ENABLING SUSTAINABLE INNOVATION IN THE MOBILITY SECTOR

How our commitment to greener products is reshaping our business and the automotive industry at large.

Introduction

The automobile industry has a critical role to play in addressing the challenges of sustainability and reducing carbon emissions. With the right mix of approaches, automakers and their suppliers can achieve meaningful improvements in the environmental footprint of their products, while simultaneously promoting a more sustainable future.

Today's passenger cars are effectively 'computers on wheels' that require more connections to actuate critical systems, to transfer data and signals, and to power the motor. Although these individual connectors are relatively small, there are several hundred of them in any given vehicle.

It is imperative for component manufacturers, like TE Connectivity (TE), to adopt aggressive greenhouse gas (GHG) reduction strategies, not just within their own operations, but throughout their entire upstream and downstream supply chains.

TE has been demonstrating our commitment to sustainable business for many years, but our efforts to decarbonize our automotive operations have shifted into high gear.

In this paper, we outline our automotive business unit's approach to carbon neutrality and illustrate it through some concrete examples.

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Part 1: TE's Commitment to Sustainable Mobility

TE is a global leader in automotive connectivity and sensor technologies. We offer an array of innovative, sustainable solutions that help automakers and their tier-one suppliers achieve their own environmental goals and compete in this era of disruption.

We have implemented a companywide sustainability concept — One Connected World — which outlines a systematic approach to reducing our GHG emissions. But the automotive business unit at TE is leading the charge in advancements toward our CO_2 neutrality efforts, from the raw materials we buy to our design and manufacturing processes, through to the packaging and transport methods we employ. We're transforming our operations and supply chain activities to create environmental, economic, and social benefits, and ultimately to achieve full circularity.

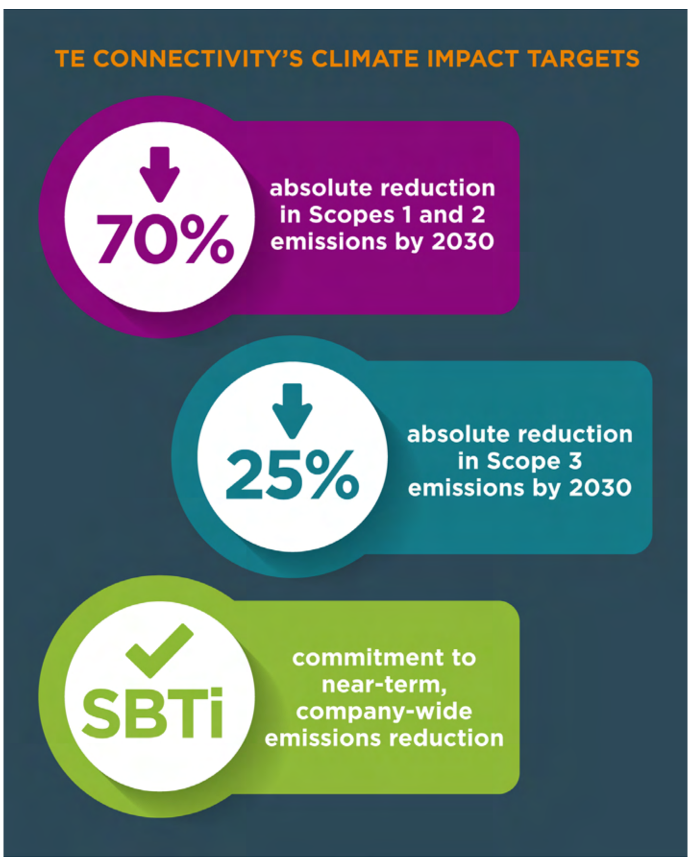
Our initiative is built on five primary action pillars:

- **CO_2 transparency —** making carbon emissions measurable at the product level
- **Net-zero supply chain —** supporting our suppliers in reducing their emissions
- **Product sustainability —** creating a next-generation, CO_2-reduced product portfolio
- **Net-zero operations —** optimizing our own operations to focus on green energy
- **Employee enablement —** training our teams to build a sustainability mindset

Additionally, we have identified these three targets:

- Achieve a 70% or greater absolute reduction in Scopes 1 and 2 GHG emissions by 2030 (baseline year 2020)
- Achieve a 25% reduction in Scope 3 GHG emissions by 2032 (baseline year 2022)
- Achieve near-term, company-wide emissions reduction in line with the Science Based Targets Initiative (SBTi)

TE is making progress toward these milestones.



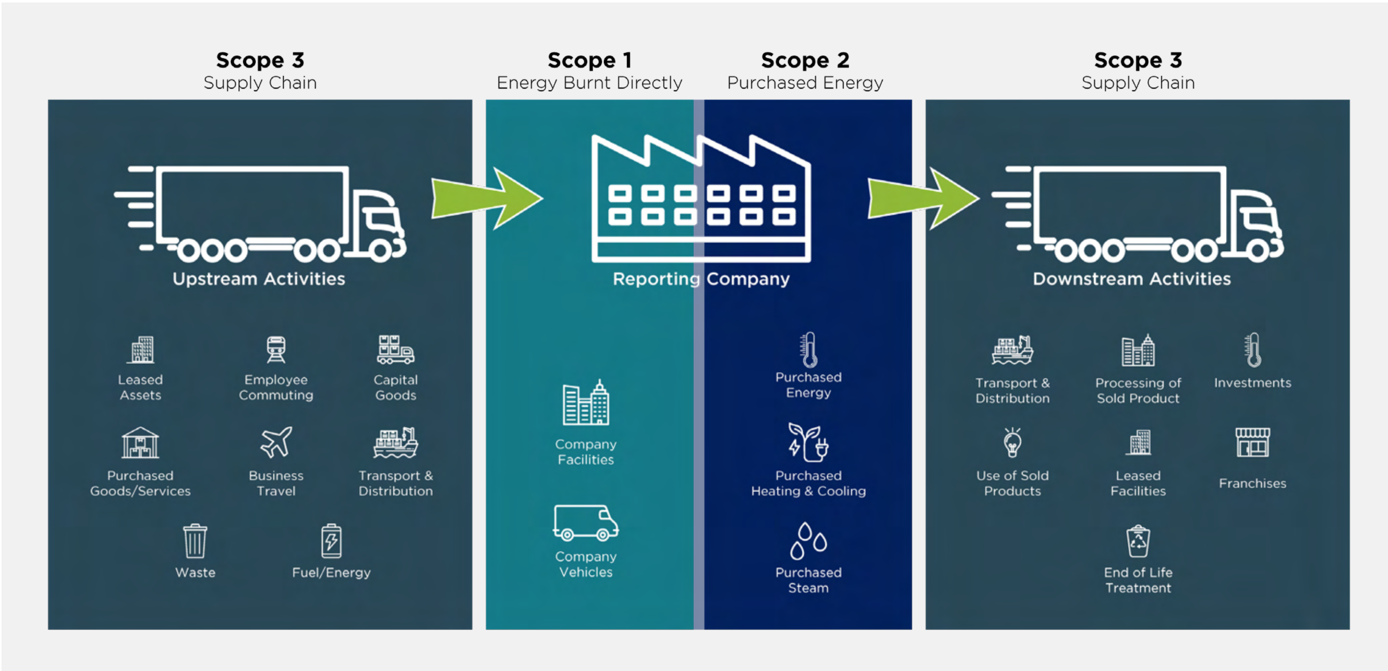


Figure 1 — The Greenhouse Gas Protocol categorizes emissions into three scopes, enabling organizations to understand their carbon footprint and take appropriate actions to reduce their environmental impact.

The Greenhouse Gas Protocol and the Elephant in the Room

The Greenhouse Gas Protocol, which provides a framework so that organizations can measure and report their GHG emissions, defines company emissions in terms of three scopes, explained in the above graphic.

Scope 3 GHG emissions encompass the carbon footprint of a company's up- and downstream activities around its products — they're passed along the value chain and grow with each successive processing step. That means they're huge, and largely not under a company's direct control.

TE estimates that some 90% of our overall (companywide) GHG emissions fall under the Scope 3 rubric, which, according to the GHG Protocol, is typical for productive industries. The levers we have that can influence this part of our carbon footprint include:

- The materials we use to manufacture our products
- The suppliers we purchase materials from
- Production approaches
- Product logistics and packaging

We're active on all these fronts: we decisively pursue weight and waste reduction in the design and manufacture of our products (using less material), more efficient processes (using less energy), and the incorporation of 'green' materials (to displace those with higher GHG emissions).

We're also working in close partnership with our suppliers to initiate sustainability change. In fact, most of our suppliers are also striving to reduce their own carbon footprints. Through these efforts and awareness-raising activities, we aim to cut our Scope 3 emissions by 25% by 2032.[1]

[1] Against a 2022 baseline and assuming 5% company growth.

TE Connectivity's green and next-gen products are, first and foremost, leading-edge connector and sensor technologies — highly functional, tried, tested, and reliable.

Part 2: Supporting our Suppliers in Reducing their GHG Emissions

Our automaker customers have defined clear emission reduction targets aligned with the Paris Climate Accord, setting strict targets along their supply chains regarding the use of renewable energies and recycled materials. It is incumbent on all of their suppliers to follow suit.

The largest share of TE's CO_2 emissions is associated with materials and semi-finished products that are sourced from our suppliers. For this reason, the change toward sustainability must also be initiated with them.

By working in partnership with one another, we can unlock the opportunities associated with a sustainable world of mobility while creating a circular economy, especially as it pertains to metals and plastics.

Our goal in this regard is to align on approach, methodology, definitions, and standards. The GHG Protocol has proven to be a great source of information and guidance on how to calculate company and product specific carbon emissions. TE, working in concert with our suppliers, is committed to increasing efficiency, optimizing processes, and reducing material usage.

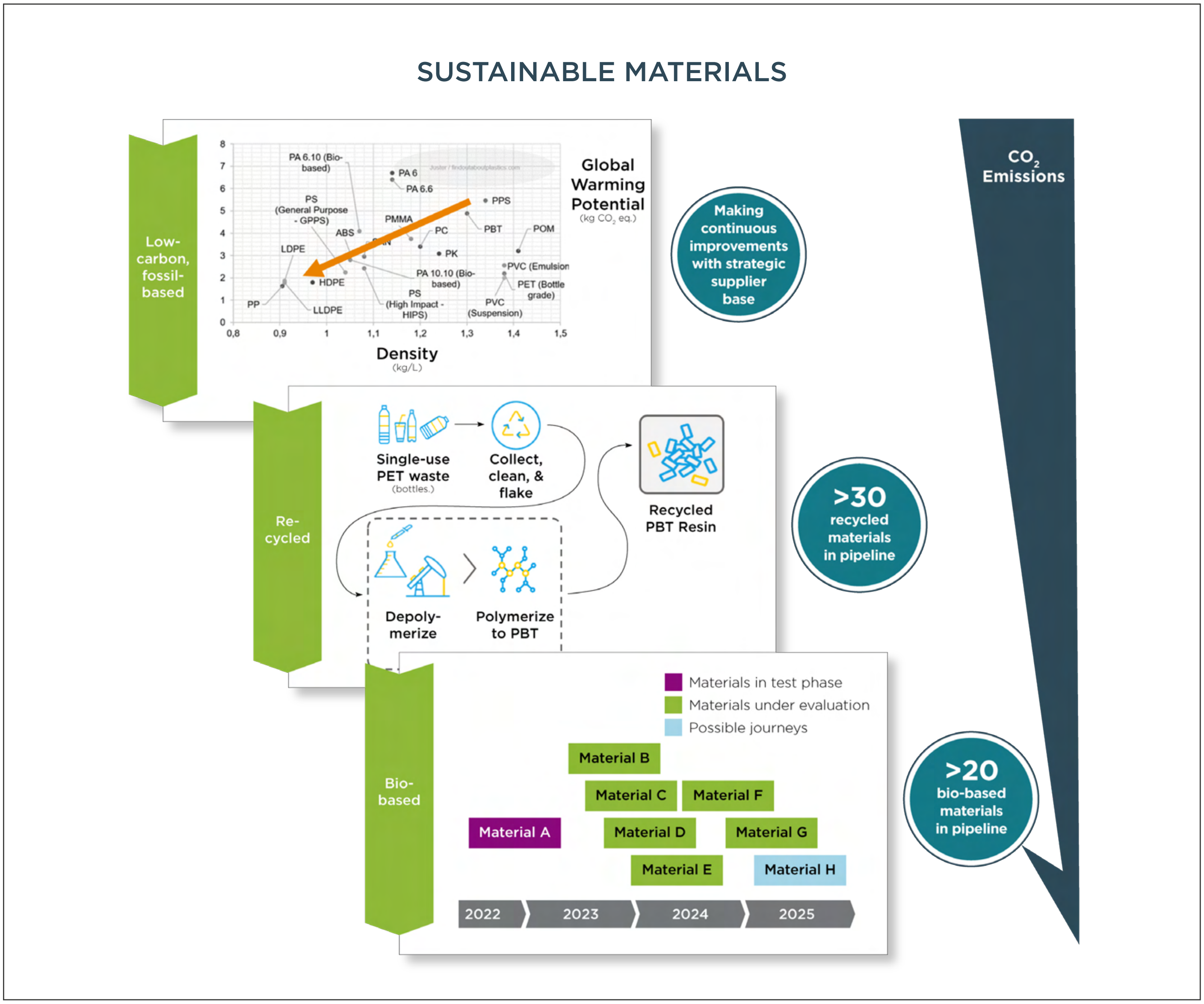


Figure 2 — We actively evaluate green materials that include a certain portion of recycled material or are bio-based. Targets are to meet our high-quality standards and match existing requirements and performance expectations.

Sourcing recycled and bio-based content for more sustainable resins

By choosing to work with suppliers that can provide raw materials with a lower global warming potential, TE is supporting the overall market for those materials. Indeed, our strategic goal is to have 70% of our portfolio designed to include components made with sustainable resins by 2032. Certain connectors, such as those for e-mobility, which are large and designed to carry higher voltages and currents, may use a proportion of mechanically recycled post-consumer PET blended into the resin base. And we're currently developing a variety of connectors (e.g. MATE-AX Header, NextGen+ MCON) made of resins that include recycled or bio-mass balanced content to further cut GHG emissions.

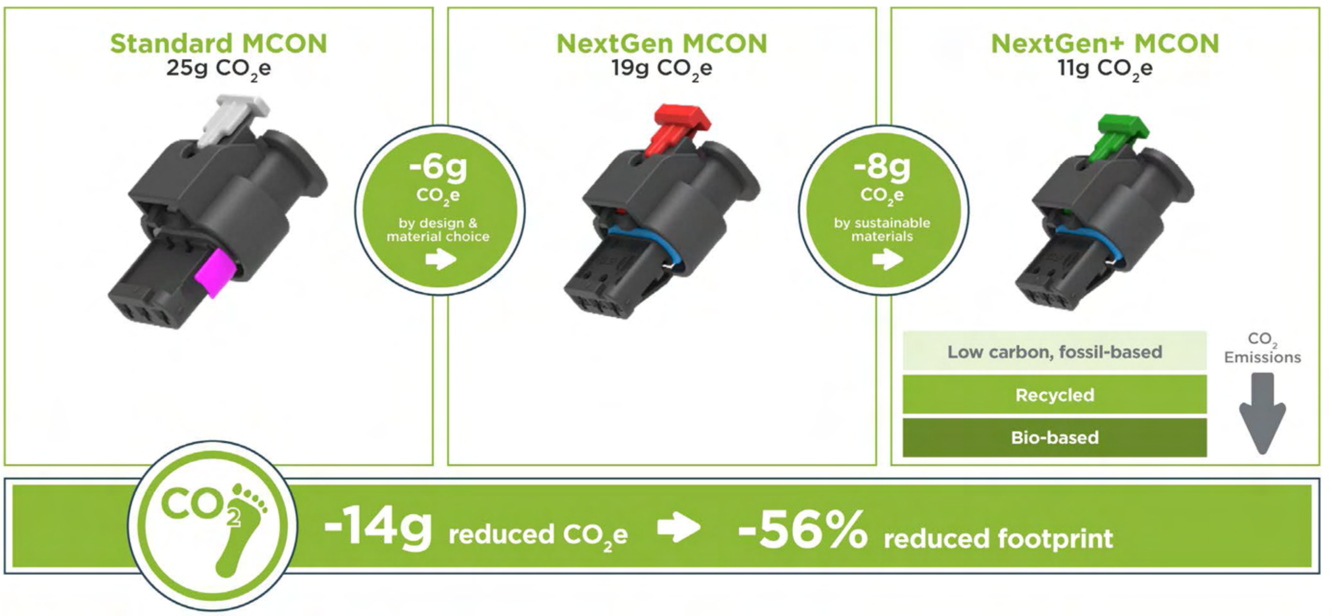


Figure 3 — TE's MCON NextGen connectors make use of PBT resins with lower global warming potential and, optionally, incorporating bio-mass-balanced resins to displace some of the petrochemical content.

Combining techniques multiplies GHG reductions

An example of this is our MCON series, TE's robust connectors for applications in harsh environments. Intelligently redesigned as a least-mass part, the NextGen MCON and the NextGen+ MCON connector families do without the MCON's PA46/PA66/PA6 resins and their corresponding higher GHG emissions. Instead, they use PBT resins that have a lower GHG potential and a more robust supply chain.

To further shrink the CO_2 footprint, OEMs may elect to have us displace a portion of the PBT content with bio-mass-balanced resins (NextGen+ MCON). In the case of the NextGen+ MCON, this combination of design and material advancements achieves a total reduction in GHG emissions of 14 g of CO_2e per connector (in case of 3-position version; other versions with comparable reductions).

These green enhancements come at no cost to functionality. The NextGen features improved CPA design and vibration performance (increased from SG3 to SG4), backward compatibility with the standard and Gen2 series (same interface), and of course, they're fully validated according to LV214 and USCAR2 standards.

TE's AMST tool helps engineers choose the greenest materials

TE's transportation solutions team has employed the Automotive Material Selection Tool — or "AMST." It empowers our automotive and commercial transportation engineers when designing connector components while keeping the highest levels of carbon neutrality in mind. By integrating cutting-edge technology and data analytics, AMST enables our engineers to make informed decisions and select the most sustainable raw materials for their designs. The database takes into account the environmental impact of the various resins, silicones, metals, and 3-D printing materials; the carbon footprint of those materials; resource consumption; and waste generation throughout the manufacturing process.

With just a few clicks, our engineers can compare different materials and evaluate their global warming potential. The tool takes regional variances into consideration and is updated frequently with the latest carbon footprint data from our procurement team and our suppliers. With AMST, we're helping to revolutionize the automotive industry by creating greener and more sustainable products from the ground up.

TE ► AMST AUTOMOTIVE MATERIAL SELECTION TOOL | ► CO2 FOOTPRINT including SUSTAINABILITY and CIRCULAR ECONOMY ASPECTS

GLOBAL MATERIAL STRUCTURE → GROUP_PN		► GWP / PCF - MEAN VALUES					
PART SYMBOL RESIN TYPE	COLOR DESIGNATION	SUSTANABILITY - TECHNOLOGY - RATING [Material Rating] RESIN SOURCE 1. Fossil 2. Fossil → low GWP (<=3,0 kg / C02 Emission) 3. Fossil → Micromolding (<2g Part Weigth) 4. Fossil → Miniaturization (High Flow Resin) 5. Fossil → Physical Foaming (Mucell) 6. Mechanical Recycling → PIR / PCR 7. Chemical Recycling → PIR / PCR 8. Bio based Resin (Bio Source >25%) 9. Mass Balance (Fossil-Bio based-Chemical) REMARKS GWP < 3,5 = good improvement	SUSTAINABILITY - GWP [kg CO2 Eq. / kg Resin] GLOBAL WARMING POTENTIAL - VIRGIN RESIN >>GWP<< *(Green Design Aspect)* BY PLASTICS EUROPE >>Mean Values<<	EMEA - SUSTAINABILITY - PCF [kg CO2 Eq. / kg Resin] PRODUCT CARBON FOOTPRINT >>PCF<< *(Green Design Aspect)* BY SUPPLIER DATA 1. Polymerization & Compounding 2. Base Resin and Additive 3. Data covered by → NDA Easy ways to improve your carbon footprint	NA - SUSTAINABILITY - PCF [kg CO2 Eq. / kg Resin] PRODUCT CARBON FOOTPRINT >>PCF<< *(Green Design Aspect)* BY SUPPLIER DATA 1. Polymerization & Compounding 2. Base Resin and Additive 3. Data covered by → NDA Easy ways to improve your carbon footprint	AP - SUSTAINABILITY - PCF [kg CO2 Eq. / kg Resin] PRODUCT CARBON FOOTPRINT >>PCF<< *(Green Design Aspect)* BY SUPPLIER DATA 1. Polymerization & Compounding 2. Base Resin and Additive 3. Data covered by → NDA Easy ways to improve your carbon footprint	MEAN VALUES - PCF [kg CO2 Eq. / kg Resin] DATABASE - SOURCES: A. ECOINVENT B. PLASTICS EUROPE C. GABI D. OTHERS ... ADDITIONAL - SOURCES 1. Resin Suppliers 2. Plastics Literature TE GENERIC - PCF DATA → ONLY for KPI calculatior *Just in case* *Supplier PCF not availab*
PP	NATURAL - NC001	Fossil → low GWP	x.xx	under evaluation	under evaluation	under evaluation	x.xx
PBT-GF10	NATURAL-NC103	Fossil → Miniaturization	x.xx	under evaluation	under evaluation	under evaluation	x.xx
PBT-GF10	BLACK-BK102	Fossil → Miniaturization	x.xx	under evaluation	under evaluation	under evaluation	x.xx
PBT-GF15	NATURAL- NC123	Fossil → Miniaturization	x.xx	under evaluation	under evaluation	under evaluation	x.xx
PBT-GF15	BLACK- BK128	Fossil → Miniaturization	x.xx	under evaluation	under evaluation	under evaluation	x.xx
PBT-GF20	NATURAL-NC116	Fossil → Miniaturization	x.xx	under evaluation	under evaluation	under evaluation	x.xx
PBT-GF20	BLACK-BK123	Fossil → Miniaturization	x.xx	under evaluation	under evaluation	under evaluation	x.xx
PBT-GF30	NATURAL-NC116	Fossil	x.xx	under evaluation	under evaluation	under evaluation	x.xx
PBT-GF30	BLACK-BK123	Fossil	x.xx	under evaluation	under evaluation	under evaluation	x.xx
PBT-GF30_HS	NATURAL-NC121	Fossil	x.xx	under evaluation	under evaluation	under evaluation	x.xx

Figure 4 — TE's Automotive Material Selection Tool goes beyond material selection by offering intelligent recommendations for reducing material usage, improving energy efficiency and enhancing overall product performance.

Part 3: The Effect of Intelligent Product Design on Sustainability

TE's 2030 goal is to reduce the overall weight of our new product portfolio. This initiative will have a direct impact on our Scope 3 emissions reduction target of 25% by 2032.

To do this, we use innovative product design and manufacturing technologies to cut overall component weight wherever possible. This 'lightweighting' practice mitigates the product's environmental impact in terms of both production and end use. It simultaneously reduces the quantity of raw material consumed — an especially important factor when the material is of petroleum origin — and boosts the efficiency of the associated production processes, saving on energy, packaging, and transport.

A big plus is that it also contributes to reductions in gross vehicle weight, both directly and, perhaps more critically, indirectly as an enabling factor that permits OEMs and harness makers to utilize lighter-weight cabling and other innovative solutions.

All our green and next-gen products are, first and foremost, leading-edge connector and sensor technologies — highly functional, tried, tested, and reliable. They start with ingenious designs that reduce component weight and manufacturing wastes, that make use of materials with lower global warming potential, and that employ sustainable manufacturing practices.

Reducing component weight is especially important for parts made of resin. Not only are resins hard to recycle, a single kilogram of virgin resin can start out with a carbon footprint of 6 kg of GHG emissions.

GENERATIVE DESIGN

Figure 5 — Product designs can be iterated using state-of-the-art simulation techniques combined with artificial intelligence. The optimal shapes found can reduce the amount of material needed to fulfill all specifications and manufacturing constraints.

Generative design saves the waste before manufacturing

One powerful tool we use in the design process conserves resources while improving both the GHG profile of the manufacturing process and the performance of the finished piece.

'Generative design' is an approach to product development that uses algorithms and computer simulations to generate component designs based on specified objectives and constraints (material properties, manufacturing type, performance criteria). It can be used to develop complex geometries that optimize material usage, and it's especially useful for parts that are subject to multiple loading scenarios or have requirements regarding stiffness, strength or durability. It helps to create designs that would be very difficult — or impossible — to achieve using traditional design methods.[2]

Iterations of refinement in the design process trim away the component's bulk until only the essential minimum is left. Less material means less weight, fewer GHG emissions, and more efficient manufacturing processes.

For parts such as latches, we may use physical foaming to create a lighter-weight structure by forcing nitrogen gas into the molten resin. This creates small bubbles within the resin, reducing its density while maintaining strength and other physical properties. This technique also makes less raw material go further than before.

[2] Background info: www.engineering.com/story/what-manufacturers-need-to-know-about-generative-design-a-technology-white-paper-for-executives

MINIATURIZATION

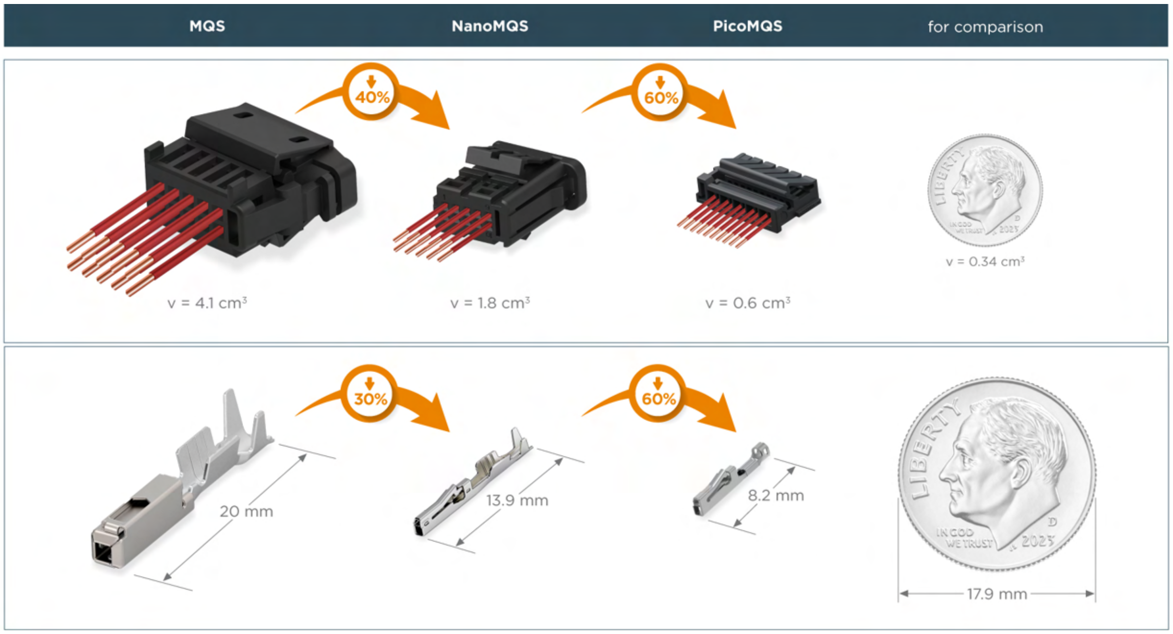


Figure 6 — Size reductions contribute materially to sustainability. The GHG emissions of the smallest version of the PicoMQS connector represent a savings of 60% over its largest predecessor, while retaining high performance and quality levels..

Miniaturization cuts down on raw materials while enabling more connections in the same space

In response to the automobile industry's need to pack more connections into the same spacial constraints, TE has worked for years to make our terminals increasingly smaller with no loss in performance. For example, our PicoMQS Miniature Connector series[3], see Figure 6.

Besides shrinking the connector's land pattern (or PCB footprint), it's easy to see that the smaller component also requires less material to manufacture. That applies not only the metal terminals themselves, but also to the resin housings, the latches, the plated contacts, etc. Smaller is simply… less.

TE's miniaturized connectors further facilitate an OEM's use of lighter cabling, which contributes to substantial material savings.

[3] TE miniaturization whitepaper 08-2018

Sustainable technologies for e-mobility

Technologies that enable e-mobility de facto contribute to sustainability. With zero tailpipe emissions and lower overall greenhouse gas emissions, electric cars have the potential to greatly reduce the environmental impact of transportation.

E-mobility is also the way of the future. With the EU's recent passing of the general ban on combustion-powered transportation by 2035, this wave will soon become a tsunami.

Several factors have contributed to the uptake in battery electric vehicles (BEVs), including the expansion of public charging infrastructure, which by most metrics is still insufficient. Range anxiety persists. Many of the latest BEVs now come equipped with peak charging capabilities of 150 kW or more. This can provide a significant amount of range in a short amount of time, reducing the need for hours-long charging stops on road trips. But when charging power is increased to 350 kW, it takes only about seven minutes to replenish 200 km of range , which truly approaches the speed and convenience of filling a conventional fuel tank.

With the high currents used in high-power DC charging (HPC), heat is generated as a consequence of the electric resistance of all the components (connectors, cables, etc.) along the charging path. These heat losses must be factored into the design and dimensioning of all electrically conductive components to avoid overloading or overheating, which can lead to a controlled de-rating (reduction in the current) by the charging station equipment to protect the car's battery. De-rating prolongs the charging time even at a HPC station!

TE has developed a methodology that addresses this heat challenge while also bringing sustainability advantages.

The aim of high-powered charging is to compress 200 km of range into 10 minutes of charging time, but an acceleration factor of 16x is equivalent to a 256x increase in heat dissipation.

E-MOBILITY SOLUTIONS ENABLE ZERO-EMISSION CARS

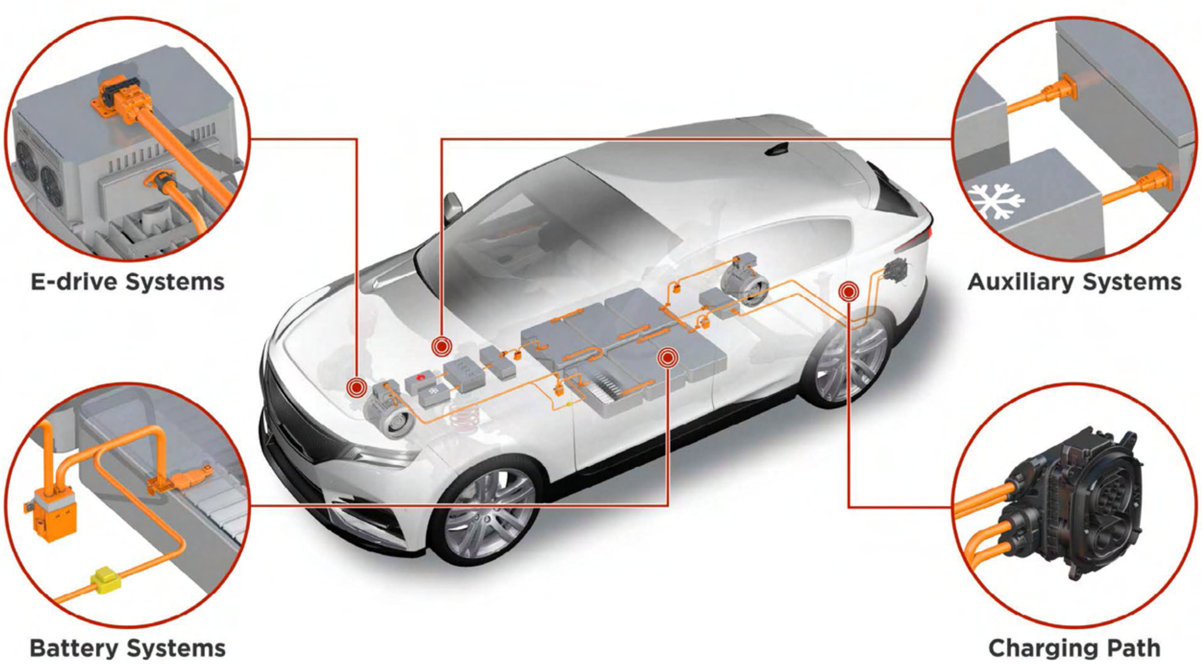


Figure 7 — TE's high-voltage connectors, terminals, charging inlets, and contactors offer safe, reliable, and flexible connections that reduce power losses and weight, improve charging speed, and protect EVs from electrical hazards.

Thermal simulation for optimal component dimensioning in the charging path

High-powered charging represents a peak load state for the electrical system in an EV: no other operating condition produces such a constant, high-energy flow between the charging point and the battery. The sharp heat rise during HPC is made worse by the lack of airflow around the parked vehicle.

A major challenge is that the higher the current, the larger the cable needed to carry the power without overheating. This matters in terms of weight and space. There's a considerable difference as to whether a 50 mm^2 or a 95 mm^2 sized conductor between the inlet and the battery will suffice. If HPC is to be a realistic proposition, we must avoid over-dimensioning of the electrical components, especially the cables. This overcorrection adds bulk to the wiring and weight to the vehicle, taking more resources to produce and more energy when in use. To facilitate safe HPC, then, all electric-conductive components — from the charging point to the battery — must be designed and dimensioned mechanically and electrically, but also thermally.

To date, electrical components have been developed based on static load points originally used for the design of relays and (switch) fuses, and they often include safety margins of up to 20%. But these underlying assumptions are no longer suited for either the dynamic load profiles of driving or the requirements of HPC.

The actual load profile in an EV differs dramatically from other vehicle applications; during HPC charging, the individual components along the charging path can show vastly divergent temperature profiles. Facilitating a peak load of 350 kW charging power therefore requires a different approach to designing the electrical components and the entire path.

TE's methodology dynamically determines the temperature increase and the heat dissipation at all points in the system, at all times.

Through systemic and near-real-world thermal simulation, we can now examine the component design much earlier in the process, so its performance can be predicted during various operation modes over its lifespan. Model-based thermal simulation provides a verifiable basis for future load profiles, which in turn provides proof of the safety, reliability, and durability of all the interconnection components along the high-voltage/high-current path. This allows us to reclaim some of the safety margin prescribed for static circuits, helping OEMs and tier-one suppliers to correctly dimension their circuit designs. This translates directly into material — and GHG — savings without loss in safety or function, as well as faster time to market.

DYNAMIC THERMAL MODELING

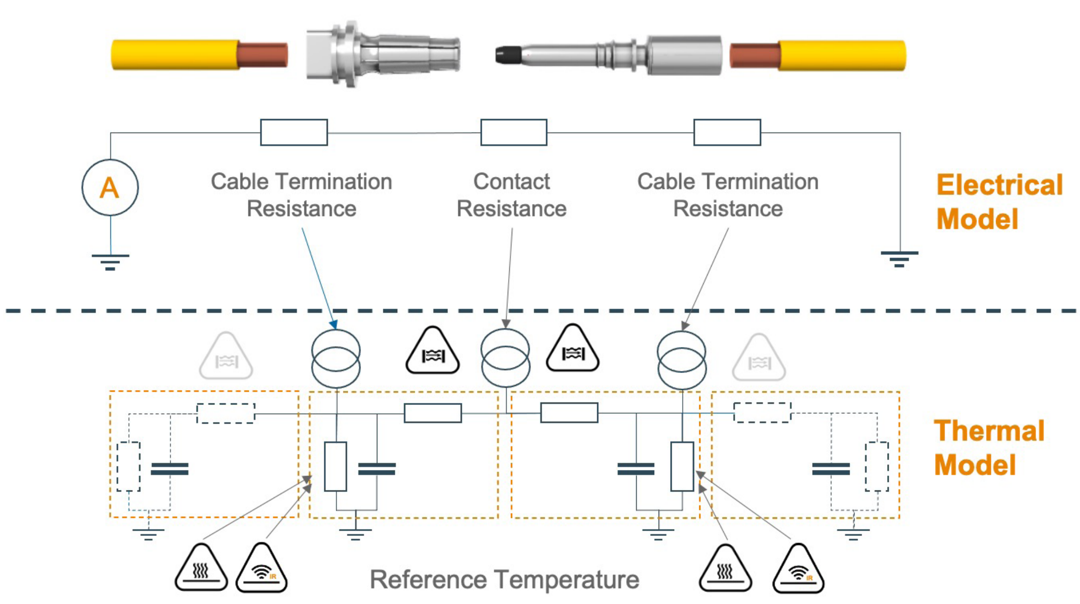


Figure 8 — Thermal modeling helps prevent overheating and makes it possible to see where terminals, connectors, and high-voltage pathways can be safely downsized to save material and weight.

Part 4: Net-Zero Manufacturing and Operations Innovations

Streamlining or re-engineering our manufacturing processes is one of the key strategies we're employing to achieve our ambitious Scope 1 & 2 GHG reduction goals, which foresee cutting those emissions by 70% by 2030.[4]

Avoiding wastes and byproducts is a strategy that we've employed for decades, but we continually look for ways to make our production leaner, less water- and energy-intensive, and more environmentally responsible. This always was good economic practice, but now it's an imperative.

RESINS

REGRINDING
Injection molding with a portion of grinded sprues directly in the closed-loop process

RECOMPOUNDING
Injection molding with a portion of grinded excess residuals outside of the machining process

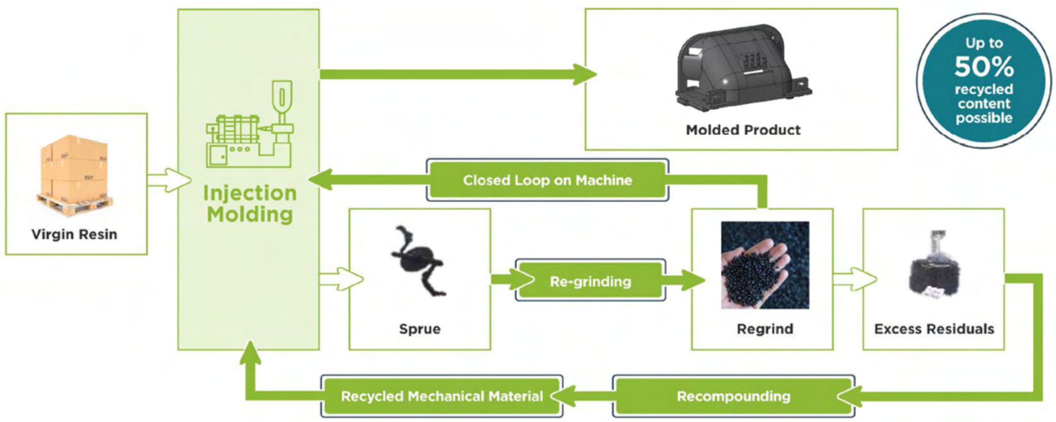


Figure 9 — Closed-loop manufacturing prevents the sprues — a byproduct of the injection molding process — from being wasted. A pre-determined portion of the sprues are immediately ground and reincorporated into the virgin resin.

Regrinding sprues reduces resin waste

For many of our injection-molded resin products, our closed-loop manufacturing equipment captures and regrinds the small waste parts generated in the process: the sprues. These are pieces of solidified resin left over in the channels used during the injection molding process; they allow the molten material to flow into the mold cavity. Once the resin has cooled, the 'extra bits' that are not part of the component's design must be removed from the finished part.

Without ever leaving the cycle, these pieces of resin are reground and returned directly to the manufacturing process for use. Sprues that cannot be reground and excess residuals are sent to a third-party provider for re-compounding, so they never enter the landfill.

[4] Against FY 2020 baseline

GREENSILVER PLATING TECHNOLOGY

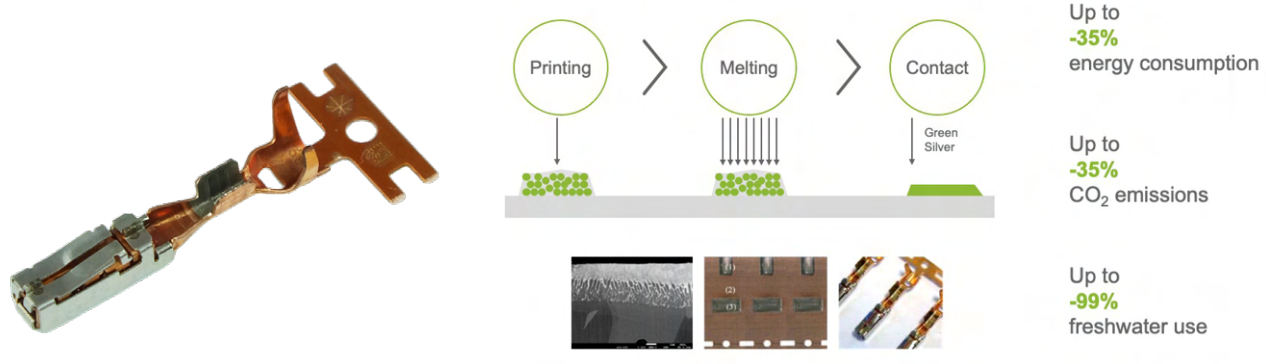


Figure 10 — TE's GreenSilver plating technology uses virtually no freshwater, generates no hazardous wastewaters, uses 35% less energy, and requires less silver.

GreenSilver terminal plating saves vast amounts energy, emissions, and water

TE's GreenSilver plating technology is both an original manufacturing process and an innovative new material that replaces electroplated silver as a protective-conductive layer. GreenSilver plating produces none of the poisonous wastewaters associated with galvanic electroplating. And it consumes about 35% less energy and less precious metals than electroplating. The result is a smoother, harder surface treatment bonded to the terminal through molecular intermixing between the silver coating and the underlying copper.

Not only does GreenSilver plating avoid toxic wastes and consume less energy during the manufacturing process, it also results in a finish with novel physical characteristics that withstand abrasion, vibration (up to SG6, depending on the terminal) and heat (max 180°C max operating temperature) better than electroplated silver can. Due to its close-packed, nanocrystalline structure, GreenSilver plating is not susceptible to cold welding or delamination. It's also a universal conductive coating, so it can connect to itself, to silver, to tin, or to gold, which greatly extends the range of application of any connector coated with it.

Since it can be paired with safety-system connectors that are mandated to be coated in gold, it enables further CO_2-saving decisions in the wiring harness. Given that the carbon footprint of just one ounce (0.03 kg) of gold can be nearly a ton of CO_2e, using terminals with GreenSilver plating on the other side of a safety-system connection can add up to significant GHG savings for OEMs.

Conclusion:

The Automotive Business Unit at TE Connectivity is the Company's Standard Bearer for CO_2 Neutrality

No multinational company can afford to ignore the importance of climate protection. Between consumer demands and governmental mandates, high energy costs and the very real risks associated with climate change, there are compelling incentives for businesses to take concrete steps to reduce their environmental impact and embrace sustainable practices.

We are excited to play our part in this effort. By prioritizing sustainability and taking proactive steps to reduce our own environmental impact, we're not only meeting our own targets but also helping our customers to achieve their sustainability objectives. And this will ultimately lead to a more sustainable mobility ecosystem for everyone.

Our approach to product design is collaborative, working directly with our OEM customers and their tier-one suppliers from the earliest stages of vehicle development, as well as to assess where they are in their sustainability journeys. Together, we're able to co-create products that are precisely tailored to their specific requirements.

Our global presence and flexible manufacturing capabilities enable us to achieve this at scale. TE provides local support to our global customer base with more than 2,500 automotive engineers and scientists in 26 manufacturing plants, plus another 19 centers of excellence around the world.

We're using our talent and resources to effect a sustainable transformation of our business and products to create environmental, economic, and social benefits. Because every connection counts.

For more information:

You can read more about our corporate sustainability concept, One Connected World, and our company-wide greenhouse gas targets in our Corporate Responsibility Report.

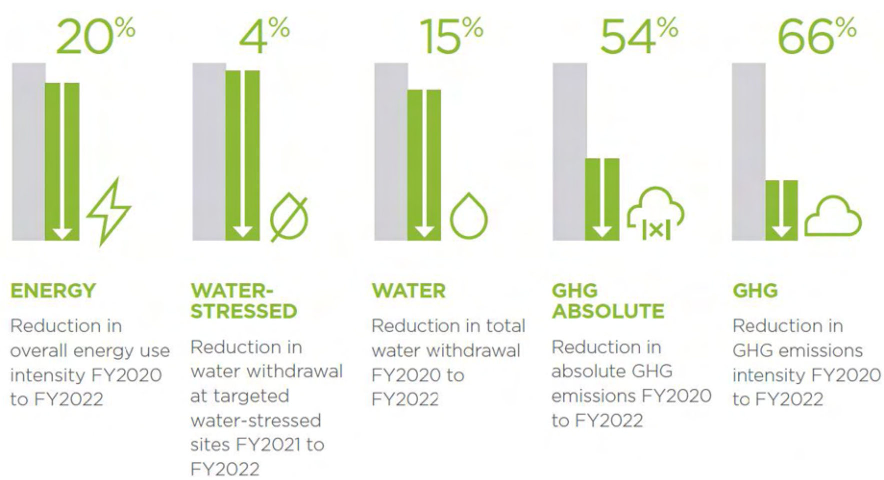


Figure 11 — An overview of how TE's manufacturing footprint has improved since FY2010.

te.com/automotive

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