

Swiss start-up aims to decarbonize heavy-duty, off-road vehicles with its ambitious electric drive systems platform

Automotive Low Frequency Market trends Products & solutions Responsibility and Sustainability Transportation

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Written by **Lilian Furrer**
Corp. Responsibility Communication Lead

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David Pöschel returning to the TERREN after scouting the road (Photo credit: Anna Plocinska)

Doing what many deemed impossible, three Swiss entrepreneurs established a new altitude record for electric vehicles (EVs) on the clear, cold, and windy afternoon of 3 December 2023 with the Peak Evolution project: They summited the world's highest volcano in their own prototype solar-powered, heavy-duty, off-road TERREN electric truck. In setting the altitude world record for EVs, the TERREN Electric Drive Systems team also achieved their shared vision of spotlighting the need for a global transition to clean energy, demonstrated technology's role in that transition, and put their prototype – including connectivity solutions from HUBER+SUHNER – to the ultimate test.

[Peak Evolution project](#) >

Blockbusters of change

While solar-powered EVs may be on the far horizon in terms of total cost of ownership and uptake by manufacturers of heavy-duty, off-road vehicles, the team added rooftop solar panels to their expedition vehicle as a means of putting the TERREN to the ultimate test: some of the world's most rugged terrain and demanding conditions—and absent a readily available charging infrastructure. Ultimately, experts say, their record-breaking achievement will help drive EV innovation.

That's an important contribution, given global megatrends associated with natural evolution and climate change. These decades-long, society-shaping blockbusters of change include trends that are right in TERREN Electric Drive Systems' wheelhouse: connectivity, mobility, and neo-ecology. Global population is increasing: The United Nations (UN) expect it to rise by nearly 2 billion people to 9.7 billion in 2050, and two out of every three people will be living in cities or other urban centres. At the same time, the International Energy Agency (IEA) predicts that the average annual growth rate of total energy demand will be 0.7 percent (about half the rate of the last decade) to 2030 and continue to increase through to 2050, while the global middle class grows rapidly.



These trends mean that an array of industries, from mining and agriculture to construction, freight, and waste management, relying on heavy-duty vehicles will face an uptick in activities in parallel with increasingly demanding regulations around vehicle emissions.

[World Energy Outlook 2023](#) >

Positioned to make an impact

With its modular EV platform, TERREN Electric Drive Systems is positioned to make an impact in the very industries that will be tasked with navigating the scenarios posed by these megatrends. Mining is just one example: The independent, nonpartisan, nonprofit Responsible Mineral Initiative, which transforms global energy systems through market-driven solutions to align with a temperature increase of 1.5 °C, says there are around 28,000 large-mine hauling trucks operating today; virtually all of them are diesel powered and each consumes 900,000 litres (237,700 gallons) of diesel per year, representing 30 to 50 % of their mines' total energy use. Collectively, these mining trucks emit 62 million tonnes (68 million tons) of CO₂ per year; RMI points out that this is equal to the total greenhouse gas footprint of Finland or New Zealand and suggests mining companies serious about combating their carbon emissions and lowering operating expenditures need to find a way to replace or upgrade their diesel fleets.

[Responsible Mineral Initiative](#) >

A record-breaking ascent

TERREN Electric Drive Systems cofounders – Chief Financial Officer Patrik Koller, Chief Operations Officer David Pröschel, and Chief Technology Officer David Koller – are ready to help drive that change. The expedition vehicle's record-breaking ascent to the summit of Chile's dormant Nevado Ojos del Salado volcano – 6,510 metres (21,358 feet) above sea level and with high winds and daily low temperatures of around -5 °C to minus -15 °C – proves it. More than just setting a world record, the team wanted to turn the global spotlight to the urgent need for a transition to clean energy, to demonstrate technology's role in that transition, and prove their prototype heavy-duty, off-road TERREN electric truck.

[TERREN Electric Drive Systems](#) >

The company's all-wheel-drive TERREN is based on a conventional, internal combustion engine-driven Aebi VT450 multipurpose transporter, powered by two, 120 kW, 12,000 rpm Bosch synchronous electric motors. The expedition vehicle relied only on its mobile solar power plant to charge three parallel, 300-volt Eco Volta lithium-ion battery packs.

David Koller, a mechanical engineer, said TERREN was unfazed by the expedition's challenges, including sandstorms; a loose, 30-degree grade along terrain comprising a mixture of large stones, pebbles, and sand.

"Just the sheer steepness was a challenge," he said. "But our TERREN didn't care much about any of that."

[Aebi VT450](#) >



The team setting up the solar power plant at base camp. Altitude: 6,200 metres above mean sea level (Photo credit: Anna Plocinska)





The final ascent to 6,510 metres above mean sea level (Photo credit: Sidario Balzarini)

Success-driving partnership

Contributing to the vehicle's robustness were several components from HUBER+SUHNER, who provided these often hidden but critical connectivity solutions as an in-kind contribution to the TERREN project:

- High-voltage RADOX® cables for EVs to ensure highly reliable and stable power transmission throughout the TERREN, from the charging port all the way to the battery, and for driving power from the battery to the electric motor, with no electromagnetic interference (EMI).
- RADOX® EV-C plugs guaranteeing a safe connection, including EMI protection, from the cable to TERREN's onboard devices.
- Two modular High Voltage Distribution Units (mVDUs) protecting the battery from overloading in the event of power supply issues or an off-road accident.

"These connectivity solutions were important because they connect the whole power path of the vehicle. If one of these cables had failed, the vehicle would have just stopped," Koller said. "At the same time, with 300-volt batteries, a cable failure presents a potential danger to the team, so safety was another important factor."

The performance of cables from HUBER+SUHNER didn't disappoint.

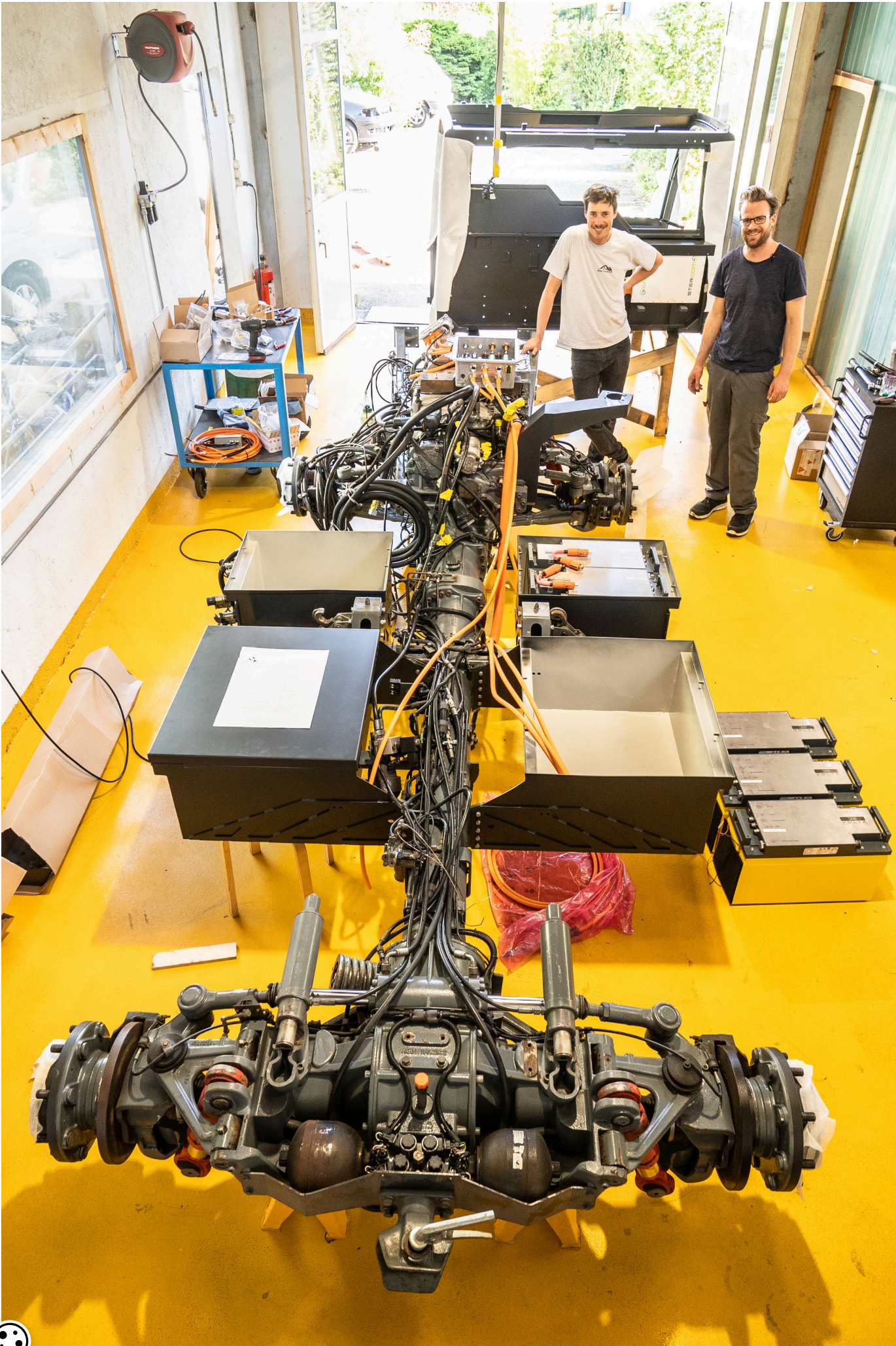
"The cables are much more exposed to harsh environmental conditions [e.g. weather, vibrations] compared to the batteries and inverters which are all packed and protected," Koller said. "The cables sometimes cover stretches where they are exposed directly to their environment, and it is crucial that they function in every condition."

Koller, who personally assembled all of the components from HUBER+SUHNER, pointed out that their built-in EMI protection made another significant contribution to the project by helping get the TERREN street certified prior to the world record attempt in Chile.

"We had to pass an EMI measurement test to get street approval and we had no issues. That speaks for the products, including the cabling," he said.

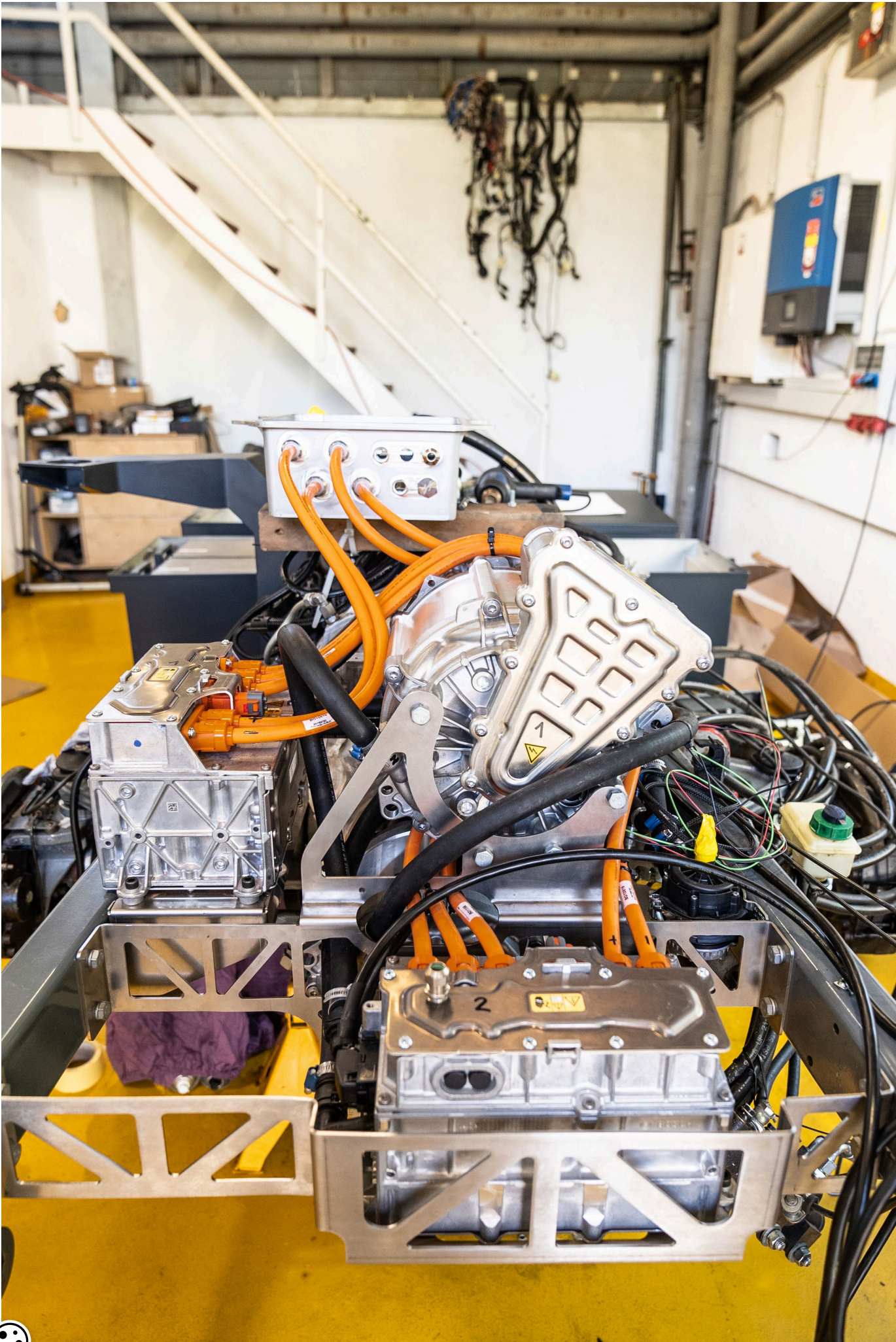
[High Voltage Distribution Unit](#) >





The chassis of the TERREN during its assembly (Photo credit: HUBER+SUHNER)





Modularity and robustness for the win

Koller additionally lauded the mHVDUs with robust fuses to protect all onboard devices, like the battery, from possible overload.

"The mHVDUs are well built, very modular, and perfectly fulfilled our needs. Our vehicle is pretty special, but due to the mHVDUs' modularity, we had no need for custom-made parts," Koller said. "Prior to meeting HUBER+SUHNER, I had considered using a custom-made part, which is always a risk. Proven, off-the-shelf products which have been tested under extreme conditions are much more reliable."

The TERREN team also valued the technical guidance of experts from HUBER+SUHNER.

"This was especially valuable in selecting and configuring the EV-C plugs to the cable we had selected. HUBER+SUHNER supported us in selecting the solution that best fit our needs. We just told them what voltage we expected, and they configured all the parts."

[TERREN Electric Drive Systems](#) >



David Koller, BSc in mechanical engineering, Head of Engineering TERREN Electric Drive Systems, Sevelen, Switzerland

Learn more about David Koller

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The experts weigh in

Copernicus, the European Union's Earth Observation Programme, reported that 2023 was the hottest year on record, with global temperatures close to the 1.5 °C limit established by the Paris Agreement and – adding urgency – a study published in Nature goes even further, concluding that 2023 was the Northern Hemisphere's hottest summer in the past 2,000 years. With that evidence, it's little wonder that the International Energy Agency (IEA) is projecting surging demand for EVs in the next decade in order to reduce oil consumption.

According to IEA Energy Modeller Apostolos Petropoulos, trends in key markets such as China and Europe indicate that heavy-duty EVs continue to make inroads.

"First of all, the batteries are becoming cheaper and, second, governments like the European Union, the United States, and China have rolled out important infrastructure installations," he said. "This would lead us to believe the passenger car trend toward electrification is also happening with heavy-duty vehicles."

Trucks and buses account for fewer than 8 % of vehicles (excluding two- and three-wheelers) but are responsible for 35 % of direct CO₂ emissions from road transports as claimed by the IEA. Heavy-duty vehicle emissions, the agency said, must rapidly peak and must begin to decline in the next decade in order to reach net-zero milestones. While the TERREN's solar charging capability was developed exclusively for the Nevado Ojos del Salado expedition, Petropoulos was intrigued by its potential.

'Quite innovative'

"As an idea, it's quite innovative and interesting to see because the heartbeat of heavy-duty vehicles is their power needs and the pressure they will put on the grid. For me, the key question is about cost, but we see that the cost of solar panels has decreased a lot. So how can you bring this innovation to the market in a competitive way," Petropoulos wonders.

[Surging demand for EVs](#) >

"I see potential use cases where a special, heavy-duty vehicle is needed for certain routes and certain applications. There could be a market for solar-powered, heavy-duty vehicles because they don't need to plug into the grid, but for now it's hard to envision this as the dominant technology. Good candidates for this kind of vehicle would be mining, the cement industry, or even some delivery companies with established routes where CO₂ emissions are high."

For purely battery-powered heavy-duty vehicles, uptake hinges to some degree on the cost of batteries and availability of charging infrastructure, but electrification is the way forward, Petropoulos added.

"It will be the key component of the carbonized sectors. What is important, especially for the mining industry, is that countries regulate the life cycle and life cycle emission of batteries to at some point force companies and production to follow cleaner ways of producing batteries, so that this can be a lever to ensure penetration of environmentally friendly technologies."

[International Energy Agency \(IEA\)](#) >





Apostolos Petropoulos, Energy Modeller at World Energy Outlook team, International Energy Agency (IEA) Paris, France

Learn more about Apostolos Petropoulos

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Scenario still 'very, very open'

Prof Kari Tammi, D.Sc., dean of the Aalto University School of Engineering in Espoo, Finland, and co-author of the step-by-step heavy-duty EV design and development guide, *Heavy-Duty Electric Vehicles: From Concept to Reality*, sees electrification as the path forward for heavy-duty vehicles. In addition to eliminating CO₂ emissions and their impact on the environment, he said there are other surprising impacts.

"Fighting climate change may be the major driver of electrification but there are also other emissions – for example if there are workers next to these [conventional internal combustion engine] vehicles, breathing nitrogen oxide emissions," he said.

While purely solar-powered heavy-duty vehicles like the TERREN expedition vehicle may be on the far horizon in terms of widespread adoption due to the challenges of requiring very high power and immediately harnessing from the sun, innovators like the TERREN team can advance the field through their research and development.

"Take Tesla, for example. In the beginning it looked very much like a rich man's hobby but became a serious actor and really a forerunner in the whole [EV] scheme, so much that others are actually copying Tesla," Tammi explained. "Very often, very good innovations come from outside of the established industry."

Tammi's advice for the TERREN team is simple.

"Timing is quite important: that you are not too early but just early enough with your innovation that the customers are interested. It looks to me like the TERREN Electric Drive Systems' technology is really perfect," he said, emphasizing that the business end of bringing a new technology to market – funding, marketing, or gaining customer acceptance – is where challenges may lie.





D.Sc. Kari Tami, Professor for Mechatronics and dean of School of Engineering at Aalto University, Espoo, Finland

Learn more about Dr. Kari Tami

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Fulfilling the customer's dreams

Peter Affolter, a professor of vehicle electronics in the automotive technology department at the Bern University of Applied Sciences in Biel and Vauffelin as head of the Institute for Energy and Mobility Research IEM, believes electrification of heavy-duty vehicles is the future – under certain conditions.

“Electric mobility in heavy-duty, off-road applications, if they have no waste gas, may be a really crucial advantage: There are very low or no heat emissions because of the high efficiency of the drive train and there is even high potential for recuperation as you need a lot of energy,” he said, explaining that regenerative braking is a unique technique that EVs use to capture energy.



Energy density is another issue, Affolter said. While high-voltage batteries are essential to electrify and decarbonize vehicles, the specific energy and energy density limitations of current battery technology present challenges. For example, heavy-duty commercial EVs and other long-endurance vehicles need to be able to store hundreds of kilowatt hours of energy onboard, and most lithium-ion batteries typically don't hold more than 400 Wh/kg.

Other challenges to the electrification of heavy-duty vehicles are affordability for customers. Moving boundaries to promote vehicle electrification often requires government intervention and support. But start-ups like TERREN Electric Drive Systems and partnerships like Volvo's investment in Designwerk Technologies can take risks with new technologies, he said.

"The TERREN vehicle really is a kind of proof of concept. I will be interested in seeing, 'Who is their first customer? What is the customer asking for?' And then, I'm sure they will have to be flexible in order to fulfil the needs and dreams of the customer."

[Department of Automotive Engineering, Bern University of Applied Sciences](#) >



Peter Affolter, Professor for Automotive Electronics, Head of Department Automotive Engineering, Bern University of Applied Sciences, Switzerland

Learn more about Prof. Peter Affolter



That first customer might not be too far in the future for TERREN Electric Drive Systems: Koller said the TERREN platform currently has no direct competitors but actually bringing the technology to market will require partnerships.

There are smaller vehicles that are already available but they do not fulfil all of the needs. On the other hand, there are big electric trucks available, but the off-road sector is really, really limited," he said. "It's not entirely clear when we will start actual production because we are

a team of just three people and we do need some partners, but I would say within five years.”

With one major adventure behind them after setting a new world record, the TERREN Electric Drive Systems today is focused on the road ahead – for their business and for the planet.

Get in touch with our Market Manager Automotive, Marc Moser, Market Manager Automotive, HUBER+SUHNER Group, Switzerland

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