Sustainable and Reliable
Value for our Clients

Helping our clients and suppliers evolve to operate within planetary boundaries

The **metals and mining industries** must evolve to significantly **reduce their carbon emissions** and limit global warming to internationally agreed limits. Tenova Group is helping drive this transformation by developing **innovative technologies** that not only support our clients in delivering **better products** but also drastically **reduce** their **environmental impact**.

In this section, we report on how we support our clients in reducing their environmental impact with our portfolio of products, technologies, and services, with a focus on digital transformation.

Driving Sustainable Solutions

Our portfolio of solutions is primarily dedicated to the sustainable transformation of the metals and mining industries. We create value for our clients by providing innovative technologies that ensure efficiency, resulting in improved performance, reduced waste, and lower carbon emissions. These technologies support the transition to cleaner fuels, and facilitate the recovery and reuse of previously wasted materials.

In developing these solutions, we not only serve our clients but also work hard to accelerate our sector's transition to a lower environmental impact.

Energy Transition

The **iron and steel industry** is one of the largest emitters of CO_2, responsible for around 7-8%[2] of global direct energy-related CO_2 emissions. To address this, the steelmaking sector is undergoing a radical transformation to accelerate **pathways to decarbonization**, rethinking the energy sources that drive its industrial processes, and moving away from **carbon-based** iron reduction processes to **natural gas-based** and **hydrogen-based** ones. This shift is part of a broader energy transition in the metals and mining industries, driven by three key trends in which Tenova Group plays a pivotal role through its advanced solutions: **decarbonization & hydrogen**, **electrification**, and **digitalization**.

All these trends not only demand increased metal production but also require that production itself evolves in alignment with them. To meet these challenges, Tenova positions itself as a leading figure in fostering a **shift** in the metals industry **energy paradigm** by promoting **hydrogen-ready technologies** to its clients for the transformation process of their business. This is further achieved through partnerships and collaborations with gas supply operators, electrolyzer manufacturers, and other third parties that support a green energy transition.

In this context, the following section presents key products, research cases, and partnerships that are driving the Group's shift in the energy paradigm.

[2] https://worldsteel.org/climate-action/climate-change-and-the-production-of-iron-and-steel/

Electrical Steel

As the world invests in electric vehicles (EVs), improves and expands the electrical grid infrastructures, global appetite for electrical steel grades is growing substantially. **Electrical Steel** exists in different specialty steel grades containing **silicon** as its primary **alloying element**. They are prized for their ability to conduct magnetic fields, and as such are used for electrical applications, from transformers to rotating machines such as generators in wind turbines and electrical motors in EVs. Electrical steels (silicon steel grades) are estimated to make up roughly 1-2% of total crude steel production globally. Tenova's portfolio includes **silicon steel processing lines** and batch annealing furnaces that enable our customers to more efficiently produce metals that will be critical in facilitating the energy transition. Tenova has developed several **technological advancements to improve the performance of electrical steels**, including innovations in the annealing, pickling, decarburization, recrystallization, flattening, and coating operations.

Improvements in silicon steel

As demand for magnetic steel (a special steel alloyed with carbon and other elements that exhibit magnetic properties and is used in electric machines) and silicon steel continues to grow, the need for **more efficient production methods** is increasing. Thus, Tenova's R&D team has been working intensively to develop technologies that improve the silicon steelmaking process. In addition to **our suite of technologies for silicon steel**, the focus is on improving the **magnetic properties of silicon steel**, hot and cold rolling, and new descaling processes, like laser and other mechanical descaling. Our research intends to find the optimal process to improve surface finishing and enhance magnetic properties.

DRI & ENERGIRON

The global steel community agrees that the partial or total use of hydrogen **for DRI (Direct Reduced Iron)** production is the most effective route to the decarbonization of the industry. More and more steelmakers are adopting this solution in the installation of **new green steel plants** or in the **decarbonization of integrated steel mills** (i.e. steelmaking from ores as raw materials).

Our **ENERGIRON** technology, jointly developed with Danieli, is at the forefront of sustainable steel production. By utilizing innovative DRI processes, ENERGIRON can reduce carbon emissions by up to 80% compared to traditional steelmaking methods.

This technology has been designed to use **different types of reducing gas sources**, including **pure hydrogen** to reduce iron ores into metallic virgin iron and produce a wide range of **high-quality steels**. ENERGIRON plants efficiently reduce any iron unit into "energized" hot or cold DRI or hot briquetted iron with controlled metallization and carbon levels. ENERGIRON offers unparalleled flexibility: even with the same process scheme configuration, the client can select the best energy source - natural gas, reformed gas, syngas from a coal gasifier, coke oven gas or even hydrogen - without any process modification and can control the amount of embodied carbon during operations.

ENERGIRON plants meet the **most stringent environmental regulations**. Thanks to its unique features, ENERGIRON has the lowest carbon footprint of any ironmaking technology, with the further advantage that the selectively removed CO_2 can be sold. Additionally, the water byproduct of the reduction reaction, easily condensed and removed from the gas stream, can be used as cooling water in a zero-water consumption circuit.

ENERGIRON technologies have concretely contributed to global steelmaking innovation over the past years. At the end of 2024 Tenova, working with Sinosteel Engineering & Technology Co. Ltd, successfully completed the performance test for the new **hydrogen-based 1,000,000 tons/year ENERGIRON Direct Reduction (DR)** plant for Baosteel Zhanjiang Iron & Steel Co. Ltd.

With a full capacity of 1 million tons per year and installed for Baosteel – a Baowu Group company – it will be **China's largest hydrogen-based DRI facility**. The plant, which uses natural gas enriched with hydrogen leveraging coke oven gas as the process gas,is also equipped to capture CO_2 for commercial use, further cutting emissions and creating an additional revenue stream. The **strength of our design** lies in the fact that the transition to better gases is possible while keeping the plant open, without requiring fundamental changes to its functional structure.

In **February 2024**, our ENERGIRON technology was also selected by **LKAB**, an international mining and minerals group, for the basic engineering of its 100% hydrogen-based Direct Reduced Iron (DRI) plant in **Gällivare, Sweden**.

The Gällivare demonstration plant has a capacity of 1.35 million MT/yr (metric tons per year) of **fossil-free DRI**. It will combine LKAB's **HYBRIT** and Tenova's **ENERGIRON technologies**, drawing on shared expertise in DRI production. Results from the HYBRIT pilot plant show that DRI made with **pure hydrogen** as a reducing agent **outperforms fossil-based alternatives** like natural gas.

DRI plants are typically coupled with **Electric Arc Furnaces (EAF)** for the melting of the DRI and its transformation into sellable iron or steel. Reducing the oxides with natural gas or hydrogen and melting by electric energy instead of using energy from coal generates much less GHG emissions than the traditional BF-BOF route.

ENERGIRON for NeoSmelt

In 2025, Tenova has been selected as the preferred technology supplier for **NeoSmelt**, a major project aimed at developing low-emissions steelmaking in Australia. The company will lead the **Front-End Engineering Design** (FEED) of a **Direct Reduced Iron** (DRI) pilot plant - one of the key components of the NeoSmelt initiative.

The NeoSmelt project is part of a broader effort to explore **cleaner**, **more flexible** ways of **producing steel**. It is backed by a consortium of major industry players, including BlueScope, BHP, Rio Tinto, Woodside Energy, and Mitsui Iron Ore Development, and involves a feasibility study for a pilot facility that integrates DRI and electric smelting furnace (ESF) technology.

The NeoSmelt initiative is a critical step in addressing the steel industry's decarbonization challenge. **By integrating DRI** and **electric smelting technologies**, the project aims to validate a new, **lower-emissions route** to produce molten iron using Pilbara iron ore.

ENERGIRON for Hyundai Steel

Hyundai Steel has selected Tenova and Danieli's ENERGIRON technology for its new sustainable steelmaking facility in the United States. Situated in RiverPlex Mega Park, Louisiana, the plant will have an annual production capacity of 2.5 million tonnes of hot and cold Direct Reduced Iron (DRI). Incorporating the Zero Reformer ENERGIRON technology, the facility will integrate carbon capture solutions and be prepared for hydrogen utilization, providing one of the most environmentally sustainable steelmaking solutions currently available.

SAF and Open Slag Bath Furnace

Open Slag Bath Furnace (OSBF) is the perfect solution for melting high-carbon DRI to produce hot metal. The electric furnace, a **Submerged Arc Furnace (SAF)** in this case, works using Søderberg electrodes operating "submerged" in the slag or with a very short electrical arc or "brush arc". The OSBF can tap hot metal into ladles or torpedo cars. The resulting slag produced is similar to blast furnace slag and can be sold to the cement industry. The work done on OSBF slag treatment has identified a potential alternative processing route for the treatment of EAF slag, which is discussed in more detail in the Circular Economy section (p. 30).

Tenova joins RINA's 100% hydrogen-fueled Hydra project

Tenova partnered with RINA on the Hydra project, funded by NextGenerationEU and supported by the Italian Ministry of Enterprises and Made in Italy. The project aims to enable European steelmakers to test 100% hydrogen fuel for greener steel production. Tenova provides a **30-meter high DRI tower**, using **ENERGIRON** technology, and an **Electric Arc Furnace (EAF)**. The pilot plant produces up to seven tons of steel per hour with reduced carbon emissions. The project will help test various hydrogen-natural gas blends and iron ores, providing valuable insights for future investments. The EAF can also process residual materials from steelmaking and other sectors, such as plastics, biochar, and construction by-products, supporting more sustainable resource use.

Mineral Wool Applications

Historically, the mineral wool flow sheet made use of fossil fuel-fed Cupola furnace technology, a process with high carbon emissions. Tenova has identified the use of its bespoke **hybrid SAF design** (a SAF using graphite electrodes) to replace Cupola furnaces. This technological innovation has the potential to **reduce mineral wool carbon emissions** by **up to 90%** depending on the electrical energy carbon footprint. Tenova has references in different countries like US and South Korea and offers this technology to existing mineral wool producers (as a retrofit) or producers planning to expand their mineral wool production capacity.

iBLUE®

Conventional blast furnace-basic oxygen furnaces or oxygen converters (BF-BOF) dominate global steel production, producing two tons of CO_2 for each ton of steel produced (as a comparison, the EAF route from scrap produces 80% fewer emissions). Modifying their technology is the best route to CO_2 reduction for the steelmaking industry. As of 2023, 57% of global steel was produced via the BF-BOF route, while only 43% was produced via the electric (EAF) process. Tenova's technology to substitute any Blast Furnace is **iBLUE®**, which enables the production of **Liquid Pig Iron** via the **BF-BOF** route while massively **reducing emissions**. iBLUE® combines the production of high-carbon DRI with an electric arc melter (ESF or OSBF) to produce hot metal and granulated slag. It can also utilize BF grade pellets as raw material, making it the perfect substitute for blast furnace technology. The use of green hydrogen in the reduction process can further minimize greenhouse gas emissions.

In 2023, Tenova started a **pilot project** on an **industrial-sized Submerged Arc Furnace** for the production of hot metal and achieved positive results. **iBLUE®** is increasingly confirmed as the **sustainable alternative to blast furnaces** to **convert integrated steel mills** with existing BOFs into "green metal plants". In addition to its environmental advantages, iBLUE® allows steelmakers to maintain existing steel grades production procedures and quality control: from this perspective, implementing iBLUE® does not require the qualification of the production process, and is highly recommended for high-quality steel grades, exposed automotive parts, etc.

A number of projects and studies with steelmakers in different parts of the world kicked off in 2023 and will result in the construction of new iBLUE® plants. The relevance of the technology was further confirmed in 2024 with a successful test conducted in a Swedish laboratory in February. In 2025, at the European level, the decision was made to include **the iBLUE® technology** among the **Best Available Techniques (BAT)** recognised for the production of pig iron from DRI. This recognition represents an important step forward in promoting sustainable and low-carbon technological solutions within the sector. This represents a less costly option to produce hot metal with a minimal carbon footprint and results in minimal disruption to the operations of an integrated steel plant that plans to shift towards green steel production.

Tulum Energy

On October 31st, 2024, Tulum Energy S.A. was established and incorporated in Luxembourg, with equal ownership by Tenova S.A. and Tech Energy Ventures. Tulum Energy is developing **an innovative technology**, initially conceived by Tenova, for the **production of low-carbon hydrogen** from **methane pyrolysis** ("turquoise hydrogen"). Tulum subsequently raised venture capital from a **consortium of institutional**, **strategic**, and **financial investors**, as part of a capital increase successfully completed in July 2025.

Tulum's technology aims to produce low-carbon hydrogen (90% CO_2 reduction compared to traditional technologies) on an industrial scale and at **competitive costs**. Its technology could therefore play a significant role in decarbonizing the steel industry. Tulum is currently developing its first demonstration plant in Mexico, at Ternium's site, with start-up scheduled for the end of 2026.

Combustion Systems for Furnaces

Traditional hot rolling and heat treatment processes utilize fossil fuels, resulting in a high carbon footprint for final products like long or flat steel products. Tenova is committed to developing and deploying **highly efficient low-emissions combustion systems** for reheating and heat treatment furnaces. Since the 1950s, we have specialized in the development of combustion technologies, recently leading to the adoption of **regenerative and self-regenerative burners** to provide about **10% reduction in CO_2 emissions** when firing standard fossil fuels. Furthermore, Tenova's regenerative burners are also **Hydrogen-Ready**: whenever green hydrogen becomes readily available, our clients can immediately use any variable amounts of hydrogen blended with standard fuels and drastically reduce their carbon emissions without any additional investment.

In 2021, we reached a key milestone in this endeavor by developing the first burners for heat treatment furnaces using up to **100% hydrogen**, while keeping NO_x below the strict emission limits of 100 mg/Nm³. Tenova's regenerative flameless burners combine the lowest NO_x emission level with high temperature combustion air preheating, thus combining a relevant reduction of CO_2 emissions with high combustion efficiency. That means our burners provide clients with improved plant sustainability even before cleaner fuels such as green hydrogen become readily available.

We believe **hydrogen** will play a key role in the **future of combustion systems**. However, many countries and markets are not yet structurally prepared to adopt this technology. Therefore, over the coming years, we are committed to providing our clients with reliable and sustainable solutions that serve as incremental steps toward the energy transition guiding this process with a *"stepwise decarbonization strategy"*.

While our clients and we look forward to the necessary developments in the hydrogen distribution infrastructure, in 2024, we developed a **basic concept study for hybrid burners** which will support steelmakers in pursuing their emission-reduction targets by directly utilizing renewable electricity to cut standard fossil fuel consumption. During the year, we filed intellectual property so that this partially electrified solution allows our clients to use the **clean electricity** already available from the grid in order to reduce their emissions potentially up to 25%[3] while keeping the hydrogen-ready feature for future decarbonization steps.

In a collaborative project with **thyssenkrupp Hohenlimburg GmbH, Tenova LOI Thermprocess** proceeded with **advanced heating hoods** for batch annealing furnaces, featuring our patented **Ultra-low NO_x HPH®-flameless concept** and increasing air preheating temperatures to 600°C. It achieved up to 12% energy and CO_2 savings. In production trials, the project

aimed to **decarbonize steel production** by gradually shifting the fuel gas supply for the heat treatment of hot-rolled narrow strips from natural gas to 100% hydrogen. Despite the higher combustion temperature, the flameless concept resulted in low NO_x emissions.

To assess the impact of increased hydrogen use on the overall system, we employed a mobile natural gas/hydrogen mixing station. This allowed us to **test different gas mixtures during annealing cycles**. To this end, Tenova developed the THSQ Burner family that can work with any hydrogen/natural gas mixture while maintaining consistent thermal performance and NO_x emissions. LOI Thermprocess's bell-type annealing plants are inherently well-suited for hydrogen use. The HPH®-flameless technology further enhances their performance by enabling the lowest NO_x emission levels while also improving fuel gas efficiency.

[3] This emission reduction percentage is an estimate based on a case-study reheating furnace, representative of our baseline design.

TenovaLAB

We continuously invest in new **research and development activities** to create cutting-edge technologies that provide low-carbon solutions to our clients in the metals and mining industries. For this reason, between 2023 and 2024, Tenova invested in its own R&D facilities by installing an **experimental laboratory** at our **headquarters in Castellanza**.
Our **TenovaLAB** carries out **experimental industrial activities** for the **development** and **testing** of all **heating technologies**, lately expanding its research activities into electrification technologies. Equipped with **four test furnaces** of varying thermal power, TenovaLAB allows our R&D team to close the loop between our in-house CFD modeling and simulation capabilities and the engineering of industrial products. Lab testing activities, including thermal and emissions measurements, enable Tenova to fine-tune its product specifications, minimizing any technology risk for the end user. Furthermore, TenovaLAB allows our customers to see our products in action in real operating conditions.

During 2024, after we expanded our facilities at TenovaLAB with preparatory works, we completed the **installation of a 1.5 MW water electrolysis unit** directly connected to the solar panels' roofing of our Pomini Workshop. This expansion is partially financed through a Horizon EU grant[4] to demonstrate the full green hydrogen production-storage-utilization route at full industrial scale, from the generation of hydrogen to its blending with natural gas and use in the combustion systems of the different test furnaces at TenovaLAB.

[4] Co-funded by the European Union, Grant Agreement number: 101092087.

Energy Efficiency

In cases where it is not yet feasible to transition to cleaner fuels, we have developed a suite of technologies to help our clients use their existing fuels more efficiently or adapt their existing processes to reduce their emissions.

Metals Advancements

Consteel® EAF

In use for over 30 years and on 80 sites across all continents, our **Consteel® EAF** has proven its value to clients around the world. Consteel® EAF is a process which **preheats** and **continuously charges** raw feed materials, in particular scrap, into an EAF, melting them by immersion in the liquid steel present in the furnace. The EAF operates in constant flat bath conditions, a key advantage over conventional batch processes, where scrap is melted by the direct action of the electric arc. The EAF off-gases are used to preheat the incoming scrap and feed materials. Their composition is controlled and sent to a fume-cleaning plant in conditions suitable for the complete combustion of carbon monoxide and other pollutants without the need of any fuel consumption (differently from other scrap preheating techniques). This process produces **liquid steel** with **high productivity**, a short and adjustable heat cycle, and a lower power cost compared to other EAF installations using conventional or other alternative steelmaking technologies. To further improve its Consteel® EAF, Tenova introduced additional features, like the Electro Magnetic Stirring technology, such as **Consteerrer®**, which improves energy consumption and refractory lining life.

iRecovery® Captures and Reuses Thermal Heat

Today, **process optimization** and **energy efficiency** to reduce emissions are more important than ever for steel producers. Tenova began working on this over a decade ago, well before other companies were thinking about sustainability in the industry. In the past ten years, we developed the **iRecovery® system** for **recovering thermal power** from EAF waste flue gas and using it as an energy source. This energy comprises the biggest fraction of the primary energy input in the EAF process, yet it typically goes to waste. iRecovery® captures the thermal energy created by the off-gas and uses it to produce steam to power steelmaking and other activities. In Brescia, for example, ORI Martin uses the heat captured with iRecovery® to heat 2,000 homes in winter and power 700 homes in summer, reducing 10,000 tons of CO_2 every year.

In 2023, Tenova developed the iRecovery® solution for application at high pressure, up to 60 bar(g) of steam produced. This solution increases the applicability of iRecovery® in the transformation process of steelmaking from BF-BOF to DRI-EAF through integration into the existing plants steam distribution network. Tenova coupled **Consteel® EAF** and iRecovery® in order to improve the effectiveness of our technologies: while the high temperature thermal power contained in the waste gases (up to 800°C) is first used in scrap preheating by Consteel® EAF, the Waste Heat Boiler (WHB) downstream uses the recovered residual waste gas energy after scrap preheating. This combination can produce about 90-140 kg/tls of steam.

In 2024 Tenova signed a contract for the supply of two iRecovery® systems for Voestalpine Donawitz new electric arc furnaces to be supplied by Danieli. Each of the systems is sized to produce around 50 tph of steam from each of the 75 t EAF. The first of two furnaces will be put into operation in 2026, with the steam production plants managed by Tenova.

Multiple Pre-Heater for Ferroalloys production

In 2023, Tenova and one of the world's largest ferrochrome producers successfully brought Tenova's patented **Multiple Pre-Heater (MPH) system** to full performance. The solution recovers the chemical energy contained in the furnace off-gas and uses it to pre heat the furnace feed materials (chrome ore and reductants) before they enter the furnace, thereby reducing the electrical energy required and improving stability of the furnace process.

From a technology standpoint, the **Tenova MPH** concept is based on the combustion of CO rich cleaned off-gas as an energy source. The system can reduce electrical energy demand by up to 15%, while also improving process operability: volatiles are removed from the feed blend prior to the furnace (improving off-gas CO quality), hot and dried feed reduces electrodes movement (supporting stability), and the system architecture (multiple units on a single SAF) enables independent control that reacts to furnace conditions.

Environmental impact framing:

- The MPH reduces the electrical energy required by up to 15% by using the chemical energy in CO-rich cleaned off-gas.
- If the grid electricity has a non-zero carbon intensity, a reduction in kWh/t FeCr translates directly into reduced indirect (Scope 2) CO_2 per ton of product.
- The MPH is a system that utilizes the chemical energy contained in furnace off-gas as a fuel for feed pre-heating.
- Volatiles are removed from the feed blend prior to the furnace, thereby improving off-gas CO quality.

Mining Advancements

In-Pit Crushing & Conveying (IPCC)

IPCC systems represent an innovative and more sustainable approach to materials handling in surface mining operations. Instead of relying on diesel-powered haul trucks to transport run-of-mine (ROM) material from the pit to the processing facility, an IPCC system crushes material or ore directly at or near the mine face and transports it via a network of **energy-efficient conveyors**. This system **increases safety** and **efficiency**, while also significantly **reducing emissions** and **lowering operational costs**, furthering the mining industry's **global green transition** and decarbonization goals.

Gearless Conveyor Drive (GCD) Technology

TAKRAF, together with its drive technology partners, is able to design and supply **conveying solutions** that adopt **advanced GCD technology** into their **drivetrains**. GCDs eliminate the need for a gearbox, thereby significantly reducing the number of **main wear parts**, which results in increased **efficiency** and **reliability**, as well as **less maintenance** being required. Further significant advantages include a considerable **reduction** in the **drive system's footprint** and **emissions**. In fact, for a large copper mine in Chile, studies showed that CO_2 emissions were reduced by 66% as compared to diesel truck engines for the same copper production volume.

TAKRAF is proud of its position as the **only existing global original equipment manufacturer (OEM)** boasting an operating reference in the **use of advanced GCD technology in conveyor systems** and the important benefits the implementation of such technology provides.

High-Pressure Grinding Rolls (HPGRs)

Employing HPGRs for grinding is increasingly recognized as a key technology for **improving energy efficiency in ore processing** – comminution is the most energy-intensive of mining processes. HPGRs employ **high pressure** to compress and fracture ore particles between two rotating rolls, which significantly reduces the energy required, especially when processing hard materials. This energy-efficient technology allows for a **reduction in process energy intensity** and, at the same time, enhances **downstream flotation efficiency** by improving particle size distribution and mineral liberation.

DELKOR BQR Flotation Cells

Efficient and reliable **flotation** is essential for **maximizing mineral recoveries**, and DELKOR's BQR Flotation Cells are designed with this goal in mind. **DELKOR's BQR Flotation Cells**, which now boast DELKOR's proprietary **MAXGen mechanism**, improve the recovery rate of valuable minerals while using less energy, thereby increasing overall processing efficiency.

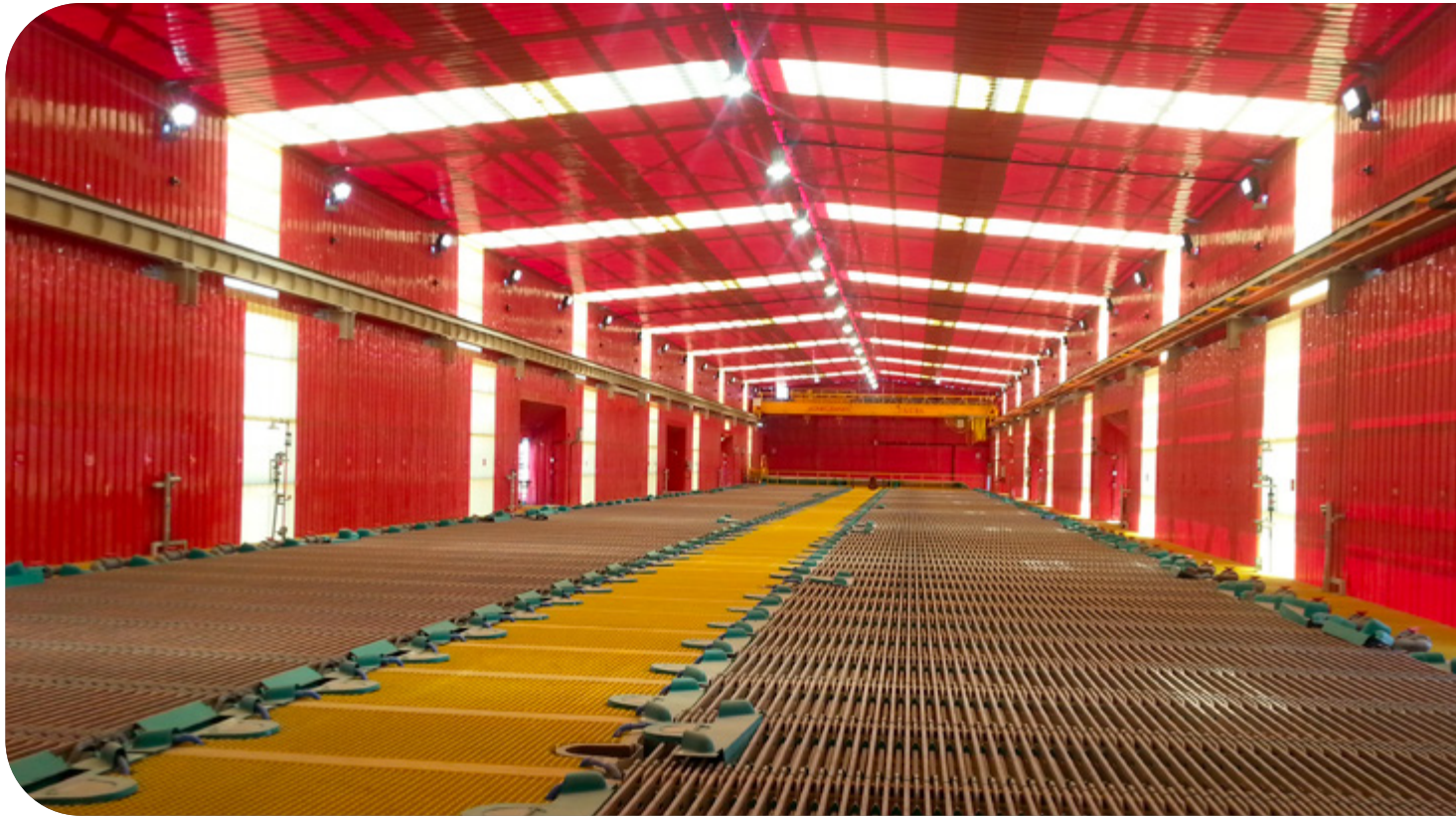
Circular Economy

Industrial processes inevitably generate a variety of waste byproducts. At Tenova Group, we are committed to supporting the circular economy by developing technologies that enable the recovery, reuse, and valorization of these materials, reducing their environmental impact. In the metals business, our solutions focus on the efficient treatment and transformation of steelmaking byproducts, such as slag, into valuable secondary materials. In the mining business, our comprehensive portfolio of dewatering equipment is designed to reduce freshwater usage and manage tailings and waste more effectively. Together, these efforts help our clients operate more sustainably across the entire metals and mining value chain.

Metals Advancements

Auto Catalyst and Battery Recycling

Melting furnace technology is used to recycle the **PGM's (Precious Group Metals)** contained in spent auto catalysts. As the first generation of electric cars reaches the end of its cycle, there is a real opportunity to **recover valuable materials contained in various electric car systems** (primarily the battery and auto catalyst). Tenova offers both **hydro and pyrometallurgy process paths** to recover these materials.



Electric Arc Furnaces

The primary production of steel from virgin iron ore is highly energy intensive. This can be mitigated without loss in quality by using **ferrous scrap mixed with DRI/HBI** and other virgin iron units (pig iron / hot metal) when necessary. Quality and availability of steel scrap are therefore important factors, especially considering the decreasing quality of world steel scrap. To this end, we are conducting research and implementing **new industry 5.0 technologies** to manage low-quality scrap in furnaces, improve EAF flexibility, and achieve cost savings while enhancing environmental performance. EAF steel production is already an integral part of the circular economy.

Additionally, Tenova is implementing **innovative approaches** to **increase the recycling process**, replacing the use of injected coal in the EAF with alternative materials that are byproducts from other industrial processes, like polymers from waste plastic and by treating EAF process residues, such as slag and fume dust, to recover both metal and mineral fraction for internal use or application in other industries.

In October 2024, Tenova secured a contract with **Tata Steel UK** to supply a **high-productivity Consteel® Electric Arc Furnace (EAF)** and associated equipment for their **Port Talbot plant**. By **replacing** the current **blast** furnaces, the new state-of-the-art production line will significantly reduce carbon emissions while ensuring the continued production of **high-quality flat steel**. This project is a key element of the joint agreement between Tata Steel and the UK government, aimed at the decarbonization of steelmaking in the UK, with an estimated reduction of 50 million tons of direct carbon emissions over the next decade.

Tenova Goodfellow Inc.'s NextGen® for Dongkuk Steel Mill in Korea

In 2024, Dongkuk Steel Mill Co. Ltd. contracted Tenova Goodfellow Inc. to supply and install its **NextGen®** System at their Incheon Plant in **South Korea**. Designed for a 120-ton AC shaft furnace, the system includes advanced sensors for off-gas measurement, featuring two sampling stations and a central cabinet. With hybrid laser/extractive off-gas analysis, the system **offers fast response times and monitors CO, H_2O, CO_2, O_2, and H_2**, enabling real-time control and improving efficiency. Its low maintenance needs also lead to cost savings in hardware and installation. Unlike other laser technologies, **Tenova's patented NextGen® system offers full-spectrum analysis**, enabling complete control without compromising dynamic burner, lance, and fume system suction management. It also provides enhanced water detection and real-time mass and energy balance, essential for controlling both chemical and electrical energy inputs to the **EAF**. In contrast to in-situ systems, which offer only intermittent off-gas analysis, **NextGen® delivers continuous, simultaneous analysis from all sample locations**. The system uses a high-velocity pump to extract, filter, and clean off-gas before it enters the sample station laser cells, ensuring uninterrupted laser beam transmission. Key components include the gas probe, heated sample line, sample station cabinet, control cabinet, and analyzer server.

Dry Slag Granulation

The **capture and reuse of currently wasted materials**, such as EAF or ladle furnace slag, is a critical step in the decarbonization of the steel industry. In 2016, the European steel industry generated about 43 million metric tons of slag, of which about 7% — or 3 million metric tons — is not being reused, posing not only a serious environmental problem in Europe, but representing a huge amount of available material for potential **recycling**. Today, slag handling is a costly and time-consuming operation that poses significant safety and operational risks, requires water, and is a potential source of fugitive dust and fumes.

Tenova has developed a **Ladle Furnace (LF) slag granulation solution**, which uses forced air flow to rapidly cool and solidify slag. The fast cooling transforms the slag from liquid to solid, enabling the reuse of slag as raw material in the construction industry. Our solution **decreases workers' exposure to harmful chemicals** in slag, reducing water use, and the need for virgin lime. Furthermore, we extended our dry granulation technology to EAF slag generated during high alloy steel production via the DRI/EAF process.

In 2023, Tenova was awarded the first contract for the installation of an LF dry slag granulation solution system in Italy, which will process more than 20,000 tons/year of slag. The first of its kind, the plant will be equipped with the **latest artificial intelligence algorithms** to assist production optimizing the granulation process. The granulated product will then be utilized for the preparation of chemicals for the construction industry.

The **air granulation technology** represents an important advancement compared to traditional slag treatment methods. In the first industrial plant started up in Italy in 2025, the granules produced by air granulation maintain superior stability and do not tend to pulverise, unlike traditional granulation where slag easily turns into fine dust. This advantage helps create healthier and safer working environments by reducing the dispersion of harmful dust into the air and improving operational conditions.

In 2025 Tenova launched on the market the **Tenova LIBS (Laser Induced Breakdown Spectroscopy) technology**, a tool that allows slag analysis without the need for sample preparation, instantly providing the slag's composition both from a metallurgical perspective and for its valorization and subsequent granulation. The system operates by directing a laser beam onto the slag; the instrument analyses the electromagnetic spectrum of the plasma generated by the laser, while a mathematical model, supported by artificial intelligence, enables real-time results.

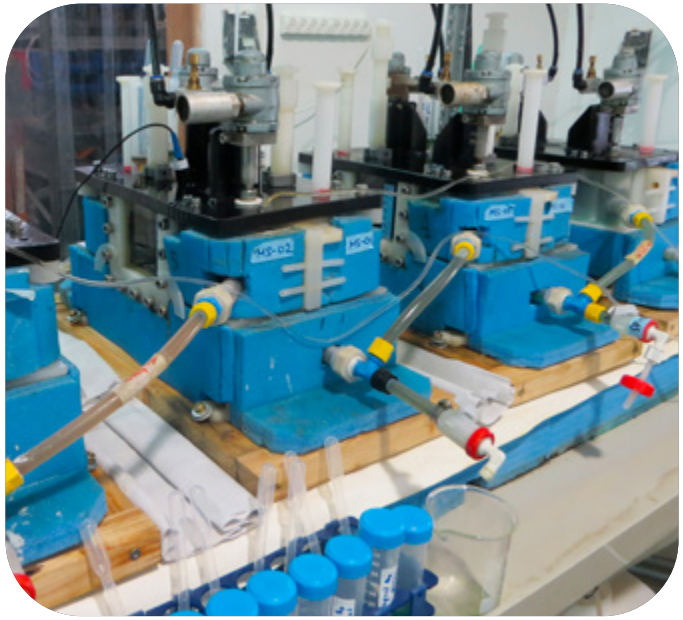
This instrument can fit easily in an operating pulpit of existing facilities enabling operators to reduce to zero the delay to obtain an **accurate slag analysis**: this speeds up the secondary metallurgy processes and reduces consumption of both electricity and additives.

Lithium Recovery

Lithium is widely used in metallurgical processes for **metal melting**, to **eliminate the formation of oxides, and absorb impurities**. Its growing use in clean energy technologies, like solar arrays and electric vehicle batteries, make it a **critical metal for a net-zero future**. Building on this potential, Tenova's engineers have studied a number of processes to produce lithium more efficiently. **Tenova Advanced Technologies (TAT)** adapted its Solvent Extraction (SX) technology for producing **lithium from primary sources** to produce **lithium recycled from batteries**. For this project, Tenova Advanced Technologies secured funding from the Israel Innovation Authority to complete the process development from both brine and battery sources. One of the main uses of the funds was the purchase of the **LiEL™ Electrolysis skid** for the TAT Research and Development (R&D) Center in Israel. The new process can be applied across all feed streams, originating from any source, including solar, hard rock, waste recycling, and process waste streams, to produce high-quality lithium hydroxide. The key characteristic of this process is the **high efficiency of extraction**, superior to the traditional process, and a **lower use of water**.

Rare Earths

Rare earth elements are among the most **sought-after chemicals** worldwide, **essential to modern technology** and everyday life. They are found in devices like smartphones, computers, electric vehicles, wind turbines, and solar panels. Recognized as critical raw materials by both the European Commission and the US Department of Energy, rare earths are vital for **advancing the energy transition** and achieving global decarbonization goals. Tenova offers a range of solutions for a sustainable **rare earths metal extraction**.



Black Mass and Rare Earth Solvent Extraction

TAT specializes in both innovative technology development and robust process equipment for **solvent extraction**. Our experience and expertise in all aspects of SX includes the development of SX processes utilizing an in-house R&D center and detailed design, supply and construction of SX plants.

Tenova Turbulent Technologies Mixing System is a new mixing technology which enables **significant reduction of entrainment levels** without changing the process flow. It can be easily retrofitted to most existing mixer settlers or installed in new SX plants. The main advantage of this technology is the reduction of entrainment of expensive extractants, organic contamination in the product stream, aqueous contamination in the loaded organic stream, ecological impact of organics in the raffinate stream, operation, and maintenance costs. It further enables increased settling flux and eliminates the need for after-settlers. Thanks to this technology, our clients are able to **recoup precious metals** such as **lithium**, **nickel** and **manganese** from battery forms.

The World's Strongest Permanent Magnet[5]

Tenova has designed, manufactured, and commissioned **advanced electrolytic cells** for the efficient commercial production of NdPr metal. Equipped with cutting-edge automation and an automatic tapping system, **these cells ensure operational efficiency, stability, and high product quality**. Our proprietary sensors and integrated control system optimize performance and reliability, supported by auxiliary equipment to enhance plant operations.

This technology has been deployed by MP Materials, marking the **first commercial-scale production of rare earth metals in the USA** in decades. MP has an agreement with General Motors to supply permanent magnets to make **electric cars** in the US, and, to date, it is the only manufacturer of these magnets. At this facility, NdPr metal will be used to produce NdFeB magnets—among the most powerful permanent magnets available commercially, and is essential for vehicles, drones, robotics, electronics, aerospace, and defense. Tenova Group, which initially developed this technology with the University of Toronto, is proud to contribute to this milestone, reflecting our **dedication to innovation and the energy transition**.

Twin-chamber Furnaces for Aluminum

Aluminum's many useful qualities have made it ubiquitous across all areas of modern life. Additionally, its recyclability makes it a highly valuable material. **Recycling aluminum** uses up to **95% less energy** than it would take to produce primary aluminum from ore or bauxite, creating fewer emissions. Tenova has created new technologies to further enhance the environmental benefits of recycling aluminum. Our **Twin-Chamber Melting Furnace (TCF®), a Tenova LOI Thermprocess technology**, enables the remelting of up to 6% organically contaminated aluminum or other scrap metal without pre-treatment. Its dual-chamber design includes a post-combustion process to completely incinerate contaminants and use the resulting energy generated for furnace processes, thus reducing consumption of external energy. Our TCF® technology has **30 installations worldwide**, producing approximately 1,500,000 MT of liquid aluminum every year. And for existing casthouses, the application of TCF® to the recycling of post-consumer scrap can significantly reduce the overall CO_2 emissions of the plant, as the process generates only 80 kg of additional CO_2 per ton of liquid aluminum.

Magnesium Production from Coal Ash

As global demand for magnesium metal rises, **Latrobe Magnesium Limited (LMG)** in Australia uses Tenova's technology to **harvest this metal from fly ash byproduct** – a waste material derived from coal power generation. Originally developed as a recycling process for spent acid used in pickling of steel coils, our **pyrohydrolysis process** was adapted to suit LMG's unique challenge to **recover magnesium** from secondary sources. The related emissions from this technology are roughly half of those of conventional magnesium production plants. Launched in 2022, LMG is currently operating its 1,000 tons per annum magnesia demonstration plant in the Latrobe Valley of Victoria integrating the Tenova Spray roaster unit. From the production experience acquired through this initiative, LMG eventually intends to develop a commercial scale operation producing about 10,000 tons of magnesium metal per year.

[5] https://tenova.com/metals-insights/worlds-strongest-permanent-magnet

Mining Advancements

DELKOR Thickener

The DELKOR Thickener is renowned for its ability to effectively **dewater process slurries** across various mining and industrial sectors. This enables **significant water recovery** and allows for the reuse of such process water, significantly **reducing freshwater intake**. This is especially relevant in **water challenged areas** in which many mining and minerals processing operations are situated.

The DELKOR Thickener also features an **advanced feedwell design**, employing either auto or forced dilution techniques. This innovative design significantly **reduces flocculant consumption**, typically by 10 to 15% compared to traditional feedwell designs, which further **lowers operational costs** and **enhances** the overall **efficiency** of the thickening process.

DELKOR's supply of seven **60-meter diameter DELKOR high-density thickeners** to the world's largest **thickened tailings project in Chile** (currently still under development) is a testament to DELKOR's thickener technology and its ability to provide a **safe and sustainable** dewatering solution for tailings management.

DELKOR's high density thickener technology helps the mining operation reduce freshwater intake and operate more safely. Its position as a leading global provider of high-performance dewatering solutions is essential for water recycling, for increasing safety and for reducing the environmental footprint of tailings facilities in arid regions such as Antofagasta, Chile.

DELKOR Horizontal Belt Filters (HBFs)

In line with circular economy principles, **DELKOR horizontal belt filters (HBFs)** offer an efficient solution for resource recovery and waste reduction across various industrial processes. These high-capacity vacuum filtration systems are able to dewater a wide range of materials, enabling both **water reuse** and **more sustainable residue management**. DELKOR pioneered the application of belt filters in acid filtration, and this technology is now widely accepted and employed for tailings filtration too. By supporting closed-loop processes and reducing freshwater intake, HBFs help improve overall operational efficiency and environmental performance across sectors.

DELKOR Filter Presses

DELKOR Filter Presses offer an effective solution for reducing waste and enhancing the reuse of water in both mining and industrial operations. By applying **high pressure** to dewater a wide range of commodities, these systems produce a dry filter cake that can be safely handled, stored, or even reused, depending on the application. Commonly deployed downstream of mineral processing plants, as well as in chemical, fertilizer, and wastewater treatment facilities, DELKOR filter presses support the **sustainable management of tailings and sludge**. Their ability to effectively recover water and significantly reduce waste volumes contributes directly to greater resource efficiency and a lower environmental footprint.

Impact Monitoring

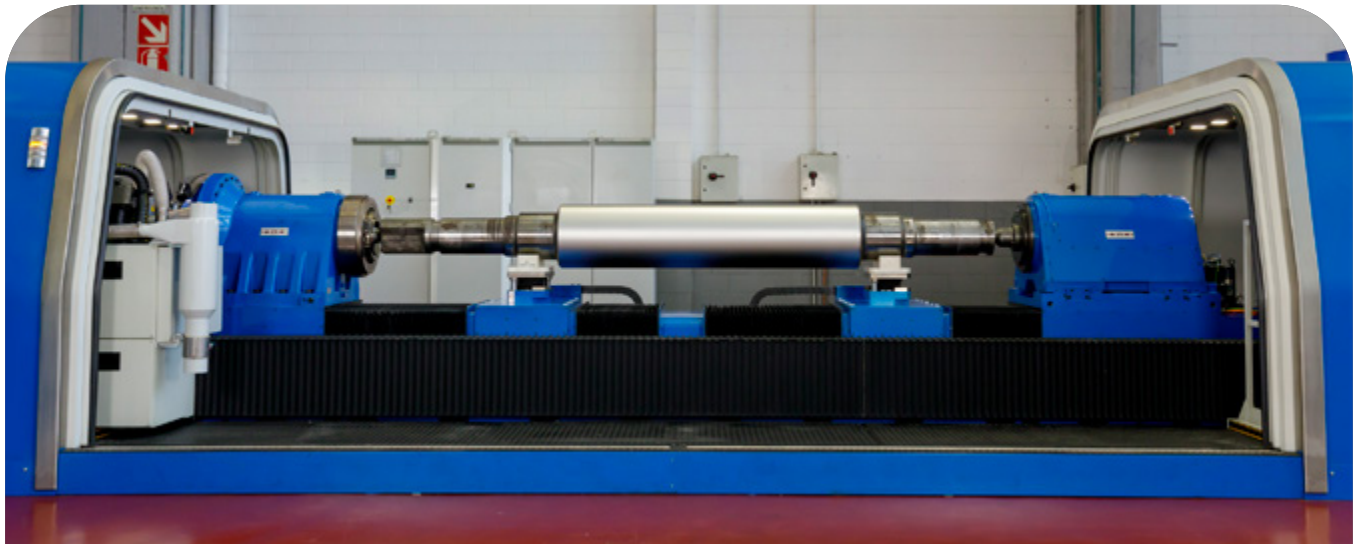
As a responsible company, we recognize the importance of monitoring the impact of our products and services on the environment and human health. We commit to improving our processes and products to ensure their impact is accounted for throughout their entire life cycle.

Pomini Digital Texturing™

Our **Pomini Digital Texturing™ (PDT™)** equipment covers an extensive range of surfaces for **work roll texturing** in **cold rolling mill applications** for both the steel and aluminum sectors. With up to four state-of-the-art lasers, the process requires **minimal power consumption**. A fully digital process, based on modern **fiber-optic laser heads**, PDT™ enables an unparalleled range of surface possibilities compared to any other existing texturing technology.

PDT™ offers benefits beyond energy efficiency. It does not have adverse impacts on human health. Other texturing technologies may require the use of significant quantities of hexavalent chromium to further increase the hardness of the roll surface. **Hexavalent chromium** is a highly carcinogenic material which can be difficult to remove from the environment. PDT™ makes it possible to **significantly reduce**, and even completely eliminate it from the process, making it a much safer and less toxic alternative.

Looking ahead, Pomini Tenova foresees **several impactful potential uses** for the revolutionary PDT™ technology. One use we are currently exploring is in the field of electrolyzers - machines that convert water into hydrogen to be used as a clean-burning fuel, a key enabler of a low-carbon future. A second area of development is in **electric vehicle batteries**. We are exploring the use of PDT™ on aluminum foil to obtain a reduction in intrinsic resistance characteristics through texturing. We look forward to sharing more about these and other potential applications in the future.



PDT™ becomes "Product Category Rule" through Life-Cycle-Assessment (LCA) as per ISO 14025:2006

In 2021, **PDT™** became the first machine in the metal surface finishing sector to complete a **life cycle analysis** (LCA). As a result, the technology was certified as complying with the **ISO 14025:2006 standard**. The LCA analysis was registered on the EPD® Portal – the platform of the International EPD® System, the world's leading global LCA program operating in accordance with the ISO 14025, ISO/TS 14027, and ISO 14040, among others, standards, and is now accessible to all users. Subsequently, thanks to the experience gained through the LCA process, Pomini Tenova legitimately takes on the position of the "**Product Category Rule**", the rules, requirements, and guidelines to develop a high-quality EPD for a specific product category, ensuring that functionally similar products are assessed and compared in the same way when measured through an LCA.

Delivering **Safe Products by Design**

Tenova Group encourages employees at every level to focus on eliminating potential dangers before they emerge. This means safety starts at the design stage, leveraging the experience, know-how, and innovative approaches of our experts and engineers to build safety directly into products from the start. This unwavering attention to detail has enabled us to build an extensive, multi-decade track record of safe and high-performing products, systems, and facilities.

Safe Technology for Clients

A **tech-forward approach**, focused on digital technologies, data gathering, data analysis, and dedicated training, enables us to deliver products with **considerable safety advantages**. We build monitoring features, including robotics, smart sensors, and AI, directly into our products. We collect digital data on facility performance and production errors and compile digital report cards for maintenance effectiveness and troubleshooting. These innovations provide real-time and predictive analytics to **enable clients to prevent accidents** and **reduce potential harm to their employees**.

Metals – Safe Technologies

Water Detection System (WDS)

Our **Water Detection System (WDS)** enables **EAF process monitoring optimization** by measuring the sound of the water flowing in the water-cooled sidewalls. Additionally, our WDS **monitors leaks and alerts plant operators** when higher-than-normal water conditions are present in the EAF. Tenova's WDS is the only commercially available system that is capable of continuously interconnecting with the EAF off-gas for both H_2 and H_2O vapor. The real-time EAF process information and NextGen® off-gas hardware include full spectrum analysis of the water conditions in the EAF, which are evaluated for abnormalities.

Copper cooling systems for SAFs

Submerged Arc Furnaces (SAF) for PGM concentrates Tenova's Submerged Arc Furnaces (SAF) are engineered to provide **reliability and safer operation** when processing **Platinum Group Metals (PGMs)** concentrates, supported by an electrically driven process with **high process efficiency at low energy utilization levels**. A key safety-by-design feature is Tenova's patented approach combining graphite with copper cooling to **prevent sulfide corrosion** of copper cooling elements in the furnace sidewall. In this design, the graphite acts as a protective barrier against corrosion caused by free sulfur present near the sidewall adjacent to the concentrate feed layer, helping preserve the integrity of the cooling system and extending stable furnace operation. Tenova also integrates advanced automation and robotics to reduce human exposure to hazardous areas. In particular, the automated casing addition solution for Søderberg electrodes addresses one of the main contributors to electrode failure by improving the quality standard of electrode casing welding and supporting more stable, safer operations, while removing personnel from a potentially hazardous environment.

Complementing these measures, Tenova's safety portfolio includes **MEGtec™**, an alternative cooling medium approach designed to drastically reduce the risk of explosions caused by leaks from furnace equipment such as sidewall coolers, taphole block, and electrodes, with minimal equipment changes and suitability for adoption in existing operations. Tenova reports that 2024 tests demonstrated no explosion in liquid metal even with substantial leaks from sidewalls or copper coolers using this system. Finally, Tenova's SAF equipment heritage for high temperature smelting includes dedicated cooling and protection concepts (e.g., copper cooling and graphite tiles for sulfur attack) that support robustness in aggressive environments.

PDT™

PDT™, presented in the "Impact monitoring" paragraph (p. 36), is inherently fire risk-free and fully enclosed, thus reducing the exposure of workers to internal processes.

SAFE+ (Safe Plus) EAF configuration

Our **SAFE+ (Safe Plus) EAF configuration** allows **operators to remain in a comfort area** and **detect several possible critical situations**, like water leakage. The introduction of several robotized operations and remote control of the furnace improves the working conditions of operators in the melt shop, particularly in the area surrounding the furnace.

Tenova, through its Business Unit Tenova Material Handling (TMH), is developing a main R&D project with the aim of improving the value for clients in terms of safety and workers' wellness.

SafeForPorts is a **pioneering initiative** that leverages **Virtual Reality (VR) and AI** to revolutionize **port operations**, prioritizing **safety** in the maritime industry. The project is part of the Istituto Italiano di Tecnologia's (IIT) **RAISE** (Robotics and AI for Socio-economic Empowerment) and is implemented under Italy's National Recovery and Resilience Plan, funded by the **European Union – NextGenerationEU**, highlighting its significance in driving innovation and safety within the maritime sector.

A combination of **digital twins** and **VR** allows company stakeholders to immerse themselves in port operations and fully understand data, providing solutions. Digital twins enable companies to show their technical teams the global layout of the equipment and train for the operation that will be required. All of this can be presented concisely through the interlinking digital twins with virtual and augmented reality. This **allows the operators to train** without the stress of incidents and builds confidence for when they will operate on real machines.

Thanks to **remote control**, the **TMH machine** can be operated **remotely**, typically in a building. This allows operators to work in more comfortable conditions and increases machine availability, reducing the time for shift changing and allowing the machines to work in poor weather conditions.

The remote control feature has been highly **appreciated by ADI (Acciaierie d'Italia)** which is going to include this operation mode for their **continuous ship unloader** supplied by TMH in 2025.

The SafeForPorts project has gained significant momentum thanks to the **synergies** between **automation teams** in Tenova. A **pilot system** has been implemented to assess the confidence level of a skilled operator while driving the **ship unloader remotely**, i.e., without a direct view of the working area. The goal is to determine whether the working environment reproduced at the remote station provides a **sensory experience comparable to direct view** operation. The evaluation focused on key factors such as visual details, granularity, and realistic perception of each piece of equipment as well as dimensions and sounds. Thanks to all the sensors and cameras installed, the operator is allowed to experience optimized visibility from a remote station as if he were on board the unloader.

Full Automation represents the most ambitious goal that TMH wants to achieve. The target is to reach **unmanned operation of TMH Port Machines**. The expected results are: an **optimization** of the **operation sequences** with a consequent **energy consumption reduction, better operating conditions** for operators who will have to supervise the activities but in less stressful conditions, and a **reduction** of overall **operating time**.

Mining – Safe Technologies

Tenova Group prioritizes safety in all its designs, including the mining industry: both **TAKRAF** and **DELKOR** promote a **holistic maintenance philosophy** that enhances safety, operational efficiency, and reduces the total cost of ownership by integrating maintenance requirements from the earliest engineering stages.

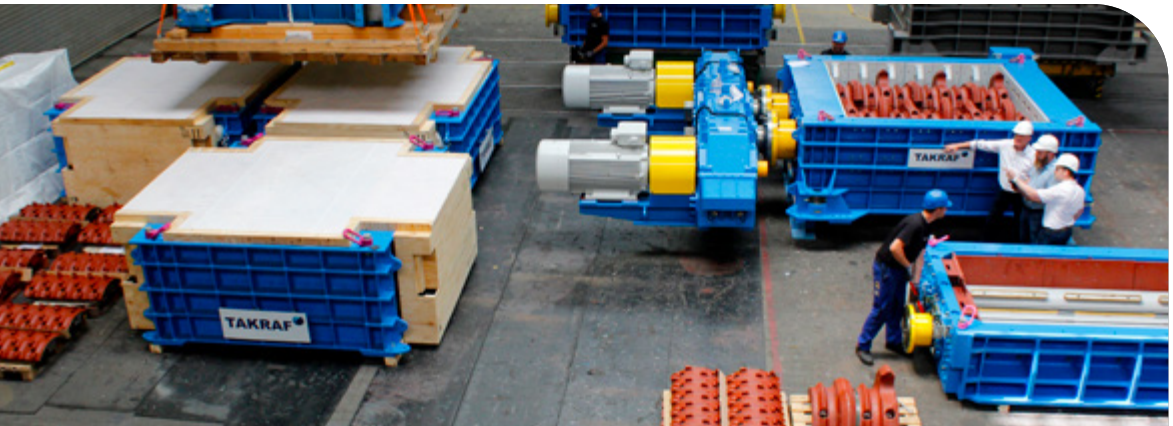
TAKRAF's innovative solutions for **chute maintenance**, from modular or rotatable chute sections, which allow maintenance to be performed in a much safer manner and significantly reduce downtime, to TAKRAF's technology that physically replaces liners safely from outside the chute, all contribute to a much safer work environment. Techniques such as external ultrasonic wear measurement enable planned **maintenance without entry into confined and dangerous spaces**.

TAKRAF continues to design and sell maintenance carts for **elevated and/or steep** belt conveyors. These carts enable the safe and quick access to any point along a conveyor, significantly enhancing safety and efficiency, even in complex terrains with elevated sections and curves.

At Tenova Group, safety is **non-negotiable** and prioritizing it can mean turning down opportunities that do not meet our standards.

In 2024, TAKRAF declined to bid on an important project with a major global mining company **on the grounds of safety**. TAKRAF engineers deemed the required technical operating parameters of the requested machine too extreme and outside of what would be considered safe parameters for slope steepness and technical feasibility. TAKRAF's proposed alternative solution to reduce slope steepness was rejected, leaving TAKRAF with no choice but to **decline to bid**, **citing significant safety concerns** regarding the operation of such a machine within the required technical operating parameters and harsh operating conditions of the mine site.

The following content provides further background on some of the **innovations and challenges** that TAKRAF and DELKOR continued to develop throughout 2025, proving that **safety and efficiency can complement one another.**



TAKRAF X-TREME Class Sizer: Redefining Maintenance, Safety and Productivity

As mining operations adopt more advanced equipment and face tougher conditions, there is an urgent need for maintenance concepts that are both safe and efficient - increasing the protection of workers, whilst at the same time minimizing downtime. While traditional views suggest that increased safety complicates and slows down maintenance, TAKRAF's **X-TREME Class Sizer** challenges this assumption.

Designed according to TAKRAF's holistic maintenance philosophy, the brand's X-TREME Class Sizer combines durability and abrasion resistance, together with a modular-type design to **minimize wear** and **simplify maintenance**. The machine's components allow for quick and adaptable servicing, from replacing individual crushing teeth to roll segments or even entire rolls with reduced disassembly and downtime.

Key features such as a quick-release system, split housing for shaft removal, and integrated sliding units all contribute to increased safety and reduced maintenance times. **TAKRAF** emphasizes that **safety and efficiency in maintenance** are complementary goals, with safer operations leading directly to higher productivity.

The TAKRAF Sizer Hot-change Method

Another prime example of increased safety and efficiency is **TAKRAF's sizer hot-change method**, which allows for safe and quick swapping between an operational sizer and a spare machine on the same platform, minimizing downtime. For larger operational setups, a checker-type arrangement enables multiple sizers to share a common spare machine, which can be supported by an optional bridge crane for handling, further boosting efficiency.

These solutions allow maintenance activities to occur separately from operations, **improving safety and ergonomics** while **reducing time pressure** that can lead to unsafe shortcuts. While such systems may require higher initial investment, they ultimately reduce overall ownership costs by enabling safer and faster equipment reintegration, maximizing production time.

TAKRAF's commitment to separating operation from maintenance exemplifies how safety and efficiency can go hand-in-hand, proving that **smarter maintenance solutions** are able to combine both increased safety and increased efficiency, without compromise.

Innovative Tie Rod Replacement on a Ship Unloader: Safe and Efficient Solution

In recent years, TAKRAF's Brazil office was tasked with replacing the **tie rods** connecting the main boom to the counterweight boom of a **Continuous Ship Unloader (CSU)** commissioned in 2002. The challenge was to complete the work safely, efficiently, and within tight time and budget constraints.

Traditional tie rod replacement involves extensive scaffolding to support the machinery, but this method was unsuitable for the project's tight schedule. TAKRAF Brazil's engineering team devised an **innovative solution** by employing a **temporary tie rod** to maintain stability, eliminating the need for scaffolding altogether.

This approach allowed the project to be completed in less than 15 days, 60% faster than by using a traditional approach with scaffolding, and reduced costs by nearly 50%. Importantly, the work was carried out without any accidents and without disrupting other critical equipment, such as the jetty conveyor beneath the CSU.

This project is just one of many examples that highlight TAKRAF's commitment to **innovative, safety-first solutions that optimize efficiency.**

TAKRAF's Advanced Remote and Condition-Based Maintenance Systems

Bulk material handling systems are the life blood of mining operations, linking mines to processing plants, stockyards, and markets through reliable and efficient material movement and storage. Any disruption in this chain impacts productivity, making maintenance essential. To address this, TAKRAF develops automated solutions that **maximize safety** and **efficiency in maintenance** across mining, material handling, and mineral processing equipment.

TAKRAF's equipment features advanced **Programmable Logic Controller (PLC)/ Distributed Control System (DCS)**-based control systems with built-in protection to **reduce operator errors** and **support troubleshooting**. These systems integrate with clients' asset management, Enterprise Resource Planning (ERP), and Manufacturing Execution System (MES) platforms to plan preventive maintenance effectively. Remote access and support enable software updates and expert assistance via smart glasses, augmented reality tools, and web-based dashboards, showing key performance indicators and maintenance schedules.

Condition-oriented maintenance is facilitated through sensors and advanced monitoring tools that track component health, such as idler bearings and belt conditions. Additionally, intelligent lock-out procedures enhance safety by allowing maintenance teams to securely isolate power, increasing safety, and reducing downtime during troubleshooting and repairs.

Advancing **R&D** Innovation

Research, **Development** and **Innovation**

At Tenova Group, we enhance existing technologies in the metals and mining sectors, while also designing and producing innovative solutions that minimize the environmental impact of our clients' facilities and boost their efficiency and performance. Our solutions reduce CO_2 emissions to some of the lowest levels in the metals industry. We create cutting-edge technologies that **reduce** fine particles, NO_x emissions, dioxins, and other **hazardous substances**. We strongly believe in the potential of alternative and renewable energy sources, incorporating them into our solutions wherever possible. We have already put **hydrogen-ready technologies** on the market, and many of our solutions are designed around the concept of **recovery**, **reuse**, **and circularity**, from dispersed energy to reutilized residues and more, fostering an effective circular economy.

Our innovation process begins with **research, an open-ended, creative ideation phase**, and is followed by development, where ideas with high potential are turned into prototypes of future products. Finally, once tested and finalized, the product is produced and marketed to customers. This process cuts across a number of teams and business units, including engineering, functional units, sales, and more. Our attention to sustainability has been a successful driver of business growth for Tenova Group. We are coordinating our **R&D&I** (Research, Development, and Innovation) efforts across **business units and product lines**, to find integrated, synergistic solutions through collaboration.

Our R&D&I focus areas currently are **energy transition**, **local environment**, **process flexibility and efficiency**, **raw materials and residual valorization**, **safety**, and **final product quality**. We have identified how each of these focus areas contributes to the United Nations Sustainable Development Goals (UN SDGs). The UN SDGs serve as a useful guide for businesses and society to align on to advance sustainable development. To further our impact, we also participate in national and regional working groups, including EU ones, on sustainable topics like circular economy and decarbonization to generate projects, roadmaps, and partnerships.

Metals - 2025 R&D projects

Between 2024 and 2025, Tenova submitted seven proposals for EU and Italian funding for projects covering several areas of interest and involving different business units. Of these, five were selected for funding. Three of them have kicked off in 2025.

Slag2Build[6]

The Slag2Build project aims to demonstrate, at industrial scale (TRL 8), the technical and environmental feasibility of a large demonstration dry granulation technology for the treatment of ladle furnace slag (LFS). Unlike the Best Available Technique (BAT) currently adopted in the EU iron and steel industry, this technology relies on a **controlled air-jet collision system** to instantly quench **liquid slag without using water**, thus **preventing** the generation of **dust** and **alkali fumes**.

Slag2Build's innovation lies in transforming an **unstable by-product** into a **valuable secondary raw material** for hydraulic binders, road stabilisers, and cementitious products, addressing both industrial decarbonization and **resource efficiency goals** set by **EU policy**.

PRISMA[7]

PRISMA is pioneering sustainable practices in the European steel industry, aligning with the **Green Deal** and **Twin Transition** objectives. Central to PRISMA is the development of a **Unified Environmental Data Model (UEDM)**, streamlining **environmental reporting** and **analysis** across the **steel value chain**. Leveraging modern digital infrastructure and platforms, PRISMA aims to quantify and mitigate steel production's carbon footprint through, for example, dynamic Life Cycle Assessments (LCAs) and Digital Product Passports (DPPs).

SYRIUS[8]

In light of the pressing challenges posed by climate change and the necessity of a transition towards more sustainable and efficient energy systems, the industrial sector is urged to achieve significant reductions of energy consumption and CO_2 emissions. The steel industry stands at the forefront of this challenge.

SYRIUS aims to address such challenges by integrating a **SOEC system** producing **green hydrogen** into a real **steel manufacturing plant** with a **slab reheating furnace**, integrating **heat and water recovery** and **steam generation**.

Moreover, **two additional projects** have been selected for funding, and the administrative formalization is currently ongoing with the EU Commission:

- **EU Research funded by RFCS Big Tickets call SuperHeat**: The SUPERHEAT project aims at developing, integrating and demonstrating a novel electrified burner (eBurner) technology for CO_2-neutral steel reheating for hot rolling process with improved energy efficiency and source flexibility, and without affecting core quality indicators of the process.
- **EU Research funded by RFCS call REVOLUTE**: REVOLUTE objective is to optimize the cold rolling process through the development of a lubrication procedure integrating a novel laser technology for work rolls texturing and the use of easily disposable and sustainable industrial lubricants to reduce energy costs, to reduce environmental impact and to improve product quality.

[6] Funded by the Research Fund for Coal and Steel (RFCS) GA number 101193261.

[7] Funded by the Research Fund for Coal and Steel (RFCS) Big Ticket programme under GA 101193563.

[8] Supported by the Clean Hydrogen Partnership and its members under GA number 101192534.

Furthermore, in 2025 we have made significant progress on the following projects:

HyTecHeat[9]

In 2022, Tenova was awarded a Horizon Europe project to demonstrate blended green hydrogen and fossil fuel firing in industrial furnaces. The HyTecHeat project aims to **advance hybrid heating technologies** by evaluating their effects on steel product quality, refractories, and overall heating processes. Industrial tests on real burners across three European sites will support the steel sector's transition to hydrogen. Tenova's demonstrator at TenovaLAB has been selected as a key example for hydrogen use in industrial reheating furnaces.

Initially, Tenova combined modeling and experimental testing to develop industrial burners capable of using hydrogen with conventional fuels in varying ratios. We will also provide an industrial-scale combustion system fueled by green hydrogen to validate its technical feasibility in industrial furnaces.

At TenovaLAB, existing equipment currently supports full-scale combustion systems using natural gas. Adapting the facility for hydrogen involved two approaches: hydrogen trailers or on-site hydrogen production. Due to capacity limitations of trailers, continuous on-site hydrogen production is preferred. Accordingly, Tenova installed a **1.5 MW alkaline electrolyzer** that employs the advanced Dragonfly® system - developed by De Nora, a company specializing in electrochemistry and sustainable technologies - to produce green hydrogen from renewable electricity. The hydrogen is stored in pressurized buffer vessels at 30 bar, then expanded to 0.3 bar before feeding the hydrogen-ready TLX burner prototype (350 kW) installed on the test furnace. This burner operates under real industrial conditions with natural gas/hydrogen blends and oxygen-enriched air.

The combustion system's PLC integrates control and safety signals with the electrolyzer's PLC and hydrogen buffer pressure loop, decoupling hydrogen production from consumption. This design allows the hybrid burner to closely follow furnace thermal demands while overcoming electrolyzer turndown limitations.

Additionally, the project integrates a **comprehensive hydrogen storage system** provided by Snam, a leading European gas infrastructure operator, ensuring safe and efficient handling of hydrogen produced on-site. This setup is part of a broader HyTecHeat initiative, with € 3.3 million EU funded, which includes multiple demo cases focused on hybrid burners and the progressive transition to 100% hydrogen use in steel reheating. The project targets significant reductions in Scope 1 CO_2 emissions, with potential EU-wide savings of 7.5 to 25 million tons annually.

The demonstrator highlights critical challenges in green hydrogen adoption at industrial sites, including:

- Flexibility of hydrogen production and consumption.
- Integrated control of combustion and electrolyzer systems.
- Efficient storage of surplus green hydrogen for later use.

By encompassing the entire production chain - from green energy generation via photovoltaics to hydrogen production, storage, and furnace operation - HyTecHeat sets a benchmark for safe, efficient, and scalable green hydrogen integration in sustainable steel manufacturing.

[9] Co-funded by the European Union GA number 101092087.

NGEN

The **ArcelorMittal Dofasco-led consortium**, in partnership with Tenova, developed a smart technology platform to digitally transform the secondary ladle metallurgy facility at ArcelorMittal Dofasco, Canada. The project enhanced the understanding of digitalization in heavy manufacturing, an area that often lags behind other industries. Key insights were gained in process execution for **implementing intelligence, establishing data flow standards, and understanding the impact on the workforce**, all crucial insights as global industrial economies move toward digital transformation.

InSGeP[10]

The InSGeP project, "**Investigations of Slags from Next Generation Steel Making Processes**", is a European research initiative co-funded by the **EU Research Fund for Coal and Steel (RFCS)**, launched on July 1st, 2023. As the steel industry shifts to low-emission processes like direct reduced iron, hot briquetted iron, hydrogen plasma smelting reduction (HPSR), and electrical smelting, understanding byproducts like slag is crucial for maintaining a zero-waste approach. The project aims to **identify slags produced by future steelmaking processes** and explore their **valorization** within the **existing value chain**. It seeks to define innovative applications for slag to ensure a smooth transition without disrupting industries that rely on it, such as road construction and cement production.

The project involves 13 partners from Austria, Belgium, France, Germany, Italy, and Spain, including 5 steelworks, 6 research organizations, and 2 suppliers. It will use limited quantities of slags from next-generation steel production and conduct laboratory, pilot-scale, and industrial-scale tests. The slags will be evaluated for their chemical, mineral, environmental, and physical properties, with various cooling and granulation methods applied for different applications. Testing will include using slags in road construction, cement production, liming material, and 3D printing.

[10] Co-funded by the Research Fund for Coal and Steel (RFCS) GA number 101112665.

iSteel-Expert[11]

iSteel-Expert is a remote virtual system that **monitors steelmaking operations 24/7**, analyzes data, and suggests actions to optimize the process. Acting as a human expert, it collects and analyzes furnace data, **improving maintenance** and **decision-making**. Powered by IoT, it enhances human management by detecting relevant events and identifying their impact. The system integrates a **knowledge-based approach** through an interactive, immersive training tool, helping preserve, transfer, and evolve the company's knowledge base. The main objectives pursued are the preservation and evolution of the company's knowledge, increasing process efficiency, improving equipment condition and maintenance, and reducing environmental impact.

[11] Co-funded by the Research Fund for Coal and Steel (RFCS) GA number 101112102.

LIFE H2Reuse[12]

In the production of **seamless stainless steel** and **nickel alloy precision tubes**, bright annealing is crucial for achieving the desired properties. This process, conducted in a vacuum or controlled atmosphere with reactive gases, minimizes surface oxidation, resulting in a brighter surface, a thinner oxide layer, reduced hardness, increased ductility, and fewer internal stresses. It also lowers the risk of corrosion, cracking, and distortion. **Bright annealing** is performed in a hydrogen (100% H_2) atmosphere at temperatures between 1,040°C and 1,200°C, followed by rapid cooling. In continuous plants like **Tenova LOI Thermprocess**'s at DMV, hydrogen is dispersed after use, leading to wasted resources.

The LIFE H2Reuse project aims to **mitigate the environmental impact** of bright annealing by recovering and reusing wasted hydrogen as fuel in hydrogen burners. This innovative solution, still under development, will be tested in real environments to meet technical, environmental, and socio-economic KPIs.

The process will be applied to Tenova's roller hearth furnace plants, which also use hydrogen-rich atmospheric gas, offering the potential for reduced carbon footprints, resource savings, and cost reductions. The main targets concern **emission reduction**, **energy savings**, and **resource efficiency**.

GHG EMISSIONS:	**RESOURCE EFFICIENCY**:	**ENERGY SAVINGS**:
Baseline: 990.23 tons of CO_2eq/year	**Baseline**: 0 tons/year	**Baseline**: 1.85 GWh/year
Project-End: 618.34 tons of CO_2eq/year	**Project-End**: 32.65 tons/year of hydrogen recovered	**Project-End**: 0.98 GWh/year
Savings: 372.75 tons of CO_2eq/year		**Savings**: 870 MWh/year

[12] Funded by the European Union GA number 101156487.

Mining - 2025 R&D projects

In 2025, Tenova's mining business continued to promote its internal global R&D innovation program dubbed the "**Innovation Challenge**." Now in its third year, the program is open to all TAKRAF and DELKOR employees across all global business units. In consideration of the business's commitment and sustainability statement, the Innovation Challenge ideas must align with **ESG themes**, namely focusing on: energy-efficient technologies, environmental impact reduction, circular economy, and low-carbon transition.

This initiative **aims to support the business's sustainability goals** and, at the same time, **develop a culture of innovation** and **shared value creation**, where employees are the fuel of the business, and strengthen the alignment between people and vision.

In a strong display of commitment, the 2025 challenge garnered another **impressive eighty applications**. The three winning projects included: i) **innovative flotation cell rotor and stator manufacturing** that reduces operational costs and enhances sustainability; ii) **intelligent and effective separation and removal of trash** from belt linear screens, and iii) **disposable seal strips** specifically designed for DELKOR Belt Filters. The mining business's Innovation Challenge for 2026 is poised to be a transformative initiative that builds upon the momentum generated previously; as such, 2026 will not feature a new challenge. Instead, the business will focus on advancing and putting into practice the ideas that have previously been put forward.

TAKRAF Systems focused its R&D activities on various internal projects:

- **State-of-the-art calculation tools** in collaboration with renowned international Universities
- **Integration of advanced landscape visualization** in machine automated operation.
- Building on R&D work from previous years, TAKRAF continued to refine the **dry-stack tailings conveyor test rig**, which analyzes material behavior and defines the conveyability of bulk materials on conveyor belts, enabling such TAKRAF equipment solutions to be designed to meet exacting project and customer requirements.

TAKRAF Products continued to focus its R&D activities on various internal projects:

- Building upon the fundamentals for additive manufacturing, TAKRAF focused its attention on the **development** and **testing** of specific **welding procedures**. The goal is to be able to **rebuild worn-out components** rather than scrapping them. Not only are there significant **environmental advantages** to rebuilding, but significant **cost savings** are expected together with shorter lead times.
- **Robotized welding and 3D-printing**
- Investigation of **alternative raw materials** to address acute **material supply shortages** as a result of tariffs and export restrictions.
- The fostering and extension of TAKRAF's position as a leading global supplier of **heavy engineered pulleys** for **high tensions drives**.

DELKOR also continued to focus its R&D activities on various internal projects:

- Continuation of DELKOR **filter press design refinements**, together with larger filter press sizes. DELKOR's filter presses offer advantages such as a compact footprint, ease of operation and high dewatering efficiency. They are essential for processes such as dry stack tailings (DST) which require dry solid waste and clean filtrate for reuse.
- Continuation of **separator development** with the conclusion of the design concept and prototype development for detailed testing in the future.

Digital Transformation

Digital technologies are **revolutionizing the metals and mining industries**. This is why Tenova Group not only integrates digital solutions into many of its technologies but has also created a digital strategy and team to stay ahead of the curve. Our strategy places customer value and sustainability at its center, helping us stay focused in a rapidly evolving space. It leverages technologies such as **AI**, **machine learning**, and **data analytics**. These technologies are used both to increase efficiency and reduce environmental impacts for our clients, improving efficiency of internal processes.

Adopting a Digital Mindset

To continue to optimize productivity through our new hybrid working model, we encourage our employees to adopt a digital mindset, seeking digital solutions to solve problems across categories from smart working to Industry 4.0 integration. The ambition of our digital mindset is to promote a deep cultural change wherein our teams understand and harness the pioneering modern technologies that could revolutionize our industries.

Some of our activities to advance a **digital mindset** have been around the deployment of specific tools and technologies to educate employees and raise their awareness about digitalization processes. We have several technological systems in place to support remote collaboration in Tenova and with our business partners as well, including the **Project Management Platform** and the **Supplier Portal**, all accessible on multiple, user-friendly devices.

For the last three years, our **Project Management Platform** has been providing an accessible **central repository** of **all project information**, such as relevant documents and procurement plans, which help set up Tenova's teams for success. In 2025, we started **enhancing the platform** with new features based on Gen-AI technologies to reduce repetitive processes and errors, therefore increasing efficiency and enabling employees to spend their time in value added activities. We value the **introduction of new tools** and support our **employees with additional training** to familiarize them with these innovations, enhancing their connection with one another, while also emphasizing the importance of **protecting sensitive information** through **high cybersecurity awareness** and a thorough understanding of Tenova's **procedures** and **guidelines**.

Empowering Innovation with AI

To further foster innovation and collaboration within our organization, we have introduced a **dedicated community** known as the **AI Garage**. This initiative is designed to **facilitate the sharing of knowledge, practical know-how,** and **experiences related to the use of artificial intelligence** both within Tenova and beyond. The AI Garage serves as a platform for open dialogue on AI topics, encouraging employees to exchange insights and learn best practices from one another.

Moreover, the AI Garage aims to act as a **catalyst for new ideas**, supporting the development of AI agents that enhance and streamline our business processes.

By bringing together diverse perspectives and expertise, the community helps to generate solutions tailored to real operational needs, strengthening our capacity to innovate and adapt in an increasingly digital landscape.

During 2025, Tenova **initiated** several **AI-driven projects** aimed at enhancing operational efficiency and customer service. In particular, the "**AI for Proposal**" project leverages artificial intelligence to streamline and optimize the creation of technical specification, ensuring faster turnaround and improved accuracy. The Service Desk Chatbot was launched to provide immediate, automated support to employees and clients, handling common queries and facilitating smoother interactions. Additionally, the "**AI for Legal**" initiative focuses on contract analysis, using advanced algorithms to review and extract key information from legal documents, thereby supporting the legal team in risk assessment and compliance activities.

Supporting Client Engagement

In addition to the digital features embedded in our products, we want to provide the best possible **customer service**, so we have created several systems to help employees communicate effectively with customers. Customers have access to our **Tenova Digital Portal** where they can request support for specific products and order spare parts. The portal is regularly updated with new features. Among these services, the **ESPC (Electronic Spare Parts Catalog)** allows clients to browse and request spare parts efficiently through an interactive digital catalog. For Pomini customers, the **IPA (Inspektor Performance Analyzer)** service provides advanced data analysis derived from the Inspektor system. The **TenovaLAB** Experiments section offers access management and reporting functionalities for experiments conducted within the TenovaLAB research environment. Furthermore, the **Product Portal section** allows customers to consult user and maintenance manuals for selected Tenova products. Lastly, the Slag Granulation tool allows users to perform detailed analyses of slag granulation potential based on its chemical composition, supporting a more informed and sustainable decision-making process.

During 2025, the **first customer oriented AI Agent** was launched on the **Tenova Digital Portal**: its aim is to support customers to solve maintenance issues.

The Tenova Digital Portal also features the digital twin of its reheating furnaces – the digital twin simulates the normal behavior of real equipment, and the feature allows customer to perform simulations and optimize furnace consumption and emissions.

Some of the proprietary digital tools we have developed include:

- **Tenova IIoT Platform** is the IIoT platform developed in partnership with Microsoft, which facilitates communication with our customers. Its purpose is to **retrieve plant data** and **analyze** it to develop new services and **AI applications** which help customers use and maintain their equipment.
  Additionally, the adoption of the Tenova IIoT platform enables the application of our proprietary mathematical models, including those used for the thermal simulation of reheating furnaces. This innovative use of models also allows us to provide new services to our customers: for instance, the thermal model of reheating furnaces could be used by our customers as a simulator to gain insights on possible improvements in equipment operation.
- **Emission Impact Dashboard** One of the new features introduced to the Tenova IIoT Platform is the **Emission Impact Dashboard**. This tool is designed to track the emissions produced by the cloud services utilized by the platform. Consequently, it enables the monitoring and demonstration of the environmental impact of Tenova's products and technologies across the entire value chain, extending beyond the equipment installed at customer sites.
- **Tenova EDGE** is the **field gateway** developed by Tenova, which allows the customer's plant to connect in a standard and secure way to our IIoT Platform. The EDGE device also has the capability to host and automatically manage the update of developed machine learning models and AI applications.
- **Tenova adVISOR** is a **virtual assistant** that provides suggestions on **product maintenance** and **operation**. It can be used on a mobile device and provides real-time updates. The tool's remote assistance feature, available on mobile and wearable devices, offers support to field operators..
- **Tenova Electronic Spare Parts Catalog** enables customers to easily **select spare parts** with fewer mistakes by connecting to the customer's portfolio database, accurately identifying the required part.

In addition to projects related to the digital transformation of processes, Tenova strives to develop digital solutions that reduce the environmental impact of our customers' plants and launch these solutions on the market. Notable launches have included the inauguration of **TenovaLAB** in **Castellanza**, which was established to conduct experiments and R&D in burner development, facilitating the completion of our Smart Burner platform.