We Transform Business

Helping our clients and suppliers transform to operate within planetary boundaries

The metals and mining industries must evolve to significantly reduce their carbon emissions in order to limit global warming to internationally-agreed limits. Tenova is helping drive this transformation by developing innovative technologies that not only help our clients deliver better products but also drastically reduce their environmental impact. In our efforts to transform our industries, we are also transforming our own business by seeking opportunities to reduce our environmental impact and operate more efficiently.

In this section, we report on how we help our clients reduce their own environmental impact through our varied portfolio of products, technologies, and services, with a focus on digital transformation. Lastly, we report on our own carbon footprint.

1. Driving Value for Our Clients

Our portfolio of solutions is principally dedicated to the sustainable transformation of the metal and mining industries. We create value for our clients by providing innovative technologies that ensure efficiency, resulting in better performance, less waste, and lower carbon emissions. We provide technologies that support the transition to cleaner fuels, utilize energy more efficiently, and recover and reuse previously wasted material. In developing these solutions, we are not only serving our clients, but are also working hard to accelerate our sector's transition to a lower environmental impact.

1.1. Energy Transition

The iron and steel industry is one of the largest emitters of CO_2, responsible for 7% of global direct energy-related CO_2 emissions[1]. The steelmaking industry is moving towards **natural gas-based and hydrogen-based iron reduction as substitutes for carbon-based processes**. However, current raw materials supply chain shortages and the geopolitical tensions affecting natural gas availability make this transition challenging.

Tenova is fostering a **shift in the energy paradigm** in the metals industry by promoting the use of **hydrogen-ready technologies** to its clients for the transformation process of their business. This is also carried out by means of partnerships and collaborations with gas supply operators, electrolyzer manufacturers, and other third parties that support a green energy transition.

1 International Energy Agency (IEA), "**Iron and Steel Technology Roadmap: Towards more sustainable steelmaking**" (2020).

Electrical Steel

Indirectly, Tenova's technologies influence downstream technologies as well, enabling our customers to more efficiently produce metals that will be critical in facilitating the energy transition. One example is **electrical steel**, or **silicon steel**, which makes up roughly 1-2% of total crude steel production globally. Electrical steel is an **iron-carbon alloy with silicon** as its primary additive. It is highly valued for its ability to conduct magnetic fields, minimizing power losses.

The **market for electrical steel** is growing rapidly as global demand for electricity and electric goods increases. It is required for products like transformers, household appliances, and electric vehicles. Tenova has developed numerous technological advancements to make electrical steel even more efficient including annealing, pickling, decarburization, flattening and coating.

CASE STUDY

Improvements in Silicon Steel

As demand for silicon and magnetic steel increases due to growing demand for electric vehicles, Tenova's R&D team has been hard at work to develop technologies to improve the silicon steelmaking process. In addition to our suite of technologies for silicon steel, we have been working on improving the magnetic properties of silicon steel through hot band 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 and ENERGIRON®

The partial or total use of hydrogen for **DRI (Direct Reduced Iron)** production is an excellent source of carbon reduction. This solution is already widely adopted in the industry and has become the standard for the **decarbonization of integrated steelmaking** (i.e., steelmaking from ores as raw materials).

ENERGIRON® is an innovative HYL Direct Reduction technology, jointly developed by Tenova and Danieli. It has been designed to use **different types of reducing gas sources or pure dihydrogen** to reduce iron ores into metallic iron for its use in melting facilities to produce a wide range of **high-quality steels**. ENERGIRON® plants efficiently reduce any iron pellet or lump 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 or even coke oven gas — without any modification and control the amount of embodied carbon. ENERGIRON® plants meet the **most stringent environmental regulations** as well. Because of its unique features, it has the lowest carbon footprint of any ironmaking technology, with the further advantage that 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.

DRI plants are typically coupled with **electric arc furnaces (EAF)** for the melting of DRI and its transformation into sellable iron or steel. The use of electrical energy substituting chemical energy (which creates CO_2 emissions): the world's most productive DRI-fed EAF in the world was produced by Tenova and we are currently embarking on building a second one.

"Our products provide clients with improved plant sustainability even before cleaner fuels become 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 with a very short electrical arc or "brush arc". It can tap hot metal into torpedo cars. The resulting slag has the same composition as blast furnace slag.

iBLUE®

The emissions from the conventional blast furnace-basic oxygen furnace or oxygen converter (BF-BOF) route represent the greatest potential for CO_2 reduction in the steelmaking industry: the BF-BOF route from iron ores produces two tons of CO_2 for each ton of steel produced (while the EAF route from scrap produces 80% fewer emissions). As of 2019, 71% of global steel was produced via the BF-BOF route, while only 29% was produced via the electric (EAF) process. Tenova's proven 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 to produce hot metal and granulated slag. iBLUE® can also utilize BF grade pellets as raw material, making this solution the perfect substitute to blast furnace technology. The use of green hydrogen in the reduction process can further **minimize greenhouse gas emissions**. This represents a less costly option to produce pig iron 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.

Combustion Systems for Furnaces

Traditional hot rolling heat treatment and melting processes utilize fossil feedstocks resulting in a high carbon footprint for final products like long or flat products. Tenova is committed to developing and deploying **clean-burning hydrogen-based solutions** for reheating and heat treatment furnaces. Since 2008, we have specialized in the development of **regenerative and self-regenerative burners** that provide at least a **10% reduction in CO_2 emissions** using a fossil feedstock. However, Tenova's regenerative burners are **hydrogen-ready**: whenever green hydrogen becomes readily available, our clients can immediately swap to the clean-burning fuel and drastically reduce their carbon emissions without any additional adaptations to their equipment.

We have also integrated this latest technology into our line of **SmartBurners** to provide up-to-the-minute data on the operating efficiency and processes of our burners to ease inspections and maintenance. Our **Industrial Internet of Things (IIoT)** framework offers a complete set of process diagnostics, KPIs to control key parameters like the combustion ratio, leakage of switching valves, and combustion quality. Our multi-megawatt TSX SmartBurner family for reheating and non-ferrous melting furnaces is fueled with a mixture of natural gas and hydrogen – it can run on 100% hydrogen as well. Our 200-kilowatt TRKSX (Tenova Self-ReKuperative Flameless) SmartBurner also uses a variable fuel mixture of natural gas and hydrogen and works in flame and flameless mode, helping to keep **nitrogen dioxide emissions well below the strictest limits.**

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 NOx emissions below even the strictest limits. Tenova's regenerative flameless burners combine the lowest NOx emission levels with high temperature combustion air preheating, while allowing a drastic reduction of CO_2 emissions through high combustion efficiency. That means our products provide clients with improved plant sustainability even before cleaner fuels become available.

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, Tenova has invested in its own R&D facilities by installing an **experimental laboratory in our headquarters in Castellanza**. Our TenovaLAB (T-LAB) carries out experimental industrial activities for the development and testing of all burner technologies. Equipped with **three test furnaces** of different thermal power, T-LAB allows our R&D team to close the loop between our in-house modeling and simulation capabilities and the engineering of industrial products. On-site product testing, like thermal and emissions measurement, enables us to fine-tune product specifications, minimizing technology risks for our clients. Furthermore, T-LAB allows our customers to see our products in use in real operating conditions.

In 2022, we expanded hydrogen-readiness to our self-recuperative and radiant tube burner families. Additionally, T-LAB was awarded a **HorizonEU grant** - the European Union's key funding program for research and innovation - to demonstrate the green hydrogen production/utilization chain at full industrial scale, from electrolyzer generation of hydrogen to furnace combustion. As part of this project, in 2023 we are upgrading our T-LAB combustion facility to use variable blending rates of green hydrogen with traditional fossil fuels. The on-site water electrolysis plant will be provided by our partners Snam and Industrie De Nora and powered by our new rooftop solar field, representing an industrial example of the benefits of zero-emissions hydrogen.

CASE STUDY

Partnering with Clients for a Low-Carbon Future

As our economies move towards net-zero emissions, steel companies have a major role to play in emissions reduction. Tenova is constantly innovating to develop low-carbon solutions for the metals industry.

- In 2022, we were awarded a contract with Tenaris, a global manufacturer and supplier of steel pipes and related services, to supply the first hydrogen-ready industrial furnace for the application of heat treatment on specialty steel. This moving hood furnace located at Tenaris's site in Dalmine is equipped with 34 hydrogen-ready self-recuperative TRKSX burners. These burners can use pure natural gas, pure hydrogen, or a fully variable blend of hydrogen and natural gas, providing energy savings, reduced carbon emissions, and reduced NOx emissions compared to traditional fossil fuel burners. According to Giuseppe Pandini, Senior Project Manager at Tenaris, "Besides selecting the best energy saving technology for the burners, with this project we took the opportunity to take a step forward. Working with Tenova's engineering and R&D, we designed a plant ready to start the substitution of natural gas with hydrogen as fuel for our industrial furnaces."
- We partnered with Snam, Europe's largest energy infrastructure operator, to conduct joint strategic studies and market analyses to implement green hydrogen projects within the metals industry. The aim is to bring integrated, turnkey commercial solutions tested in industrial plants to implement a substantial reduction of CO_2 and NOx emissions in metals production processes – from melting up to thermal processing of long and flat products.
- We have partnered with Tenaris and Snam to pilot green hydrogen steelmaking at Tenaris Dalmine's pipe mill on our "Dalmine Zero Emissions" project. The project marks the first industrial-scale application of hydrogen in Italy to decarbonize the steel sector. The project aims to generate hydrogen and oxygen through the installation of a 20 MW electrolyzer and will likely include the construction of a storage site for the accumulation of high-pressure hydrogen and the use of oxygen within the melting process. The results of the project could significantly reduce CO_2 emissions related to electric arc furnace steelmaking.

1.2. 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, thus reducing their emissions. One such example is our Ferrochrome Multiple Preheater technology which reduces electrical energy consumption by preheating the ores before they enter the furnace using the furnace waste gases, recovering the energy otherwise lost to the environment.

Consteel®

In use for over 30 years and in 80 sites across all continents, our **Consteel® Electric Arc Furnace (EAF)** has proven its value to clients around the world. Consteel® is a process by which raw feed materials, in particular scrap, are preheated and charged continuously into an EAF and melted 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. **EAF 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 any fuel consumption. This process produces liquid steel with high productivity, a short and adjustable heat cycle, and the lowest power cost compared to any other EAF installation using conventional or other alternative steelmaking technology.

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. 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 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, our client ORI-Martin uses **iRecovery**® at their steel plant. The captured heat from their plant heats 2,000 homes in wintertime and powers 700 homes in the summer, reducing 10,000 tons of CO_2 every year. In 2022, we further enhanced **iRecovery**® by also developing a method to capture and utilize the dissipated heat itself, in addition to the flue gas, and use it to generate energy.

1.3. Circular Economy

Industrial processes create numerous byproducts. Our solutions contribute to the circular economy by enhancing their recovery and reuse through our technologies.

EAF-LF (Electric Arc Furnaces - Ladle Furnace)

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 an important factor, especially considering the trend in the quality of world steel scrap shows a decrease in quality. Having this in mind, we are conducting research and implementing Industry 4.0 technologies to manage low-quality scrap in furnaces.
EAF steel production is already an integral part of the circular economy. This role can be further enhanced. 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.

Dry Slag Granulation

The **capture and reuse of currently wasted materials**, such as 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[1], representing not only a serious environmental problem in Europe, but also 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 slag granulation solution** which uses forced air steam to rapidly cool and solidify slag, enabling the capture of its lime content, which constitutes roughly 55% of the total slag stream. Our solution allows the **processing and reuse of slag industrially**, rather than manually, decreasing workers' exposure to harmful chemicals in slag, reducing water use, and reducing the need for virgin lime mining. The solution also successfully enables the reuse of slag in the EAF process itself or as a byproduct for industries in soil stabilization, fertilizer, concrete production, and more. Further, Tenova extended its dry-granulation technology to EAF slag to high alloy steel grades and slag produced by the DRI/EAF process.

Tenova is currently developing a **market for dry granulated slag from LF** which has applications in cement production, chemicals for the building industry, and more.

1 *European Steel in Figures*, Eurofer, 2019, eurofer.eu

Lithium Recovery

Lithium is widely used in metallurgical processes to promote metal melting, 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 crucial metal for achieving a net-zero future. Building on this potential, Tenova scientists have explored various processes to produce lithium more efficiently. **Tenova Advanced Technologies (TAT)** adapted its SX technology for producing **lithium from primary sources** to produce recycled **lithium from batteries**. The new process can be applied across all feed streams, originating from any source, including solar, hard rock, recycled waste, and process waste streams, to produce high quality lithium hydroxide. The key characteristics of this process are the **high efficiency of extraction**, superior to the traditional process, and a **lower use of water**.

Magnesia Metal from Coal Ash

As global demand for magnesium metal rises, **Latrobe Magnesium Limited (LMG)** in Australia is using Tenova's technology to **harvest magnesium metal from fly ash byproduct** – a hazardous waste material deriving from brown coal power generation. Originally developed to have a zero-waste pickling process during steelmaking, our pyrohydrolysis process was adapted to LMG's unique situation to recover magnesium metal. The related emissions from this technology are roughly half of those of conventional magnesium production plants. Launched in 2022, LMG eventually intends to develop a commercial scale operation producing 10,000 to 40,000 tons of magnesium metal per year.

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 only 5% of the energy it takes to mine virgin material** and creates 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 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 a combined 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.

1.4. Impact Monitoring

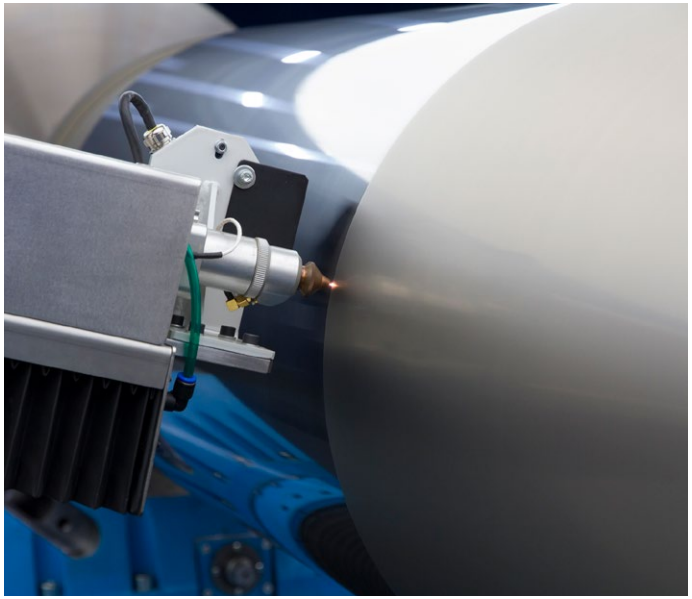
As a responsible company in the metallurgy field, we recognize the importance of monitoring the impact of our products and services on the environment and human health. We commit to improving our processes and products to ensure their impact is accounted for along their entire life cycle.

Pomini Digital Texturing™

Our **PDT™ Pomini Digital Texturing™ process** 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 and no need for ancillary equipment, the process requires **minimal power consumption**. A simple 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, as a post-process in many applications, the use of significant quantities of hexavalent chromium, a highly carcinogenic material which can be difficult to remove from the environment. PDT™ makes it possible to significantly reduce, and even completely **eliminate hexavalent chromium**, making it a much safer and less toxic alternative.

Looking ahead, Pomini Tenova foresees **several exciting potential uses** for the revolutionary PDT™ technology. One potential use we are currently exploring is in the field of electrolyzers, designing a machine that converts 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.



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

In 2021, Pomini Digital Texturing™ (PDT™) became the **first machine in the metal surface finishing sector to complete a lifecycle 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 led the creation 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.

1.5. R&D and Sustainable Innovation

We not only improve existing technologies for metals industries, but also design and produce new technologies that reduce the environmental impact of our clients' facilities while improving production 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**, NOx 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 transformed 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. We are coordinating our **R&D&I efforts across Business Units and Product Lines**, to find integrated, synergistic solutions through collaboration.

Our R&D&I focus areas for 2022-2024 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 **Sustainable Development Goals (SDGs)**. The 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.

2022-2024 R&D&I Focus Areas and SDGs

Energy Transition	7 AFFORDABLE AND CLEAN ENERGY, 13 CLIMATE ACTION	**Process Flexibility / Efficiency (OPEX)**	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Safety**	3 GOOD HEALTH AND WELL-BEING
Local Environment	11 SUSTAINABLE CITIES AND COMMUNITIES, 15 LIFE ON LAND	**Raw materials / Residual valorization**	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	**Quality of final product**	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Tenova Innovation Days

In 2022, our Global R&D Team hosted **Tenova Innovation Days** — internal ideation workshops to generate novel product ideas. During this series of four events, over 80 employees from different Product Lines and Staff Functions attended. Each event was focused around **six different R&D&I focus areas** and attendees across roles were split up into six working groups to develop ideas. The Innovation Days events were emblematic of the **collaborative mindset** the company is adopting to enable cross-Business Units R&D&I projects. At the end of the event, teams presented their ideas to an **R&D Committee** which identified the most impactful projects to consider for future development.

EcoSlag

Valorization of Ladle Furnace (LF) slag currently represents a significant target for steel producers to reach the goal of zero waste and reduced carbon emissions. EcoSlag project aims to improve the quality and handling of slag compared to current processes. EcoSlag will identify and assess potential operational solutions for waste heat recovery from steelworks' slag, while generating slag that can be used as a valuable input, minimizing slag production's ecological footprint. Industrial tests with the **Dry LF Slag Granulation** successfully proved that the new process could minimize environmental impact, increase workers' safety, and reduce operational cost. Moreover, a feasibility study on heat recovery from slag has been carried out implementing industrial test on heat recovery together with a concept study for heat utilization.

CyberMan4.0

In 2018, **Pomini Tenova** joined a cluster of other European organizations on **CyberMan4.0** — a Cyber-Physical System-based approach for intelligent data-driven maintenance operations applied to the rolling area. The consortium of the CyberMan4.0 project consisted of **five companies and three research institutes** located in Italy, the Netherlands, and Germany. We worked on four use cases: two in Roll Shop operations and two for the production of long laminates.

CyberMan4.0 was designed to develop an **innovative Integrated-Maintenance-Model4.0**, supporting the transition from traditional preventive maintenance to predictive maintenance. To properly maintain equipment, data collection is necessary but not sufficient: in collaboration with Tenova Digital, CyberMan4.0 created a **cloud-based system** that can cross-reference the data of several plants and, using algorithms, predict possible anomalies in order to schedule maintenance at the right moment. The project successfully prevented equipment downtime, resulting in greater efficiency and productivity. It also increased quality by reducing waste, and extended the useful life of cylinders, which reduced the overall use of oil and energy.

Burner 4.0

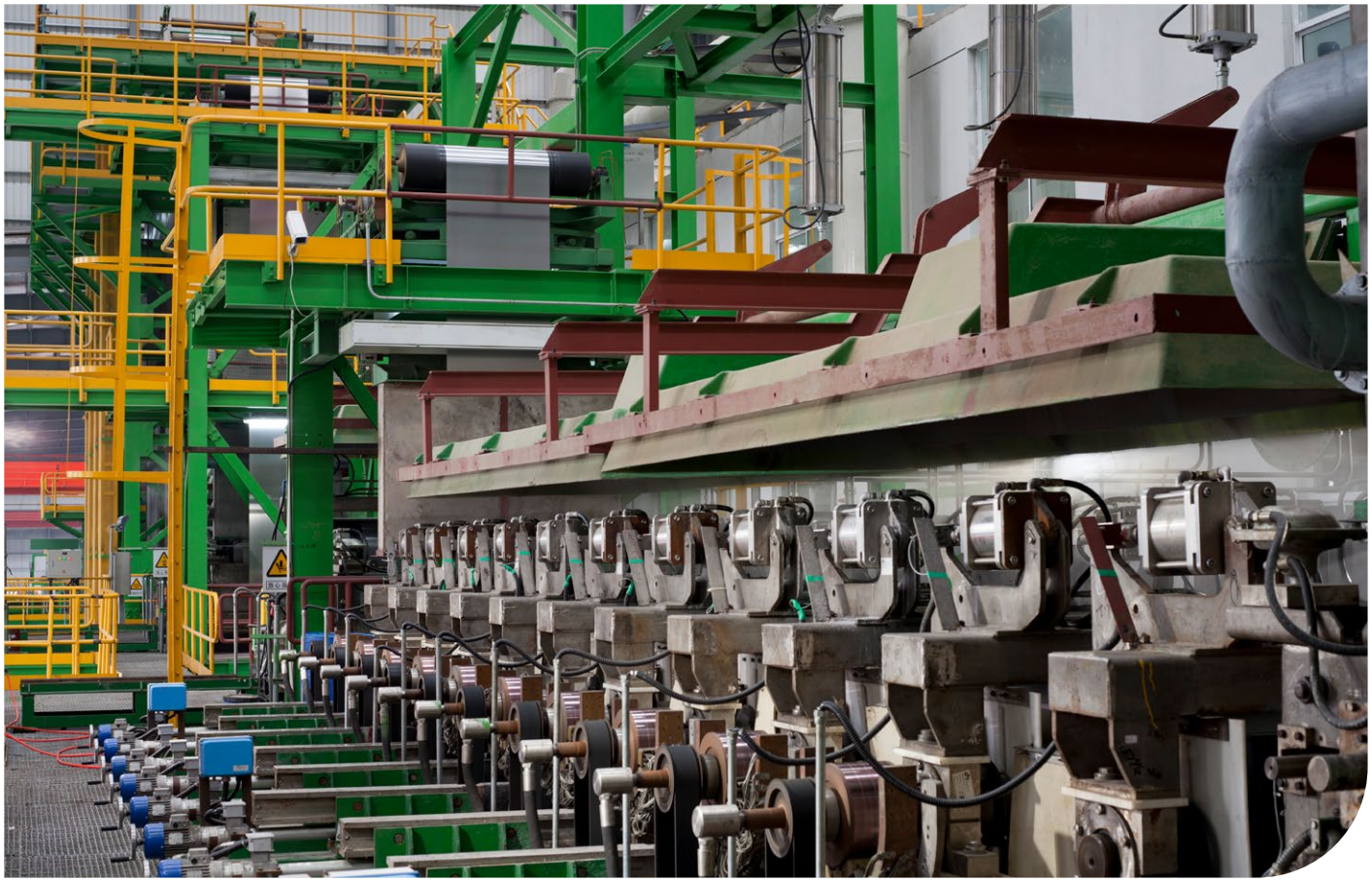
Combustion systems and burners for the steel industry have improved in recent years, with a focus on energy savings, pollutant emissions reductions, and process flexibility. **Burner 4.0** uses Industry 4.0 technologies to **extend the current technological limits of burner combustion systems** across different areas, including design, manufacturing, control and process optimization, operating life, and maintenance. Additive manufacturing, Internet of Things, smart sensors, data analytics for process optimization, and predictive maintenance have been introduced to current burner systems to find breakthrough innovations. Funded by the **European Commission**, Burner 4.0 started by identifying materials and shapes for 3D printing of critical burner components for heat treatment furnaces. In order to maintain burner performances at nominal levels throughout its life, Tenova has also introduced the concept of **SmartBurner**. SmartBurner's IIoT framework offers a complete set of process diagnostics, KPIs, and KHIs that enable important process parameters like combustion ratio, leakage of switching valves, and combustion quality to be controlled and facilitate burner inspections and maintenance interventions.

Insoluble Anode Tin Coating and Chromium-Free Passivation

Due to its anti-corrosive qualities, tin is used as coating in many steel applications, such as food canning and pipes. **Tinning**, however, is the **most complex and sophisticated strip processing line**. In the most advanced lines, tin plating is performed using insoluble anodes where, in older plants, the dissolution of tin results in the generation of large quantities of sludge — with a high loss of tin, a valuable commodity, in the sludge.

Tin coatings are also often passivated using chromium to prevent oxidation. **Hexavalent chromium**, however can have negative health impacts on workers and its use will soon be banned by the EU.

Tenova's **insoluble anode tin coating process** greatly **minimizes the amount of sludge** produced and, hence, the loss of tin, and its **chromium-free passivation process** provides tin passivation without the harmful effects of chromium. The resulting tin coating also provides more uniform coverage and better edges while more efficiently utilizing the tin. Other benefits are the **reduction of manpower** for anode handling and therefore an increase in safety during operation, the generation of fewer fumes, better process control, more flexible campaigns, and the lowest tin coating thickness reachable on the strip.



2. Digital Transformation

Digital technologies have the potential to revolutionize the metals and mining industries. This is why Tenova has not only integrated digital solutions into many of its technologies but has also created a digital strategy team to stay ahead of the curve. Our strategy places customer value and sustainability at its center, helping us stay focused in this rapidly evolving space. It leverages technologies through the use of AI, and leverages machine learning and data analytics to increase efficiency and reduce environmental impacts for our clients.

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 mentality 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 promote them amongst our employees. We have several technological systems in place to support remote collaboration within Tenova and our business partners as well, including the Project Collaboration Portal and the Supplier Portal, all accessible on multiple, user-friendly devices.

We have begun digitizing certain business processes using workflow engines and increasing efficiency by automating repetitive processes through **robotic process automation**.

We also provide employees with **supplementary training** to help them feel connected to each other, learn how to use new tools, and remind them to protect sensitive data, such as enhanced **cybersecurity awareness** features and information about Tenova procedures and guidelines.

"Acciaio_4.0" Plant of the Future

The **Cluster Fabbrica Intelligente**, or Italian Smart Factory Cluster, is an association sponsored by the Italian Ministry of Scientific Research with the aim of implementing a strategy based on research and innovation for the competitiveness of Italian manufacturing. To promote the development of digitally-enabled factories, the Cluster launched its **Lighthouse Plant** challenge. Lighthouse Plants are factories that are already operational and ready to become smart factories by using Industry 4.0 technologies like big data, IoT, and artificial intelligence.

Tenova **ORI Martin's "Acciaio_4.0"** plant was one of four plants accepted as a Lighthouse. "Acciaio_4.0" aims to **develop a Cyber Physical Factory** that will allow the vertical, horizontal, and transversal integration of the entire steelmaking process, making it more efficient, flexible, and sustainable. As the industrial technological partner, Tenova designs innovative models of integrated process for the plant, using smart sensors (IoT) and gathering data in cloud systems to develop machine learning applications, remote support, and predictive maintenance, taking into consideration environmental sustainability, people's safety and data security.

Support Client Engagement

In addition to the digital features embedded in our products, we want to provide our clients with the best possible service so we have created several systems to help employees communicate effectively with clients. Customers have access to a **Customer Portal** where they can request support for specific products and order spare parts. The portal is regularly updated with new features. Internally, Tenova teams are set up for success with our project management platform that provides an accessible central depository of all project information, such as relevant documents, procurement plans, and more. We plan to enhance the platform with **AI features** in the near future to reduce repetitive processes, therefore increasing efficiency.

Some of the proprietary digital tools we have developed include:

- **Tenova IIoT Platform**, which facilitates communication with our customers through **Tenova Edge, our cloud platform**. The IIoT platform retrieves plant data and analyzes it to develop new services and AI applications which help customers use and maintain their equipment.
- **Tenova adVISOR**, 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, provides support to field operators.
- **Tenova Catalog Creator,** which enables customers to easily **select spare parts** with fewer mistakes by connecting to the customer's portfolio database to accurately identify the correct part.

3. Environmental Impact from Our Operations

Tenova has long recognized the harmful impacts that climate change can have on the environment. That is why the core of our business is helping clients mitigate that impact through our products, technologies, and services. Alongside helping our clients, we are also taking steps to reduce the environmental impact of our own operations.

3.1. Our emissions and energy use

26%

2024 Goal

Reduction of Scope 2 emissions (market-based) of **450 tCO_2e** by 2024 (*)

(*) equivalent to a 26% reduction (baseline 2022)

Tenova's own energy consumption and direct CO_2 emissions stem largely **from our corporate offices and a few productive sites** and laboratories located in Italy, Poland, Canada, and Israel. Due to the minor scale of our in-house production, **our direct carbon impact is negligible**.

In this report our primary energy consumption and direct CO_2 emissions are disclosed, in particular those relating to our **main Italian offices, located in Castellanza and Genoa**, as well as the **production location in Castellanza**.

We currently do not measure or disclose environmental data for our sites in Poland, Canada, or Israel, though Tenova will evaluate structuring a monitoring process to also gather this data in the coming years.

Our Energy Use[1]

GRI 302-1 Energy consumption within the organization

	2021		2022	
	Total	Total in GJ	Total	Total in GJ
Fuel consumption from non-renewable sources	**-**	**26,492.6**	**-**	**16,284.6**
Fuels used for productive purposes	**-**	**26,485.0**	**-**	16,135.7
Natural gas	737,356.0 mc	26,459.9	449,653.0 mc	16,135.7
Diesel	700.0 litres	25.1	500.0 litres	18.0
Fuels used for fleet vehicles owned by the organization or long-term leases (only company use)[2]	**209.0 litres**	**7.5**	**3,645.0 litres**	**131.0**
Diesel	209.0 litres	7.5	3,645.0 litres	131.0
Electricity consumption	**3,779,329.5 kWh**	**13,605.6**	**3,672,192.0 kWh**	**13,219.9**
Purchased electricity from non-renewable sources	3,779,329.5 kWh	13,605.6	3,672,192.0 kWh	13,219.9
Total energy consumption within the organization	**-**	**40,098.1**	**-**	**29,504.5**

Since 2018, we have utilized an energy management system that monitors utility usage at our most energy intensive site in Castellanza. Using the data from the system, we have implemented a number of energy efficiency measures including reducing our base load energy usage after work hours, which helped reduce our energy costs by roughly 12%. In 2022, we used this data to further reduce our emissions and energy use, in particular natural gas consumption, through numerous initiatives including:

- **replacing windows in the factory building at our Castellanza site with thermal block models;**
- **optimizing thermostat settings;**
- **using high energy machine tools more efficiently;**
- **replacing traditional lightbulbs with LED bulbs; and**
- **raising awareness among employees of the environmental impact of relevant daily activities, such as keeping doors open while loading and unloading.**

1 Data related to energy consumption and Scope 1 and 2 emissions refers to Tenova's Castellanza and Genoa sites

2 Data related to fuel use for fleet vehicles owned by the organization or leased long-term (mixed use) is currently not available

Our CO_2 Emissions

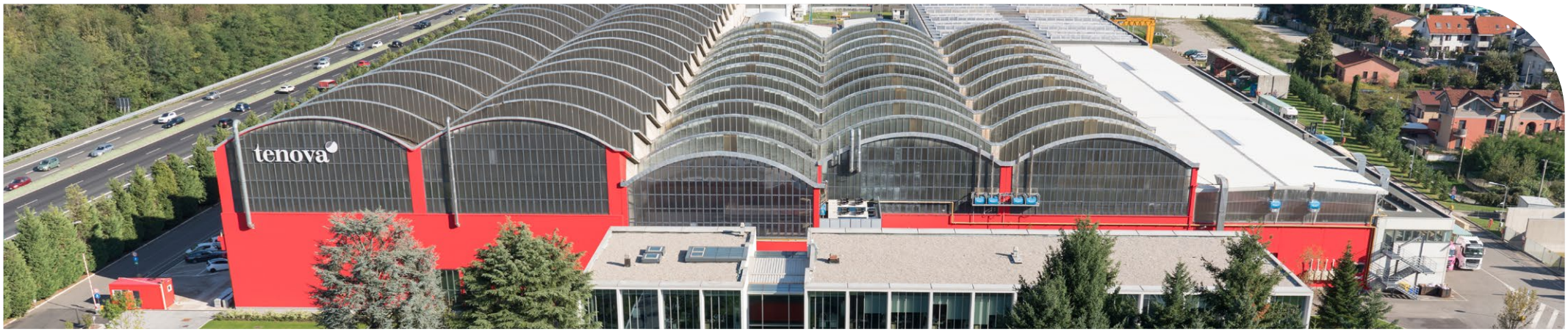
GRI 305-1 Direct (Scope 1) GHG emissions
GRI 305-2 Energy indirect (Scope 2) GHG emissions

	Unit of measure	2021	2022
Scope 1 GHG emissions[1]	tCO_2eq	438.7	278.9
Scope 2 GHG emissions – location based[2]	tCO_2eq	928.6	902.3
Scope 2 GHG emissions – market based	tCO_2eq	1,725.5	1,676.6

Our other air emissions[3]

GRI 305-7 Nitrogen oxides (NOx), sulfur oxides (SOx), and other significant air emissions

	Unit of measure	2021	2022
Particulate matter (PM)	kg	17.2	5.8
Chrome[4]	kg	<0.01	<0.01



1 Scope 1 GHG emissions include emissions related to refrigerant gases used (4.5 kg of R407C in 2021 and 0 kg in 2022). Data related to fuel use for fleet vehicles owned by the organization or leased long-term (mixed use) is currently not available

2 A location-based method reflects the average emissions intensity of grids on which energy consumption occurs (using mostly grid-average emission factor data). A market-based method reflects emissions from electricity that companies have purposefully chosen (or their lack of choice).

3 Data related to significant air emissions refers to Tenova's Castellanza site. Data based on chemical analysis at the emissions. The monitoring of the air emission is not in continuous, therefore the available data was used to estimate total emissions during the year.
4 0.0075 kg in 2021 and 0.0000528 in 2022

In order to reduce our direct CO_2 emissions, we have **committed to reducing our energy and gas consumption** across all of our Italian sites and HCFC plants (cooling systems). To achieve this, we set up an **energy measurement** system in 2018 as well as an energy and gas consumption working group to identify opportunities to reduce our usage.

We have also undertaken several **energy efficiency measures** including:

- optimizing the energy usage of our most energy-intensive locations, achieving in 2021 an average base load reduction of 10% and a reduction in average energy usage of 50% during non-working hours compared to 2020;
- replacing windows in our workshop locations with more efficient thermal break windows;
- monitoring and mitigating HCFCs leaks;
- encouraging employees to work from home two days per week to reduce transport emissions;
- installing electric vehicle charging points at our Castellanza offices; and
- encouraging employees to adopt sustainable behaviors.

Looking ahead, we have also invested in the development of a **solar photovoltaic (PV) field** that will generate **around 1 MWh/year of electricity**. Going live in 2023, the 9,000 sqm solar field will be installed on the roof of the Pomini workshop buildings located at Tenova's Castellanza site. It will produce about 30% of the current energy needs of the premises, preventing 540.6 t of CO_2 emissions.

90% of the energy produced by the solar field will be used on the **campus**, while the remaining 10% will be sold back to the grid. The solar field is set to power our forthcoming electrolyzer which will create hydrogen from water for industrial applications, further reducing the impact of this green hydrogen source. We are also considering environmental building approaches as we renovate older facilities, in particular our Castellanza site.

3.2. Waste and Water

In addition to energy and electricity, we strive to **reduce our use of other resources** as well, including our generation of waste and water use.

Our **waste collection and disposal** comply with all local regulations. Given that most of our operations are office buildings, with few small manufacturing locations, most of the waste we produce is non-hazardous. Our industrial waste is managed by authorized third-party companies.

We have committed to finding ways to **reduce the amount of waste we generate**, repurposing waste in-house when possible, and recycling as much as possible in order to minimize waste sent to the landfill. We have increased the number of waste collection points in our office locations and all employees receive training on correct separation of waste to improve landfill diversion. We also compact our waste to reduce its overall volume. Additionally, in Castellanza we have installed **water refilling stations** and offer reusable, dishwasher-safe cups to encourage the use of reusable bottles over single-use plastic ones. Since installing the stations in October 2022, we have prevented the use of an estimated 6,500 plastic bottles.

In 2022, our overall waste generated decreased while recycling increased, compared to 2021. We are currently exploring ways to improve the separation of waste types. Looking ahead, we aim to conduct more granular research on our waste's pathways downstream to further **improve our diversion rate**.

Waste Generated[1]

GRI 306-3 Waste generated

	Unit of measure	2021	2022
Hazardous waste	tons	89.3	62.5
Non-hazardous waste	tons	178.9	179.2
Total weight of waste generated	tons	268.2	241.7

GRI 306-4 Waste diverted from disposal

	Unit of measure	2021	2022
Hazardous waste diverted from disposal	tons	83.9	53.0
Recycling	tons	83.9	53.0
Non-hazardous waste diverted from disposal	tons	144.5	179.0
Recycling	tons	144.5	179.0
Total weight of waste diverted from disposal	tons	228.4	232.0

GRI 306-5 Waste directed to disposal

	Unit of measure	2021	2022
Hazardous waste directed to disposal	tons	5.5	9.5
Incineration (without energy recovery)	tons	0.2	0.1
Landfilling	tons	5.3	9.4
Non-hazardous waste directed to disposal	tons	34.3	0.2
Landfilling	tons	34.3	0.2
Total weight of waste directed to disposal	tons	39.8	9.7

1 Data related to waste generated refer to Tenova's Castellanza and Genoa sites

CASE STUDY

Improving Coolant Filtration

In 2022, Pomini Tenova piloted a process to more effectively **separate solids and liquids during the grinding process**. Coolant-lubricant used during the grinding process produces a **waste byproduct** that is filtered so it can be **recirculated and reused**. The filtration process requires a magnet and paper filter which separate solids from liquids. We tested using a magnet of 9,000 g strength, versus the existing 850 g magnet, which provided roughly double the separation capacity, extending the usable life of the coolant-lubricant. Additionally, the waste sludge that results from the filtration process was tested as a secondary raw material input for use in foundry applications. Its use significantly **reduced residual moisture** in briquettes. This innovation would provide not only an environmental benefit by extending the useful life of coolant-lubricant but would reduce costs related to the disposal of waste sludge.

We manage our water use in compliance with Italian current legislation. At our Castellanza site, water is withdrawn from on-site wells to load fire extinguishers, irrigate landscaped areas, and load hydraulic power units to test roll grinders. If water is mixed with oil or other solvents, it is discharged temporarily into a tank and subsequently disposed of as wastewater, following regulatory guidelines. For our Genoa and Castellanza sites, water for daily employee use is withdrawn from the aqueduct and discharged into the sewer. Water withdrawn from wells and discharged water are monitored through chemical analysis on an annual basis. Wastewater is monitored through chemical analysis every six months. Data is shared with management every year. In 2022, a drought in Italy required us to replenish our site wells, resulting in an increase in water use compared to the previous year.

Water Use[1]

GRI 303-3 Water withdrawal
GRI 303-4 Water discharge
GRI 303-5 Water consumption

	Unit of measure	2021	2022
Total Water withdrawal	Megaliters	28,095.0	41,169.0
Groundwater – Freshwater (≤1,000 mg/L Total Dissolved Solids)	Megaliters	17,570.0	27,410
Third-party water – Freshwater (≤1,000 mg/L Total Dissolved Solids)	Megaliters	10,525.0	13,759.0
Total water discharge	Megaliters	9,707.0	9,064.0
Third-party water – Freshwater (≤1,000 mg/L Total Dissolved Solids)	Megaliters	9,707.0	9,064.0
Total water consumption	Megaliters	18,388.0	32,105.0

1 Data related to water withdrawal, consumption and discharge refers to Tenova's Castellanza and Genoa sites, which are not located in water stressed areas (Source: World Resources Institute, Aqueduct Water Risk Atlas, www.wri.org/our-work/project/aqueduct). During 2021 and 2022 there were not significant changes in water storage.