Transportation

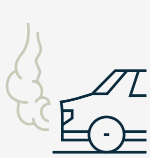
Despite rapid technological advances in recent years, transport still represents nearly a **quarter** of total global carbon emissions. By transitioning to electric vehicles (EV), incentivizing energy-efficient EV battery storage, investing in charging infrastructure and setting ambitious targets for renewable energy use in transportation, governments at the local and national levels can contribute to the decarbonization of the transportation sector.

THE NEED TO ELECTRIFY NOW

In both the U.S. and **EU**, the transportation sector contributes to approximately 30 percent of overall GHG emissions, with road vehicles accounting for nearly **three-quarters of transportation emissions** worldwide. Transportation is the largest source of greenhouse gas (GHG) emissions in the **U.S.**, which is the second largest emitter of GHGs worldwide. Likewise, the transportation sector is one of the largest emitters in both **the EU** and **China**, which is the **world's largest emitter of GHGs**.

According to the U.S. Environmental Protection Agency, **more than 95 percent** of the world's transportation energy comes from petroleum-based fuels. While more sustainable fuel alternatives, such as biofuels, provide part of the solution, they require more land for energy production. According to the **EU Green eMotion Project**, if every car used biofuels from existing farmland, there would be no land left for food production.

Bolstered by a shift to renewable energy sources (RES), electrifying transportation, particularly road vehicles, will make a significant impact on GHG mitigation. Battery electric vehicles (BEVs) do not emit fuel exhaust. In addition, they emit three times fewer GHG emissions and **consume two and a half times less energy** on a well-to-wheel basis. Prioritizing policy support for BEVs will amplify these efforts. However, to decrease the emissions from increased electricity demand, efficient battery design and smart electric grid harmonization, as well as renewably sourced electricity, will be needed to complete the decarbonization process. For example, the EU Energy Directive's ambitious targets for renewable energy use in the transport sector is expected to result in 40 million EVs on the road by 2030.



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COPPER'S CONTRIBUTION TO EFFICIENT ENERGY STORAGE AND TRANSFER FOR EVS

An EV requires efficiency not only in the battery but also in the motor, cabling and inverter. BEVs require **three times more copper** than internal combustion engine (ICE) vehicles, as copper is a key driver of energy-efficient electrical operation.

- Copper's inherent properties make it ideal for electric vehicles. **Nearly 70 percent** of copper in use today is used for electrical and conductivity applications.
- Copper can be **found in essential parts of EVs**, including the battery system, coils, windings, rotors and connectors. Copper coils in an EV's drive motor convert electric energy to mechanical energy, while copper wire connects the electronics and battery packs. Copper is a **core component** of EV electricity delivery, and more than a mile of copper wiring can be found in EV stators. BEVs **require 83 kg/183 lbs** of copper.

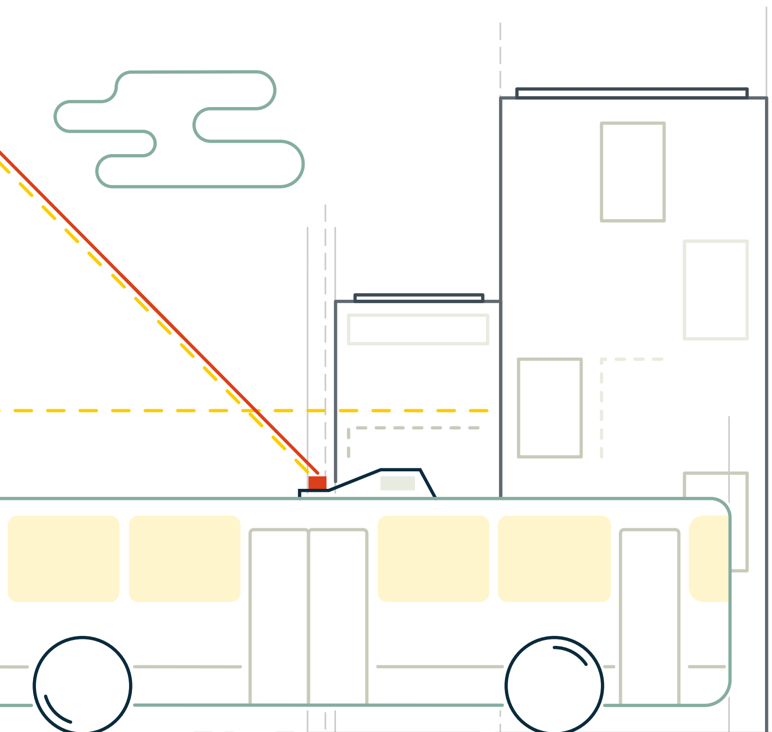
- Efficient charging stations are also essential for electrification. Charging time depends on the **vehicles battery and charging point capacity**. Copper is used in the wiring of charging stations and contributes to higher-efficiency energy transfer. Each charging station requires anywhere between **2.1 – 5.4 kg**/5 - 12 lbs of copper, with faster chargers requiring 8 kg/18 lbs of copper each. Estimates **show** that EV charging points will need 250 percent more copper by 2030.

EV HARMONIZATION WITH THE SMART GRID

- Expanding charging infrastructure and maximizing renewable electricity use will require connecting EVs into the smart grid to serve as energy storage for renewables and to reduce RES curtailment.
- Smart grid technology can **allow EV charging** to be shifted to off-peak periods and prevent stress on the electrical grid, reducing generation and network investment needs. This technology also enables EVs to act as batteries for the electrical grid, supplying electricity when variable renewable energy sources are generating less power.

DECARBONIZING THE WIDER TRANSPORT SECTOR THROUGH ELECTRIFICATION

- As of 2020, there were **500,000 electric buses and 400,000 electric delivery trucks** in operation. With the digitization of commerce and **acceleration of online shopping rates** during the COVID-19 pandemic, electrifying the shipping sector, particularly with larger road vehicles, has become more urgent. For example, trucks, buses and coaches represent less than 5 percent of road vehicles in the EU but **generate around 25 percent of road transport carbon emissions**.



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- Transitioning larger energy-efficient vehicles, such as buses and delivery trucks, to electric will offset the increase in carbon emissions. Copper contributes to buses, trucks and vans in the same way as personal vehicles but on a larger scale. Battery electric buses **require 369 kg/814 lbs** of copper.
- Electrifying public transit infrastructure, such as buses, would also contribute to decarbonization by eliminating diesel emissions from the buses themselves and replacing emissions from individual vehicles. For a 32 km/20 miles round trip, taking public transport can **offset an individual's carbon emission** by 4,800 pounds annually. Electrification will further amplify that effect. With limited driving ranges, downtime for charging and predictable, scheduled energy needs, buses are obvious candidates for electrification.
- Not only is electrification more sustainable, it is also more cost effective. For example, **electrifying the U.S. school bus fleet**, which is larger than any other mass transit system in the country, would save more than $2,000 in fuel per bus annually and cost 60 percent less than diesel buses to operate. As a result of aggressive subsidies, China hosts the **majority of the world's electric buses**, with many city centers now fully electrified as an essential part of meeting their net-zero 2060 climate goals.
- Data **shows** that rail accounts for only 2 percent of transport energy use and carries 8 percent of world's passengers and 7 percent of freight. Building and expanding high speed rail networks can also translate into significant emissions reductions if such systems are energy efficient and powered by renewable energy. Motors, alternators and the wiring harness are dependent on high conductivity. Electrified railways, trams and light railways are powered through overhead copper alloy contact wires. These wires contain high-quality brass, which has long-life resistance to corrosion, making it ideal for electrical connections.

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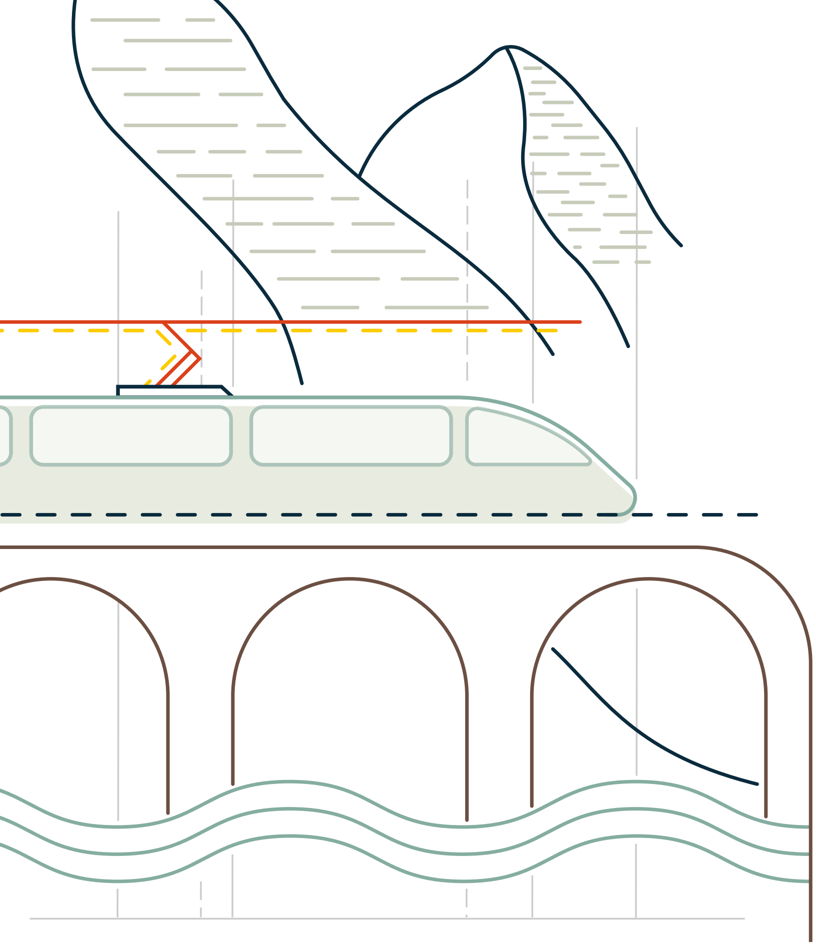
IN OPERATION



ELECTRIFICATION BARRIERS IN THE TRANSPORTATION SECTOR AND GOVERNMENTAL SOLUTIONS

Despite a myriad of benefits, many barriers remain for the uptake of electrified transportation, such as limitations in the electrical grid, consumer perceptions of EV cost, charging infrastructure and battery capacity.

While further investments in R&D for energy-efficient design are needed, governments can provide incentives and regulations regarding vehicle efficiency and carbon emissions, such as tax incentives, emission zone regulation and carbon emission trading systems. Governments can also address one of **the most significant barriers to EV adoption**: a lack of fast charging points along public roads. By investing in charging infrastructure, governments can:

- Make EVs accessible and create consumer confidence. As charging infrastructure availability increases in step with EV demand, governments can remove fear about range and accessibility, countering the "chicken and egg" problem of EV demand and infrastructure development. While BEVs have the capability to travel longer distances (>300 km/186 miles), they still have shorter ranges than traditional internal combustion engines. Minimum standards that provide for consistent electromobility, including slow (3.7 kW) electric charging in residential and nonresidential buildings, as well as public parking spaces for EVs with predictive charging capabilities (7.4 kW) and fast (150 kW) chargers on main highways will make owning an electric vehicle accessible to consumers and decrease range anxiety.
- Offset total cost of ownership. While total cost of EV ownership is already reaching parity or **exceeding performance** in terms of affordability with ICE vehicles, a regulatory framework providing for ubiquitous charging at reasonable costs will further incentivize EV adoption. Financial incentives for contribution to grid energy storage will also enable a greater share of renewables in the energy mix while incentivizing EV adoption.
- Ensure harmonization of plug and voltage standards. **Ensuring interoperability** of charging stations and devices will ensure that vehicles can be charged anywhere, anytime.

SUSTAINABLE COPPER

Copper is a **truly circular material**. With the ability to be recycled over and over without losing any of its physical properties, copper's current global end-of-life recycling rate is 40 percent, and in some parts of the world, such as the EU, China and Japan, more than half of all copper is recycled after use. Recycled copper already meets 35 percent of global demand.

As the world transitions to sustainable transport solutions, copper will be needed meet increased demand. Copper will sustainably support the energy transition at every stage, powering renewable electricity generation, expanding charging infrastructure and enabling advanced transportation solutions due to its circular and conductive properties.

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