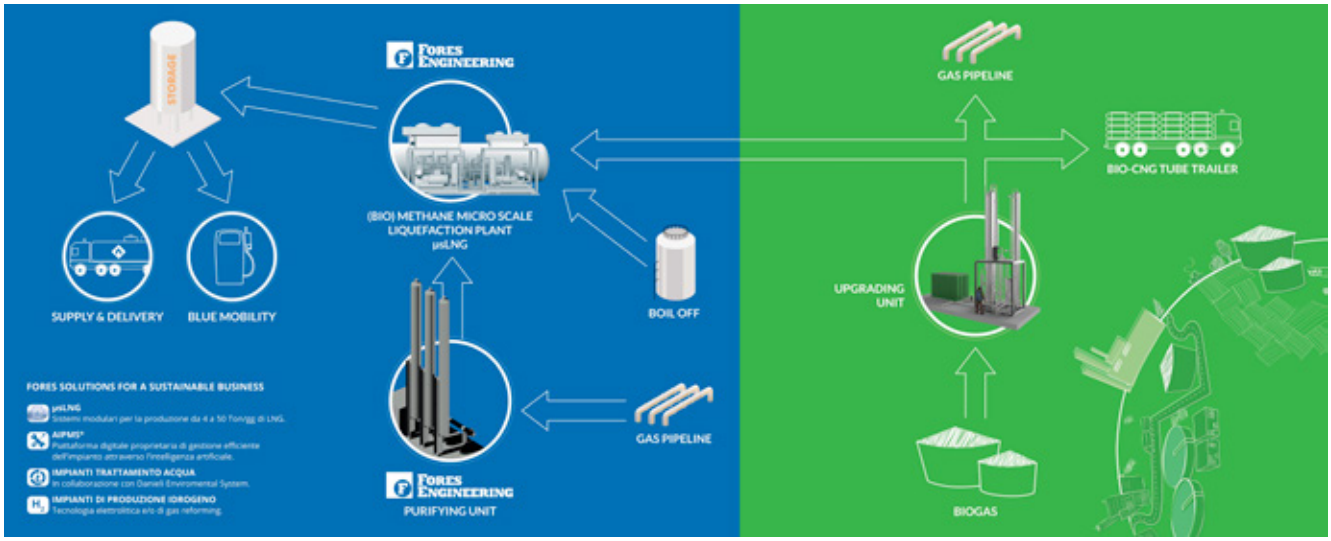
The μsLNG system has been designed to

applications in various plants in Italy and operates by means of a hot potassium carbonate water solution that traps the CO_2 present in the biogas and generates a high purity stream of biomethane (expected to be 99.9%) and consequently a high purity stream of the separated carbon dioxide (CO_2) extracted during the regeneration phase of the hot carbonate solution in the process.
This CO_2 can be further recovered or stored to reduce the "carbon footprint" in the environment while the biomethane generated can be liquefied through the μsLNG system of Fores Engineering and dispatched through fuel stations, in favour of a decarbonised mobility (Heavy Duty, railway, naval), with a minimum impact on existing infrastructures and strong compliance with available mature technology (gas engines).

"In an era in which the need for a more sustainable and conscious development model has begun decisively, the methane in its compressed (CNG) or liquid (LNG) forms, by synthetic or bio-origination, plays a leading role in the transition process

guarantee a wide operational flexibility (turndown up to 50%) with low management costs, and effective interoperability with any Upgrading process (e.g. membranes, PSA, chemical washing, etc ..), while achieving the highest operational synergies in combination with a specific solution patented by Green Methane (GM), an enterprise controlled by Rosetti Marino Spa.
GM upgrading process has consolidated

Within the Rosetti Marino group there are several innovative themes developed in cooperation either with the industrial world, or with start-ups and universities; in this context, the role historically played by Fores Engineering in the construction of pilot plants offers great added value. During its 30 years of operation, Fores has built and commissioned several innovative plants for ENI Spa, such as a "bio-oil" production system (2003) derived from a



fermented microalgae biomass, having a strong capacity to absorb CO_2 from the environment during its lifetime, and hydrogen production plants generated from fossil methane.

Natural gas, alternative to water, is another abundant source to generate hydrogen by means of specific processes: the “Short Contact Time - Catalytic Partial Oxidation” (SCT-CPO), patented by ENI, is a very effective technology to generate highly pure streams of Hydrogen and CO_2, whose complete capture and sequestration generates the so called “blue hydrogen”. The first pilot plant executed by Fores is dated 2007 (ENI Zero Regio fuelling station) with a production of 50Nm3/h, while the latest plant, currently in erection phase in ENI Taranto, could produce over 6’000 Nm3/h of “blue hydrogen” useful for the decarbonisation of “hard to abate” sectors, such as steel industries, whose highly energy-intensive production processes are a source of significant greenhouse gas emissions.

“Fores innovation through strategic cooperation”

Fores has signed a framework agreement with the University of Bologna (UniBo) for various initiatives, such as the system for the abatement

of flare gas discharged into the atmosphere (Zero routine Flaring) and a Power to Gas project for the transformation of electrical energy into chemical energy (hydrogen and synthetic methane).

"Fores is building a real technology development laboratory (2H2FORLAB) in the Fores Engineering industrial district in Forlì, Italy

These projects are shaped into what has been conceived to be a technological laboratory ("2H2FORLAB") under construction in the Fores Engineering industrial district in Forlì, where a group of Fores experts and researchers from UniBo Industrial Engineering Department will first develop green hydrogen integrated systems (PEM and/or Alkaline electrolysis) fed by photovoltaic energy, and consequently produce synthetic green methane through a dedicated methanation process by recovering the carbon dioxide sequestered from biogenic processes, such as Upgrading.

Fores Lab will also involve several industrial partners in a wide testing and possible redesign for components extensively used in the Energy industry (compressors, valves, metering, instruments), whose application will have to be suitable with hydromethane mixtures (increasingly concentrated in hydrogen), as viable energy carriers for a larger and distributed decarbonization.

"A clear example is the proprietary digital platform called Asset Integrity Performance Management System (AIPMS®), able to analyse and process the data available in the plant using artificial intelligence with predefined algorithms and tools

Leveraging on its proven references of multidisciplinary modular and compact

solutions integrated with state-of-art automation and control systems, Fores is the reliable partner also for the lifecycle operations of the plant with a specific value proposition by means of dedicated digitalised platform.
AIPMS® is an innovative platform that processes and analyses the data available in the plant using artificial intelligence, and provides a "digital twin" of the plant process suitable to simulate possible operating scenarios and maximize several operational goals in terms of a) production efficiency, b) energy consumption, c) plant availability, d) maintenance and logistics (through predictive logics).
Naturally integrated with Cyber Security features, AIPMS® is a key element to safeguard the sustainability of the plant operations along the entire lifecycle, matching economic and environmental targets.

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.

Silence is gold

How to design silent air coolers to fight noise pollution

Marco Soffiato, Sales Engineer, Air Cooled Heat Exchangers
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Noise Control Requirements are becoming increasingly stringent to preserve human wellness and health. This is particularly true in Europe where the lack of space in crowded areas, and the resulting proximity of industrial plants to sensitive receptors (e.g. residential areas, hospitals, etc.) has pushed governments and municipalities to take action. Hence, limitations have been enforced by Law for both the exposure of workers to noise and to the emission at the surrounding areas, with the effect that not all standard-noise equipment (i.e., equipment whose noise level is 85 dBA @ 1 m) suits the actual needs, even when external noise control measures are applied. Vertical barriers or enclosures, and other means aimed to limit noise propagation can surely be helpful, but related effectiveness should be evaluated case by case, by considering any possible issues related to aesthetic acceptability, as well.

While the industry is rising to the challenge, by developing new products specifically designed for low noise applications, the ability to optimise noise-restricted projects by selecting the proper equipment and applying for the most convenient control measures is not widely employed in engineering field and practice. The result is that the solutions applied to projects may not always be the most cost effective solutions.

What is to be done when noise becomes a challenge?

One of the dilemmas faced by Engineering and Procurement Contractors (EPCs) while approaching new projects is whether to select Intrinsically Silent equipment or standard equipment compensated by additional means of protection. In any case, a comprehensive approach that takes into consideration all the possible technical solutions and involves a joint cooperation with the Equipment Manufacturer should be preferred, especially when the requirements are challenging. Only the synthesis of experience and knowledge of both parties allow for the identification of the most suitable and cost effective solution.

Air cooled heat exchangers as one of the major contributor to noise emission of industrial plants

Air cooled heat exchangers are a type of process equipment used to cool down vapour or liquid flows by transferring the associated heat to the ambient air. They are composed of heat exchange sections where the process fluid passes through finned tubes, and fan units used to push the ambient air for cooling.

Due to the intrinsic characteristics of this equipment, they are often one of the major contributors to noise emission of industrial plants. Unlike other plant's equipment like pumps or machineries, air coolers are installed outdoor in the open field, as they need to operate with large masses of ambient air. This makes it almost impossible to completely shield and contain related noise emitting parts like fans or transmissions. In addition to this, air coolers are usually large pieces of

General view of air coolers installation – Denmark (Renco s.p.a.)

equipment so that any external means aimed at limiting noise propagation, such barriers or other obstacles, may be quite expensive.

The growing attention paid by the market to noise emission of air coolers is highlighted by **Fig. 1,** where the use of low noise fans and standard noise fans has been reported. As shown, the trend of the last three years is to go for low noise equipment.

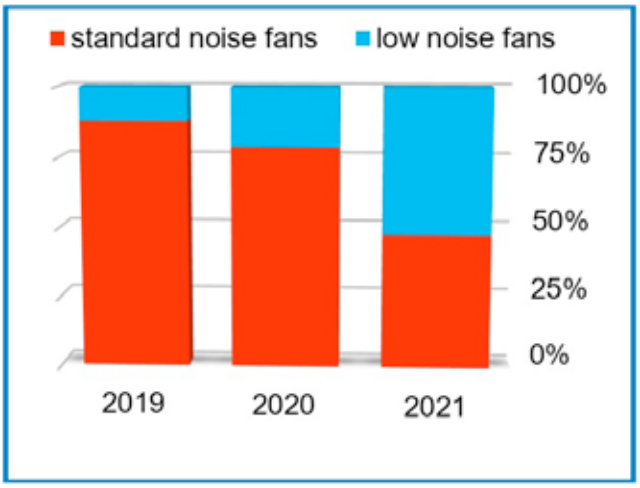

Figure 1: Type of fans on executive Projects in the latest three years (Boldrocchi database).

What are the major sources of noise in an Air Cooled Heat Exchangers?

An ACHE has several noise sources that can be easily ranked as below:

- axial fans;
- belt transmissions;
- electric motors;
- turbulence created by obstacles located upstream and downstream the fans;
- other vibrating parts (e.g., structural parts).

Among these sources, very often the major contribution comes from the axial fans, whose noise can be significantly higher than the aggregate noise from other sources.

Noise generated by fans depends heavily on their operating point, defined by the air flow rate, the static pressure and the rotational speed. In addition to this, different blades profiles and sizes allow for different noise results to occur.

The way the various operating parameters affect noise emission of fans can be evaluated by means of formulae, like the one that follows, referred to a low noise fan:

$$L_w = K + 30 \bullet \log_{10}(v_{tip}) + 10 \bullet \log_{10}(Q \bullet H / 1000)$$

where:

- L_w [dB(A)] is the sound power level;
- K is a constant depending on the fan geometry;
- v_{tip} [m/s] is the peripheral speed;
- Q [m^3/s] and H [Pa] are the volumetric flow rate and the static pressure, respectively.

The application of this equation to practical cases indicates that noise generation is usually much more affected (up to 5 times) by the peripheral speed rather than by the volumetric flow rate or the static pressure. This explains why low noise air coolers are usually equipped with slow rotating fans. The concept is indeed well taken into account while developing the thermodynamic and mechanical design of air coolers, together with all other technical constraints that affect feasibility and costs. For instance, despite the formula above suggests that fans working at very low rotational speed should be very silent, it does not consider the risk of resonance with the structure and related impact on noise, nor the impact on the mechanical efficiency of the fan.

Another source of noise of air coolers is represented by belts transmissions, which are wrapped around the drive pulleys and used to couple the electric motors to the fans. Related noise is affected by the rotational speed of the belts so that fast rotating belts are more noising than slow rotating belts.

Figure 2: Ongoing assembly of the air coolers at site (Renco S.p.a.)

Noise can then vary according to the type of belts: synchronous belts (i.e. toothed belts) are less silent than V-type belts because of the continuous impacts of the belts teeth to the pulleys teeth, and because of the very fast evacuation of air, which occur continuously during operation, when the belts teeth match the pulleys teeth.
Noise emitted by electric motors is due to different components/mechanisms like mechanical noise related to bearings, electromagnetic noise, and noise due to the cooling fans. In case of ultra low noise applications, electric motors noise can be of the same magnitude of that of the fans, requiring particular attention to their selection. A further aspect taken into account when designing air coolers is that motors driven by variable frequency drives (i.e., inverters) emit more noise than motors directly connected on-line. This is due to the harmonics resulting from the variable frequency drives.

While designing air coolers, consideration is given to the presence of any obstacles upstream and downstream from the fans like the safety nets aimed at maintenance personnel avoiding getting into contact with the rotating parts. Provisions like these affect the noise performance of air coolers because of both the additional static pressure required by the fans, and because of the turbulence therein generated.

Finally, any excess of vibration of the structural parts should be avoided by designing the equipment correctly and selecting fans suitable for the application.

How to limit noise emission of Air Cooled Heat Exchangers

Many factors can be applied to design low noise air coolers. Some of them affect the capability of the equipment to transfer heat to the ambient air (e.g., reduced ambient air flow through the heat exchanger) and shall therefore be balanced by oversizing the heat exchange surface, with impact on CAPEX. Other expediencies are instead related to detailed design and applied based upon experience or specific calculations, when convenient. Some examples are the attention to the correct positioning of the safety nets, the use of vibration isolators, and the adoption of bell-shaped fans rings.
Not only that, the collaboration between the manufacturer and the EPC / plant operator may allow creative solutions to be identified and implemented, not strictly related to the design of the equipment but to the way it is used and controlled by the plant control system as well. For instance, a possibility could be to design the air cooler for fulfilling the noise requirements set for daytime, and to turn off some fans during nighttime, when the noise limitations are usually more stringent. Depending on the application, this might be convenient as the capability of air coolers to dissipate heat increases, the lower the ambient temperature.

Table 1 lists some of the main strategies usually applied to reducing air coolers noise. Further comments and notes are reported in the history case that follows, for which a detailed analysis has been conducted to identify and rank the noise control measures to be

	STRATEGY	PROS	CONS
1	**Use of Low noise type fans vs. standard fans**	Straight noise reduction	Increased loads on steel structures, Higher electrical consumption, Higher cost
2	**Increase of heat exchange surface**	Decrease of fan static pressure and electric power absorption	Increase of footprint and piping length, Increased weight of equipment
3	**Use of V-belt type transmissions**	Slight noise reduction	-
4	**Turn-off some fans during nighttime**	Relevant reduction in case of very low ambient temperatures	Increased complexity of the control system
5	**Add Inverters for motors**	Possibility of reducing fans speed during night time	Impact on CAPEX
6	**Add precautions on structural components**	Reduced noise, by avoiding excess of vibration and air turbulence	Increase of steel structures weight and complexity

Table 1: Main strategies for reducing air coolers noise.

applied to a specific project. What is important to note is that the various expediencies are not always independent of each other, and related effectiveness can increase significantly in case of joint application with other expediencies. For instance, the use of low noise fans is more effective at reduced air flow rates, which must be compensated by an increased heat exchange surface.

Case study: Gas compression station

in 2019, we started the discussions over the Preliminary Specifications for the three Air Cooled Heat Exchangers destined for a gas compression station in Denmark. At that time, Renco was preparing their Bid to win the Project and asked Boldrocchi to co-operate and support in order to develop a solution suitable for the specific needs.

Figure 3: Aerial view of the Gas Compressor station during assembly at site. The air coolers are shown in the right side of the figure whereas the left side shows the compressors buildings. (Renco S.p.a.)

"Our Companies started the discussions over the Preliminary Specifications for the three Air Cooled Heat Exchangers destined for a gas compression station in Denmark in 2019

Although the operating pressure of the process fluid (i.e., natural gas) was relatively high, namely 113 bar-g at 92°C, the main concerns were related to the maximum allowable noise level only, which was tremendously low. The plant was planned to be located in a rural area, at a distance of about 500 m from some residential buildings and, according to the EIA permit, the maximum noise emission at these critical points should have been limited to 35dB(A). Based on preliminary estimations, the Air Cooled Heat Exchangers had been identified as the major noise sources of the Plant, whereas the other machinery were not critical, as they were considered to be installed inside insulated buildings.

The maximum allowable Noise Power Level of each air cooler running at full load was limited to 87 dB(A), based on the noise spreading simulations and the resulting expected noise level at the residential buildings.
The cooperation between Renco and Boldrocchi allowed the starting of the design process without considering any footprint constraints, nor requirements related to the type of fans, motors, and other noise affecting parts. This degree of freedom allowed for the identification of the optimal technical and cost-effective solution. Then, some adjustments have been applied to the proposed design, to better integrate the air coolers within the overall plant.

Noise driven design of Air Cooled Heat Exchangers

Coming back to the origins, the noise-driven design started from the identification of a base solution, compliant with the process needs (i.e., cooling of the given natural gas stream), but exceeding the noise requirement. The first two adjustments applied to the design have been the adoption of bell-shaped fan rings and the reduction of the fans rotational speed, as shown in the left side of Figure 4. However, this allowed only for a slight reduction of noise to be obtained, which was furtherly improved when low noise type fans were considered in place of regular fans. The specific characteristics of the selected low noise fans allowed further reduction of the rotational speed, to a level that was not possible

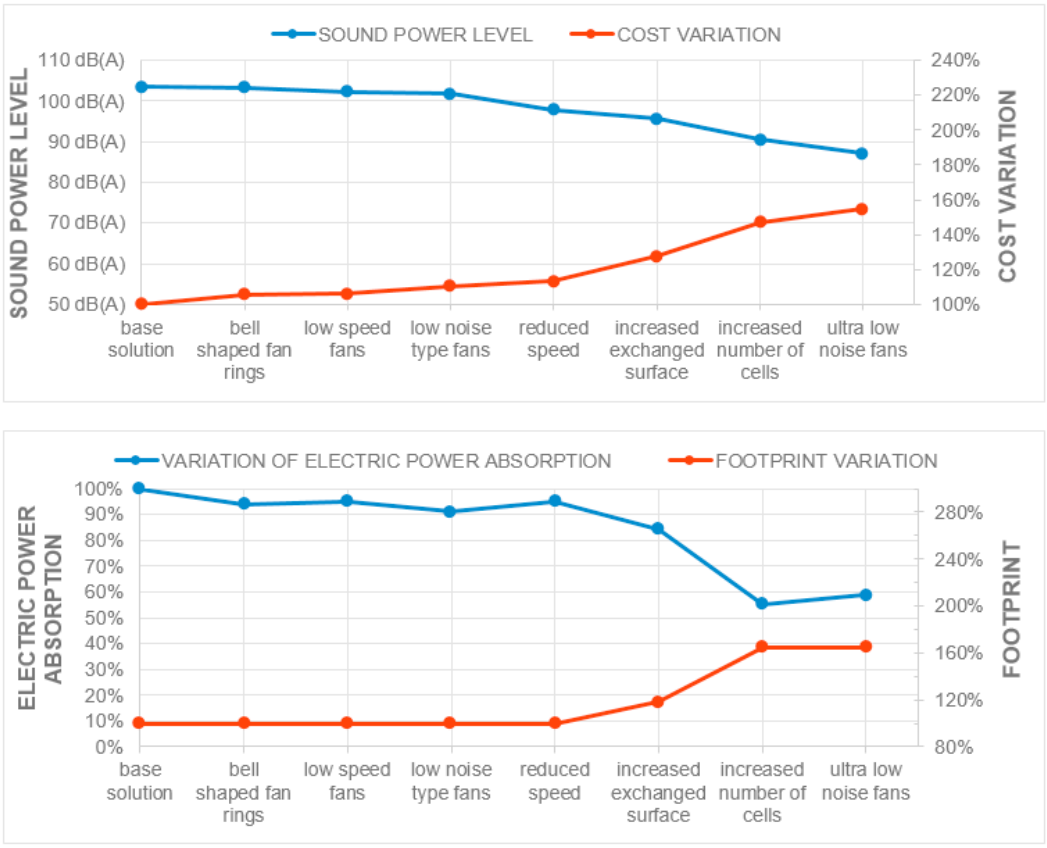

Figure 4: Steps of optimization of the air coolers for the gas compressor station (Boldrocchi S.r.l.).

to reach with regular fans. Again, this allowed the reduction of noise emission.

All these expediencies did not result in any modifications to the footprint and sizes of the equipment but increased the cost of the project of about 15%, as shown by the figure.

The further significant contribution to noise reduction came from the increase of the exchange surface of the air coolers, which had been compensated by the reduction of the fans air flow rate and pressure. The equipment, initially composed of two cells equipped with three fans each, were enlarged up to the

maximum practical and feasible size. Then, a further expansion was obtained by adding a third cell equipped with three fans. Finally, the use of ultra low noise fans (swirled blades fans) in place of low noise fans (straight blades fans) allowed the meeting of the projects needs in terms of noise.

It is interesting to note how the reduction of noise emission was obtained together with the reduction of the electric power consumption. This was basically due to the reduction of ambient air flow needed for cooling, hence the reduction of fans load, and not because of the different efficiency levels of fans. Low noise fans are indeed usually less efficient than regular fans.

Other expediencies have been applied and taken into account to reduce noise but are not reported here as related contribution to noise reduction is limited.

Conclusions

A strict co-operation was established between Boldrocchi and Renco to optimize the design of the air cooled heat exchangers for a gas compressor station in Denmark.

"Renco was awarded the contract in May 2020 and Boldrocchi fully delivered the equipment in May 2021

The possibility of discussing the project since the very beginning allowed the needed degree of freedom for finding the right compromise between performance and cost, and allowed to win the Project. Renco was awarded in May 2020 and Boldrocchi fully delivered the equipment in may 2021. The project has been challenging for all people involved but has brought great satisfaction.

Marco Soffiato

Passionate about noise, energy, and techno-economic optimizations. He holds a master degree in energy engineering and have worked in the power generation sector for 8 years. Sales Engineer at Boldrocchi's for the Air Cooled Heat Exchangers.

Nicola Mauri

Sales Manager at Boldrocchi's for the Air Cooled Heat exchangers. He joined the Company in 2006 and worked on several projects for the Oil&Gas, industrial and power generation applications, developing solutions for non-standard applications.

Stefano Vaccarini

Machinery & Package Engineer in the Industrial Plants Division of Renco S.p.A. since 2016. Followed the supplies of machineries, packages and static equipment for several compression stations. Currently Project Specialist Leader for mechanical discipline, including noise performance management for equipment and the entire Plants.

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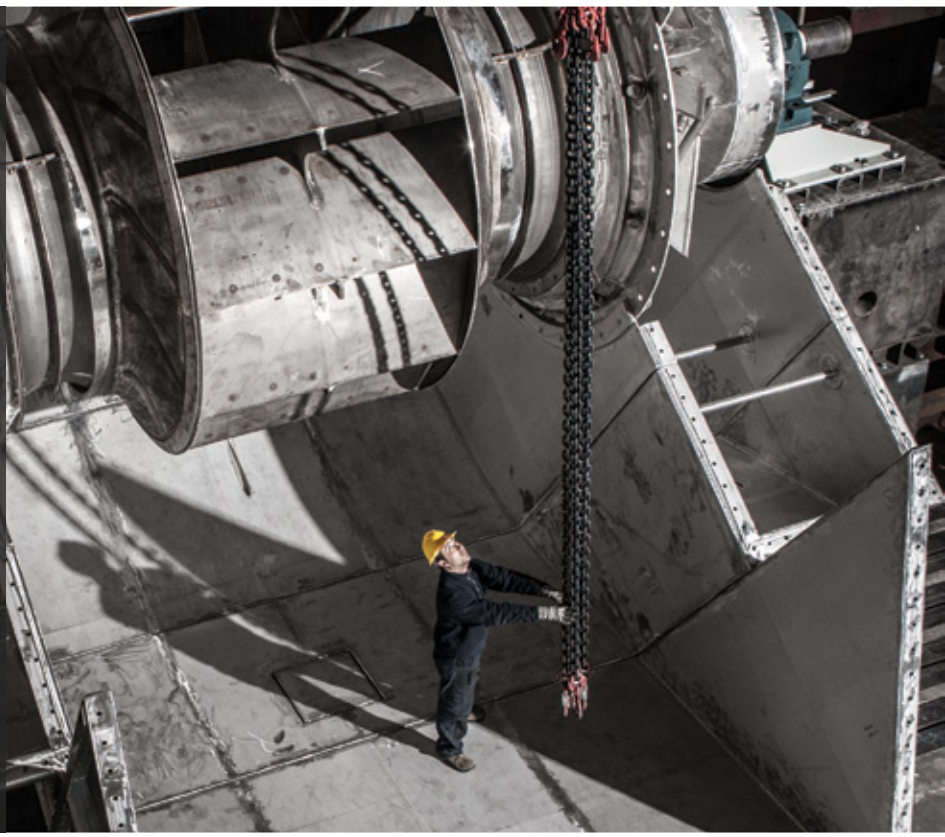

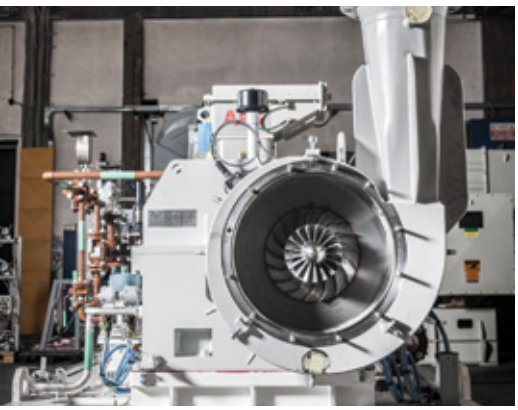

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Alberto Zecchin, Process Coordinator Reverse Osmosis Projects
Fisia Italimpianti S.p.A.

RO Building SHUAIBAH 3 EXPANSION II (Fisia Italimpianti & Abengoa)

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In particular for the Desalination business area 4,400,000 m^3/day (1,000 MIGD) is the total desalination production capacity of plants built to date, mostly in the Middle East with 20,000,000 people served by our desalination plants.

Headquartered in Genoa, Fisia Italimpianti has operations and projects spanning across the Middle East, Europe, Africa and the Americas.

The table reports the Fisia Italimpianti acquisitions in desalination fields over the last seven years:

Plant name	Location	Field	Capacity	Developer / Owner	Commercial Ops Start date
DAKHLA	MOROCCO	Desalination RO	89.101/111.376 m^3/d	Engie/Nareva	AWARDED IN 2021
GHUBRAH 3 IWP	OMAN	Desalination RO	300.000 m^3/d	Oman Power & Water Procurement (OPWP)	ONGOING
SALALAH	OMAN	Desalination RO	113.500 m^3/d	Dhofar Desalination Company SAOC	2021
SHUAIBAH 3 EXPANSION II	KSA	Desalination RO	250.000 m^3/d	Shuaibah Two Water Development Project Company	2019
MIRFA	UAE	Remineralization Plant	235.000 m^3/d	MIPCO	2017
TAKREER	UAE	Desalination MSF	16.800 m^3/d	SAMSUNG	2015

We give a brief description and report the main technical details about two recent plants now in operation, after having terminated the commissioning and the warranty period: Shuaibah 3 Expansion II, and Salalah projects.

Shuaibah Expansion II Project

Seawater reverse osmosis desalination plant with a capacity of 250,000 m3/d of potable water output, designed by the consortium between Abeima & Fisia for Shuaibah 2 Water Development Project Co. (STPC), located and constructed in Shuaibah, 120 Km to the South of Jeddah, inside existing SWCC premises.

The Seawater Reverse Osmosis plant includes the following main process facilities:

- Seawater intake;
- Effluent outfall;
- Pre-Treatment system;
- SWRO system;
- Post treatment system;
- Product water pumping station
- Waste water treatment system;
- Instrument and service air system;
- Fire protection and detection system;
- Ventilation and air conditioning;
- General buildings;
- Emergency Diesel Generator;
- Control system through plant DCS (Distributed Control System)

The desalination plant built by Abeima and Fisia has been designed in order to comply with the water output requirements and to ensure the required availability of potable water. The design of the plant and the related buildings have been developed focusing on the combination of operational suitability & plant availability, optimization of power consumption and energy efficiency in order to minimize the cost per cubic meter of desalted water, minimization of the environmental and visual impact, ensuring the maximum flexibility in operation by implementing optimal automation processes.

As brief summary of the processes and equipment included within the scope is listed hereinafter:

- Intake system, comprising the Intake Basin along with the screening channels and the seawater feed pumps, the raw water intake pipeline, the Intake risers (towers) and the chlorination injection system for treating the raw water at the intake risers.
- Pre-treatment system, comprising the multimedia gravity filters and the required coagulant dosing system.
- Intermediate system, comprising the filtered water tank, the intermediate pump station and the centralized chemical storage area for all chemicals used.
- SWRO system, comprising the cartridge filters, the RO membrane trains, the High-Pressure pumps, the Energy Recovery devices, along with the ERD Booster pumps and Sodium Hydroxide,

North West side panorama of Desalination plant in Shuaibah, Saudi Arabia (Fisia Italimpianti & Abengoa)

Sodium metabisulphite, Anti-scalant (1st pass) and Anti-scalant (2nd pass) dosing systems.

- RO CIP and CIP neutralization system, comprising the CIP/Neutralization tanks, the Flushing tank, the CIP/flushing pumps, the Cartridge filters, the Chemical preparation tank & loading pumps, the Sodium hydroxide and the Sulfuric acid dosing systems.
- Post treatment system, comprising the CO_2 generation system, the Lime preparation and dosing system for re-mineralization, and the NaOH dosing system, for pH final adjustment.
- Product water pumping Facilities comprising the Remineralized water tanks, the product water pumps, the potable water connection pipeline and the disinfection dosing system.
- Waste water treatment systems, comprising the backwash waste water basin, the clarifier feed pumps, the coagulation/flocculation chambers along with the required mixing devices, the lamellar settling decanter, the sludge homogenization tank, the dewatering centrifuge decanters along with the feed and sludge pumps and chemical stations and the dewatered sludge storage silo.
- Effluent outfall collectors, comprising the outfall chamber and one pipe with diffusers until the off-shore waste discharge point.

Additionally, to the described processes and equipment, the following connections are part of the project scope: Firefighting system, Air conditioning and ventilation system, Ancillary systems.

Salalah Project

With a Guaranteed Contracted Water Capacity (GCWC) of 113,650 m3/d, and Total Contracted Water Capacity (TCWC) of 120,000 m^3/d potable water output, the Salalah IWP project is designed by the consortium between Abeima & Fisia for Dhofar Desalination Company SAOC (DDC), located and constructed in the south of Oman, at the Salalah area, approximately 40 km east from Salalah.

The proposed SWRO plant includes the following main facilities:

- Seawater intake
- Pre-treatment system
- SWRO system
- Post treatment system
- Waste water treatment system
- Effluent outfall
- Instrument and service air system
- Fire protection and detection system
- Ventilation and air conditioning
- Emergency Diesel Generator
- Control system through plant DCS (Distributed Control System)

Salalah desalination plant has been designed to comply with the water output requirements and to ensure the required availability of potable water. The design of the plant and the related buildings have been developed focusing on the combination of operational suitability & plant availability, optimization of power consumption and energy efficiency and minimization of the environmental and visual impact.

Main Electrical room SALALAH IWP (Fisia Italimpianti & Abengoa)

RO rack arrangement SALALAH IWP (Fisia Italimpianti & Abengoa)

The seawater quality and the effluent discharge have been considered in the design and dimensioning of the desalination plant, with the aim of complying with the technical and operational expectations and requirements. In summary, the design criteria aim to achieve the following objectives:

- Ensure the guaranteed water capacity, availability and quality as required, maximizing the availability of the plant and it components.
- Optimize the energy consumption; in order to minimize the cost per cubic meter of desalted water.
- Design the plant in a comprehensive approach which considers the operation and maintenance period and the whole life of the project, minimizing operation and maintenance costs.
- Optimize the quality of the installed equipment with the best and most reliable suppliers and technologies, paying special attention in reducing the noise and vibrations levels.
- Optimize the layout of the plant to ensure a proper accessibility to equipment for a correct operation and maintenance, considering the topographical and geotechnical characteristics of the site and the logical sequence of the treatment
- Ensure the maximum flexibility in operation by implementing optimal automation processes;
- Minimize the environmental and visual impact during plant execution and operation in order to fully integrate them in the site.
- Maximize the safety of the plant operation.

Dissolved Air Flotation system SALALAH IWP (Fisia Italimpianti & Abengoa)

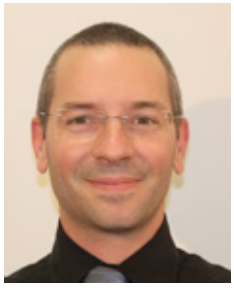
The scope of the Project includes the engineering, procurement, construction and startup of a desalination facilities based on seawater reverse osmosis technology.

As brief summary of the processes and equipment included within the scope is listed hereinafter:

- Intake system, comprising the Intake basin along with the screening channels and the seawater feed pumps, the raw water intake pipeline, the Intake risers (towers) and the disinfection system for at the intake risers and the intake basin.
- Pre-treatment system, comprising the DAF system, the multimedia gravity filters, the multimedia pressurized filters and the required coagulant and flocculant dosing system.

- Intermediate system, comprising the filtered water tank, the intermediate pump station.
- SWRO system, comprising the cartridge filters, the RO membrane trains, the high Pressure pumps, the Energy recovery devices, along with the ERD Booster pumps and sodium metabisulphite and anti-scalant dosing systems.
- RO CIP comprising the CIP tanks, the Flushing tank, the CIP/flushing pumps, the Cartridge filter, the Chemical preparation tank & Transfer pumps.
- Post treatment system, comprising the CO_2 storage and dosing system and the Limestone filters for re-mineralization, and final chemical dosing with caustic soda for pH adjustment, sodium hypochlorite for disinfection and sodium fluoride.
- Waste water treatment systems, the backwash waste water basin, the clarifier feed pumps, the coagulation/flocculation chambers along with the required mixing devices and chemical dosings, the lamellar settling decanter, the sludge thickener, the sludge homogenization tank, the dewatering centrifuge decanters along with the feed pumps and chemical dosing.
- Effluent outfall collectors, the outfall chamber and two pipes with diffusers until the off-shore waste discharge point.

Again, additional facilities included in the project scope are: firefighting system, air conditioning and ventilation system and other ancillary systems.



Alberto Zecchin

Alberto Zecchin has graduated in Chemical Engineering at the University of Padua in 2003. In 2005/2006 he attended the second level international Master course on “Innovative membrane technologies & conventional processes for waste and drinking water treatment” organized by the University of Genoa.
Following an earlier employment in various companies as water and industrial wastewater treatment plant designer and commissioning engineer, he entered Fisia Italimpianti S.p.A. in 200 and he specialized in desalination technologies.
He worked for Saipem between 2012 and 2015 on Oil & Gas Front End Engineering and execution projects on water and wastewater treatment, and in 2016 he supported the Qatari RasGas company (today Qatargas) as an independent technical advisor for the TIPW project.
Since his return in Fisia Italimpianti in 2017 he took part to the design phase of seawater reverse osmosis projects of Shuaibah III Expansion II and Salalah as Deputy Process Manager. He assumed the role of Commissioning advisor for Mirfa revamping project and of Deputy Commissioning manager for Shuaibah III Expansion II. From 2019 he is the Process Manager for the bidding and execution phase of Ghubrah III project. Since 2020 he has taken on the role of Process Coordinator for all the Reverse Osmosis projects in Fisia Italimpianti.

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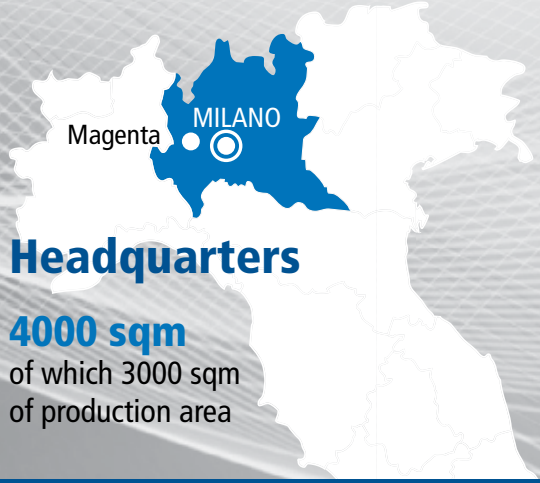

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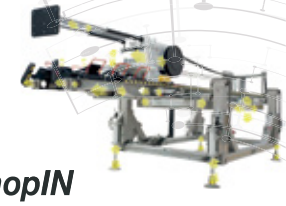

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M.M. s.r.l.

Demand for products made from innovative materials is growing and FRP (or GRP) - more commonly known as fibreglass - is increasingly being identified as an optimal solution and alternative to traditional materials, such as steel (including stainless and galvanised), concrete or wood. For 45 years now, Udine-based company M.M. has proposed gratings and structures in fibreglass; an innovative material that ensures a high technical performance, excellent benefit-cost ratio, greater procurement opportunities and the creation of products that are suitable for various uses in multiple fields of application.

"For 45 years the Udine-based company M.M. has proposed gratings and structures in fibreglass, an innovative material that ensures a high technical performance, excellent benefit-cost ratio, greater procurement opportunities and the creation of new products

What is FRP (or GRP)?

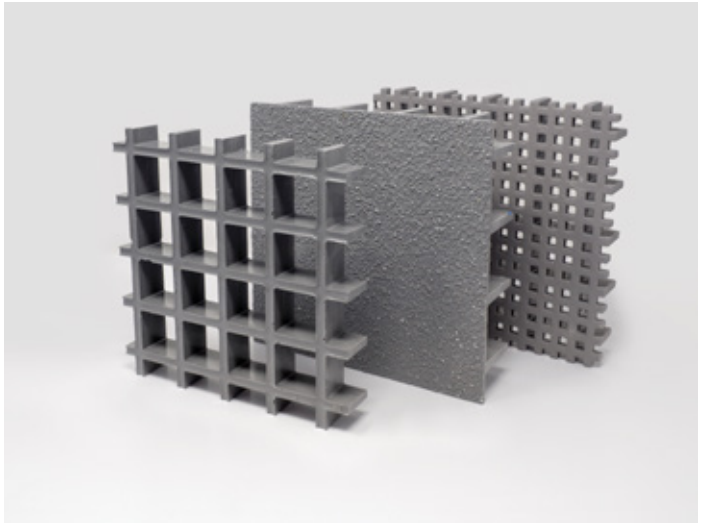
FRP (or GRP) is a composite material comprising a thermosetting polyester resin matrix and a continuous fibreglass reinforcement. The acronym stands for fibreglass-reinforced polymers. In Italy, this material is known as fibreglass, whilst internationally, it is commonly referred to as FRP (Fibre-Reinforced Polymer/Plastic) or GRP (Glass-Reinforced Polymer/Plastic); hereinafter referred to as FRP.

Fibreglass boasts numerous intrinsic properties which allow for high-quality products with a high flexibility of use to be produced.

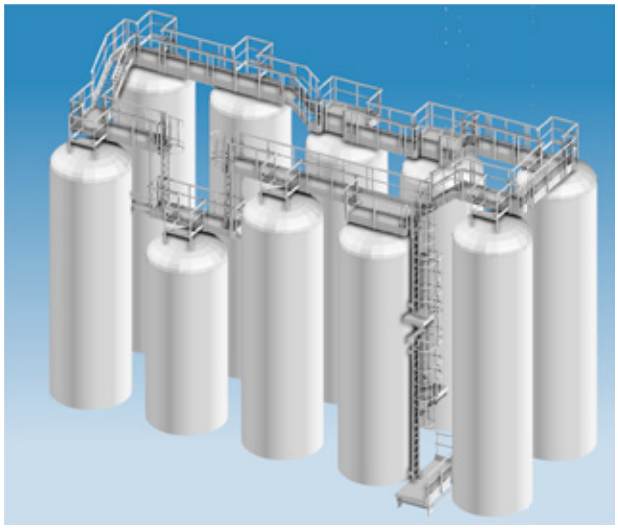
FRP fixed ladder

"FRP structures are chemical and weather-resistant to eliminate the risk of corrosion-related structural collapses; they boast non-slip walking surfaces to ensure operator safety, and are electrically-insulated, to reduce the risk of electric shocks

FRP - i.e. fibreglass - is an innovative material that engineers and designers alike have come to heavily rely on, thanks to both its performance and affordability. M.M.'s FRP structures are: chemical and weather-



M.M. fibreglass gratings



Project regarding a structure composed of M.M. FRP walkways, stairways and handrail systems for tank maintenance purposes

resistant to eliminate the risk of corrosion-related structural collapses; boast non-slip walking surfaces to ensure operator safety, even in adverse weather conditions; and are electrically-insulated, to reduce the risk of electric shocks.

Fibreglass solutions

M.M. specialises in the development, production and processing of walkover-suitable moulded gratings and pultruded profiles for constructing stairways, walkways, handrail systems, fencing and gates. The main production is accompanied by a series of FRP accessories, such as laminated sheets, threaded rods and manhole covers. The end result is usually a machinery access structures of some kind, with all elements built according to UNI EN ISO 14122 standard.

M.M. produces fibreglass products from various types of resin and glass fibres, in order to ensure the highest quality standards and propose a wide range of products. The M.M. gratings and structures are created by means of cutting-edge technologies, including closed injection moulding (RTM) and pultrusion.

M.M. project regarding a FRP inclined stairway for tank access purposes

The advantages of fibreglass

FRP solutions boasts several surprising advantages over structures made from galvanised or stainless-steel gratings/profiles:

- Weather resistance: it does not become damaged or deformed as a result of bad weather, UV rays or sudden changes in temperature.
- Corrosion resistance: it boasts a long-lasting resistance to a wide range of chemical substances (both acidic and basic) over a good temperature range.
- No maintenance is required;
- Lightness: it is, on average, 75% lighter than steel metalwork, and therefore, is less of a burden on the support structures whilst also facilitating transport and installation operations.
- Better mechanical strength than steel, in relation to weight.
- Easy installation: it can easily be manually handled, is quick to install and can also be processed on site.

- Electrical insulation: made from a non-conductive material.
- No earthing necessary: made from an insulated material.
- Radiotransparency: does not interfere with wave transmission in a wide range of frequencies.

Potential applications

The fields of application of fibreglass gratings and structures are truly manifold. Some examples being the integrated water cycle, waste treatment, energy, outdoor, railway infrastructure, shipbuilding and offshore construction, street furniture and tourist harbour sectors. Furthermore, the material's industrial applications are suitable for the chemical and pharmaceutical, petrochemical, electroplating, manufacturing and food sectors.

Two interesting case studies - provided as a means of further elaborating on the potential uses of FRP structures - are explained below: the first concerns the chemical industry, where extremely harsh environments are commonplace and various M.M.-produced support structures have been installed, such as walking surfaces, walkways, and both inclined stairways and vertical ladders. The second case study, on the other hand, touches upon the work carried out at a water purification plant, where fibreglass was chosen over traditional materials - e.g. steel - due to its corrosion, humidity, low temperature and thermal shock resistance; furthermore, its use is expected to increase in light of the forthcoming design-related European regulatory developments.

Case study: chemical plant

As far as the many advantages of using fibreglass are concerned, we would like to again touch upon its lightness, ease of installation and remarkable resistance to aggressive chemicals. In fact, it is these distinctive features that led a crop protection product manufacturer to opt for FRP structures.

Before M.M. arrived on the scene, the agro-pharmaceutical production tanks were equipped with steel walkways and stairways which, over time, had gradually corroded due to continuous exposure to a harsh environment, thus deeming their use unsafe.

As maintenance work at the top of the tanks remained an essential requirement for the client, fibreglass products were chosen which, by their very nature, do not require maintenance and therefore guarantee long-lasting consistent performance. More specifically, M.M. supplied the following FRP products for this plant:

- Vertical stairways to access the walkways.
- Walkways for walking at height to the tanks.
- Inclined stairways to connect the multi-height walkways.
- Area-confining handrail systems.

Due to the considerable height of the tanks - roughly 15 m - the walkway-accessing vertical stairway was divided into 3 parts with the creation of two intermediate landings; also made from FRP brackets and gratings.

In this case, the path of the above-tank walkways was not flat; in fact, there were several changes in level. This problem was overcome by incorporating platform-connecting inclined stairways, in addition to vertical stairways, where necessary, which compensated for the height variations of approx. 3 m whilst taking up very little space. The walkways mainly comprise low-height "C" profiles - equal to 150 mm - and 30 mm-thick open-mesh walkway gratings. The only metal elements are the bolts and connection brackets between the various profiles.

Constructing a FRP inclined stairway for tank access purposes

The purpose of the new FRP walkways is to provide access to maintenance personnel. To facilitate working on the apparatus located at the top of the tanks, M.M. also succeeded in creating work landings with removable gratings and protection systems to ensure that work is always carried out in a safe manner.

As previously mentioned, M.M.'s fibreglass products replaced the previous existing structures: the reduced weight of the FRP structures - compared to their steel counterpart - allowed the tank designers to easily adopt this new solution as no overloads were created on the existing structures.

The installation operations were extremely fast and very little machinery was used to lift the walkways and stairways which, as we recall, were supplied on site having already been pre-assembled in the M.M. plants.

M.M.: a key player in frp development for 45 years

M.M. was the first FRP (fibreglass-reinforced polymers) grating manufacturer in Europe. The Friulian company - established in 1977 - is now active on both the Italian and international markets, by offering high-quality gratings, profiles, manhole covers and composite structures.

Strengths

Competence and reliability are the strengths that have allowed M.M. to establish itself as a key international player. Besides its FRP gratings, the company has now become a fibreglass structures reference point, thanks to its many fields of applications, such as the water treatment, energy, telecommunications, railway infrastructure and shipbuilding industries.

Dedicated design team

M.M.'s in-house design team provides bespoke consultancy and value-added services, such as technical design (2D and 3D drawings, BIM), calculation reports, new-solution feasibility studies and corrosion analyses.

Turnkey projects

M.M. is the ideal partner for fulfilling "turnkey" projects: from the design and production phase to the quotation stage and after-sales service, M.M.'s No. 1 priority is customer satisfaction. The company guarantees efficient technical support throughout the entire order development process, by providing advice and specific services to create ad hoc solutions.

Therefore, installation involved focusing exclusively on the few connections required between the FRP structures and the fixing points, which had already been set up when installing the pre-existing steel walkways to the tanks.

Case study: purification plant

Another example of the use of FRP in the industrial sector is the structures built within the Hera Group-managed water purification plant in Sasso Marconi (BO), Italy. The existing plant was subjected to maintenance work on both the concrete structures that include the denitrification tank, oxidation tank, settler, thickener, sludge stabilisation tank and blower chambers, in addition to the structures that provide access to the former and are needed for inspection, maintenance and correct operation purposes. Such structures comprise multi-sized inclined stairways that provide access to the various tanks; landings; access platforms supported by columns or brackets directly mounted to the reinforced concrete walls; gratings supported by intermediate beams or installed directly on the reinforced concrete flooring; and handrail systems to confine the work areas and prevent any falls from height.

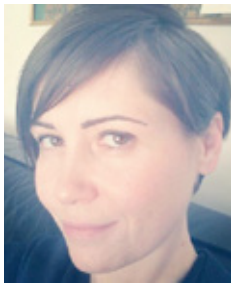
Purification plant: M.M. fibreglass structures (walkways, handrail systems and stairways)

These structures were originally made of steel in the existing buildings but, as a result of the highly corrosive environment, caused by the chemicals and gases released during the purification treatments, the client opted to replace these with a fibreglass-reinforced composite material (i.e. FRP). The same material was also chosen for the access and maintenance structures of the newly built tanks.

More specifically, M.M. predominantly supplied access stairways to the various tanks. Since such tanks were quite tall (up to 5 m in height) and vary in size and considering the rather narrow clearances for installation of the accessways, as large manoeuvring areas had to be left for the vehicles to access the purifier once it had been recommissioned, the only option was to create rapidly ascending structures. The stairways were built with short flights, connected to one another by means of intermediate landings, in turn, supported by turrets of varying and increasing heights. Alternatively, wherever ground access was not possible, landings and walkways - supported by brackets directly mounted to the tanks' reinforced concrete walls - were produced. In some cases, removable elements were

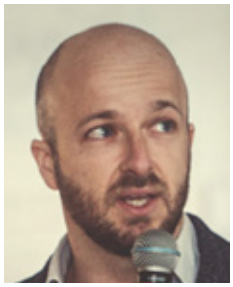
also requested, such as the handrail system that would facilitate tank inspections. The versatility and complexity of the structures that can be built is truly remarkable.
The maintenance and inspection-related structures were composed entirely of FRP profiles and gratings: stairway stringers, the relative handrail systems, the turret pillars and the relative diagonal bracing elements; even the gratings used to make up the walkways and stairway steps were made of FRP. Only the fixing elements - for the foundations and reinforced concrete walls - and the connections between the various FRP structural elements were made of AISI 316 stainless steel. All the structures were designed to withstand vertical maintenance loads according to the UNI EN ISO 14122 standard, in addition to horizontal loads of wind and seismic actions: the latter are of low entity, since FRP is much lighter than steel and therefore, the seismic mass is small, as well as the actions transmitted to the reinforced concrete structures upon which they can be secured. As a general rule, the use of FRP structures does not excessively increase the actions on existing structures, thereby allowing for minor reinforcement interventions, if necessary, or avoiding them altogether.

"As a general rule, the use of FRP structures does not excessively increase the actions on existing structures, thereby allowing for minor reinforcement interventions, if necessary, or avoiding them altogether



Sara Macor

Sara Macor is the Sales Manager of M.M. Srl, a company that has been a reference player in the FRP gratings and structures market for 45 years now.
She joined the M.M. sales department in 2013 and in 2017, was entrusted to implement a sales development process, as part of her role as head of the sales team. Her position entails overseeing the management and expansion of the M.M. sales network and supervising international activities, by coordinating with both internal and external resources.



Francesco Ciani

Engineer Francesco Ciani is the Technical Department Manager of M.M. Srl, a company that since 1977 has developed and produced FRP gratings, profiles and structures for export all over the world.
In his role as director of the M.M. Technical Department, Ciani oversees the R&D of new products, manages the order flow and technical support for the commercial sphere, and supervises the issuance of certifications. Furthermore, he coordinates the technical engineering team involved in the development of ad hoc solutions through value-added services, such as technical design and the structural calculation for composite materials, in addition to chemical and mechanical resistance tests.

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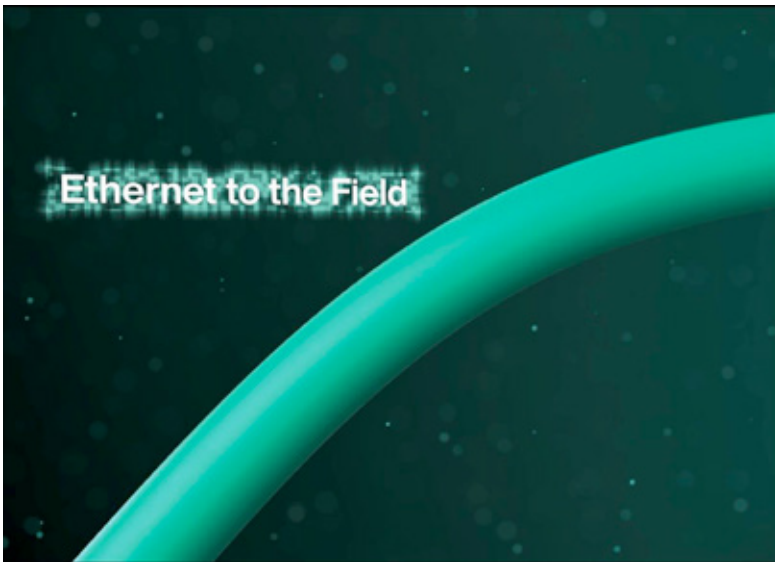
Ethernet-APL and Pepperl+Fuchs: two partners for safety and protection

With this new technology, the applications are more transparent, accessible, faster: find out how

Stefano Giunteri, Sales Director Middle East & East Mediterranean, Process Automation Division Pepperl+Fuchs



"Your automation, our passion" has been our company mission for over 75 years in the development, manufacture, and support of products and solutions which meet the continuous global requirements of the automation markets which we serve. Throughout our history, the family ownership of Pepperl+Fuchs reveals not only a strong focus on innovation but also a fundamental corporate mindset. These have been the most important pillars of our success story since the very beginning, working in partnership with you our customers.

As the world leader in global hazardous area interfacing, and a pioneer in the many aspects of explosion protection, safety is always the first word we think of at Pepperl+Fuchs. This philosophy has been with us right from the very beginning in 1945 through to the present day, still privately owned by the family of our founders. Today, we continue to protect and connect the global process industry with our products and solutions across all hazardous area protection methods and a very wide range of applications.

Whilst the ethos which forms the foundation of our company has never changed, the entrepreneurial spirit to develop the latest technology which meets our customer demands is greater than ever. Whether we are evolving intrinsic safety interfacing and surge protection systems for conventional applications or innovating with new technologies like Fieldbus or smart wearables, our commitment to continuous improvement never diminishes. This is evident now more than ever, being at the forefront of assisting the Industry 4.0 digital transformation, with our latest Ethernet for Process Automation, APL (Advanced Physical Layer), which enables companies to exploit technology and expertise to enhance processes and create IIOT capable applications.

"For the first time, Ethernet technology is used not only in the control room and in the field; the maintenance technicians can connect to the internal network, taking advantage of continuous and transparent access to the instrumentation present in the field

As a reliable industrial partner, we are acutely aware of the special challenges you face every day. This is we why develop, manufacture and support all of our products via a network of eighty locations throughout the world. To provide assistance where it is required, with products which are globally certified and suitable for your working environment. From the initial application discussion, through to project execution via one of the six Solution Engineering Centers we have across four continents, partnerships with strong

communication and collaboration are the only way to succeed.

With a team of over 600 engineers committed to developing tomorrow's solutions today, we bring a wealth of problem solving knowledge across all hazardous area protection methods. This has made us the market and innovation leader in electrical explosion protection as well as the recognized expert in functional safety, including the world's only complete SIL 3 portfolio with 10 million SIL components installed. Our commitment to improving mobile worker productivity is also clear with significant investment in digital communication development via phones, tablets and smart glasses. With over 500,000 mobile devices supplied globally, limitless connectivity and safer working conditions are achieved no matter where you are.

Whether our customers are in the chemical, metal, packaging, intralogistics, or automotive industries, supplying the correct products for operation and energy efficiency are two of the most important factor we consider. Suitable technologies must be employed in industry to realize significant reductions in energy consumption while keeping the highest standard of safety.

"Our latest Ethernet for Process Automation, APL (Advanced Physical Layer), enables companies to exploit technology and expertise to enhance processes and create IIOT capable applications

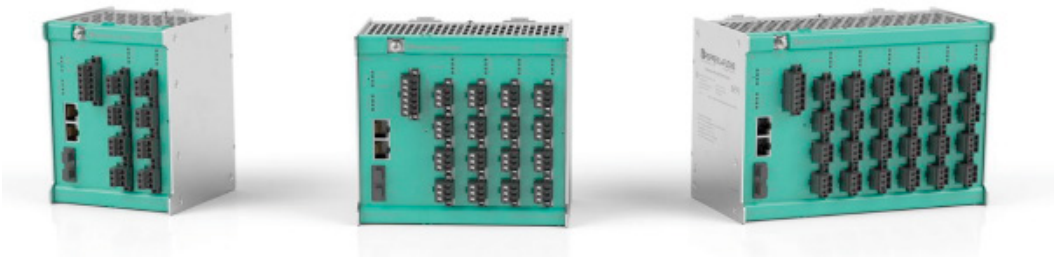
From a technology perspective, we see several areas which show increasing demand, three of these are mobile computing, two and three dimension measurement technology and data migration. Smartphones and tablets have already made their way into factories and plants, and Ethernet connectivity that will allow facilitating the Data collection is now a reality. Data is essential for creating transparent production processes for plant operators through new web based applications and cloud solutions, offering the potential for considerable efficiency in the future.

Reducing numbers of the workers that need to work in hazardous area environments, providing them with the possibility to operate the plant in a safe environment, will help to greatly reduce the risk. At the same time this is a clear answer to the challenge of having limited resources capable of performing activities in these complex plants. Equipping technicians with a basic tool such as a smartphone will make it easier to carry out their activities, enhancing communication and interface with the digital world whilst also providing additional benefits such as lone worker protection with alarm activation functionality.

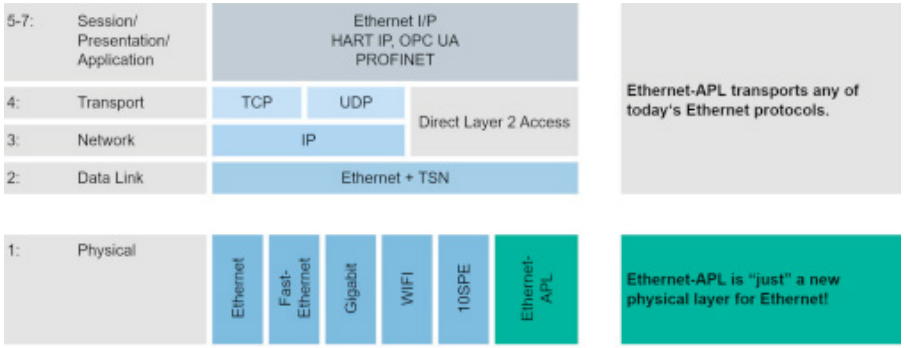
Pepperl+Fuchs has a characteristic green as its brand color, so it is natural to have a specific attention to the environment and all technologies proposed are supporting the industry to get closer to the global green deal target. In parallel, it is evident that the new trends are driving Individual business units or even different companies to come together, using their combined expertise to create a solution, particularly with complex projects. Social skills therefore gain importance in the process of digitization rather than becoming less important as some might assume. This is the reason why the Pepperl+Fuchs Group do not offer just a component for a process automation market when selecting our technologies you are getting access to the best in class technical expertise without compromising on safety and security.

When designing a completely new plant or upgrading a legacy facility, it is simply not the state of art to take reference of what has been done before, we have to adopt the technology that will allow us to design a plant that is future proof. Safe, simple, digital, flexible infrastructure is the vision of many process automation experts shared with Pepperl+Fuchs, since 2015, and once more see the company as a frontrunner in finding a "hardware" answer to this market requirement.

A ruggedized version of Ethernet fit for the rough environments in the field within process plants is the result. For the first time, process users can apply Ethernet from the boardroom, beyond the control room, and in the field. This provides seamless, transparent and concurrent access to field instrumentation. It enables completely new applications and thus how users work with instrumentation and anything else installed within the field of process plants, or simply the Ethernet Advanced Physical Layer. Ethernet-APL defines the attributes for operation in the field within process plants. Installation and connection technology is based on a shielded two-wire cable with screw terminals. Ethernet-APL can make use of the existing Fieldbus type 'A' cable. It is similar to infrastructure technologies today: power and communication over a long two-wire cable and intrinsic safety at the instrument. Cables may remain in place



and provide the pathway for migrations and upgrades to Ethernet-APL for brownfield installations.



Migration and plant upkeep: The switches can handle two different physical layers: Ethernet-APL and Manchester Bus-Powered (MBP) for PROFIBUS PA. The switch automatically detects and adapts to the communication of the field device. This is Pepperl+Fuchs patented technology and a real differentiator. If the device provides data via the PROFIBUS PA protocol, the switch translates it to PROFINET according to standardized PROXY technology. This enables mixed architectures via a single infrastructure! Renovation and upgrades can be done smoothly. The parallel operation of Ethernet and Fieldbus technologies saves investment costs by maintaining the installed base of equipment.

Diagnostic: FieldConnex APL field switches monitor the quality of the physical layer. The switch detects a weakness or fault immediately, warnings and alarms at the control system provide an overview, and a webserver on the switch provides the details. This enables users to intervene in a targeted, planned, and demand-oriented manner often before critical failures can occur. This ensures maximum safety for people and the environment, while at the same time ensuring high plant availability and optimized effort. The flat network infrastructure enables access to diagnostics and configuration in parallel to and independent of the control system. This prepares the ground for digitally-driven, automated work processes that are economical and safe. This protects people and avoids faults from unintended actions. Ethernet-APL provides the data that enables users to reduce risk, simplify design, accelerate deployment, increase asset optimization, and thus reduce the total cost of ownership.

With FieldConnex® **Ethernet-APL Switches**, users can drive the digital transformation with data from the field of their process plant. Data-driven plant operation enables operators to continuously and permanently leverage optimization potential.
Ethernet APL Rail Field Switches from FieldConnex® are the first of its kind on the market. It is a ruggedized product and is equipped with highly efficient electronics for superior thermal management. This is a key ingredient for long service life and enables a large number of field device ports as well as the high-performance switch architecture.

Communications Layers: The ISO-OSI model defines specific tasks for different communication layers. Functions in each layer can interact with any other layer in a standardized way. Example: This allows for a switch to interconnect and transmit all data over different types of Ethernet.

Users consider all layers as one building block. Therefore, when they refer to PROFIBUS PA or HART or FOUNDATION Fieldbus H1, this includes how the data is represented (layer 7) and shown on the screen, address settings (layer 2) as well as anything from the physical layer (layer 1) from cables to connectors to explosion protection. This is because existing technologies such as HART or Fieldbus define both. Ethernet-APL defines the physical layer only. This allows transmission of an Ethernet-based protocol. Communication to the field is seamless as it is all

Ethernet terminology

Table 3: Basic Terminology for Ethernet

Term	Brief Explanation
Port	A physical connection to an Ethernet network.
Node	A device or switch connected to the network. It can always be individually addressed.
Segment	The connection of two Ethernet-APL devices including the cable.

Table 1: Attributes, choices and options

Ethernet-APL Rail Switch									Attribute
PROFIBUS PA									Optional integration of PROFIBUS PA instrumentation
Intrinsic safety									Ex ic IIC at the spur port
Spur port count									8, 16, 24 selectable
Connectors									Screw-type or Spring-clamp terminals selectable
Type code and example:									
ARS1	(1)	-	(2)	(3)	-	(4)	(5)	. (6)	Selections
ARS1	1	-	B	2	-	IC	24	. 2	Ethernet-APL Rail Field Switch with PA Proxy, 20-60 VDC external power required, 2 RJ45 and 2 SFP slots, 24 spur ports intrinsically safe, Ex ic IIC, and spring terminals.

Ethernet. Communications Protocols for Process Industries Ethernet-APL transports any type of protocol. In process industries, the most prevalent are Ethernet-IP, HART-IP, OPC/UA, or PROFINET. The protocol defines the contents and structure of data and information. E.g. industrial protocols define signals like an analog input, warning message, safety communication, etc. Other protocols such as the HTML protocol (layer 7) describe what a web page looks like and how to collect user input via forms. The FieldConnex switches provide easy access to status, configuration, and diagnostics via a web browser. Devices do the same. Protocols facilitate other tasks. There are specialized protocols for network management, port identification, and more. An Ethernet-based system enables any device or system to access another device or system concurrently and without gateways. The Physical Layer The physical layer is the infrastructure that transports the signal and provides power. Ethernet-APL is the ruggedized version for the field. Standard Ethernet, Fast Ethernet, or Gigabit are also physical layers for Ethernet, and so is the entire range of single-pair Ethernet (SPE). Layers 1 and 2 of the ISO/OSI model define the physical layer. There is complete freedom to design and implement topologies with Ethernet-APL, the most popular being star and the trunk-and-spur. FieldConnex switches connect Ethernet-APL networks to higher-level networks. The solutions for installation and junction boxes are similar to Fieldbus. Similarities and Differences to Fieldbus Process Fieldbus systems such as Foundation Fieldbus H1 and PROFIBUS PA are complete definitions of physical layer and protocol. They incorporate both, a protocol definition and a physical layer definition. Manchester Bus Powered (MBP) is the name of the physical layer according to IEC 61158-2. Ethernet-APL is designed to utilize cable type 'A' saving on installation cost. With Pepperl+Fuchs patented technology and switches, users can naturally operate Ethernet-APL and Fieldbus devices on the same infrastructure. Many benefits of MBP are also incorporated into the design of Ethernet-APL. They are:

- Power and communication on a two-wire cable, type 'A'.
- High-Power Trunk-and-Spur topology.
- Same easy validation of intrinsic safety, called 2-WISE.

This allows for easy migration of automation systems with PROFIBUS PA and FieldConnex Switches. There is no easy replacement for Foundation Fieldbus H1 as of yet because there is no standardization for data transmission to other protocols yet.
Ethernet-APL in general expands the limits: More cable length, more power, more speed.

Safety and Security Safety and security are both implemented by protocols at layer 7. Ethernet-APL is just a physical layer (layer 1). Because layer 7 is completely detached from layer 1 Ethernet-APL will transport safety and security concepts – like any protocol – today and in the future. Security is always a system concept. There are specialists for this task that provide consulting services for implementation. The IEEE and IEC standards are finalized and published. Any vendor can participate in this technology through one of the four user organizations. We also expect more user organizations to incorporate Ethernet-APL into their communications standards.

"New applications, new ways of working with instrumentation: users are driving digital transformation

Stefano Giunteri

Stefano's first experience in the world of industrial automation goes back to the 1990's, when he was employed as an instrumentation Sales engineer by Foxboro (an Invensys Systems, Inc. brand, Foxboro/ Invensys was acquired by Schneider Electric in 2014.).
During that period, he grew a passion for the Process Automation world, learning the basics of Industrial Instrumentation from major experts in the sector.
He gained also considerable experience in the Factory Automation Market and related applications, thanks to his employment in company IFM Electronic in Italy.
Afterwards, Stefano became a member of the Pepperl+Fuchs family, devoting most of his carrier to this company. After having covered several international roles in the past 20 years, nowadays, he works as the Middle East and East Mediterranean Sales Director in the Process Automation Division, one of the most strategic regions, thanks to the strength of the Oil and Gas Industry.
Thanks to his deep technical background and detailed knowledge of the process automation product portfolio and their applications, Stefano supports the customers in proposing applications with specific attention to safety and efficiency. This ensures unsurpassed technical and sales support that only a market leader such as Pepperl+Fuchs can offer in the process automation market.

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