

Module 4

Electric vehicles

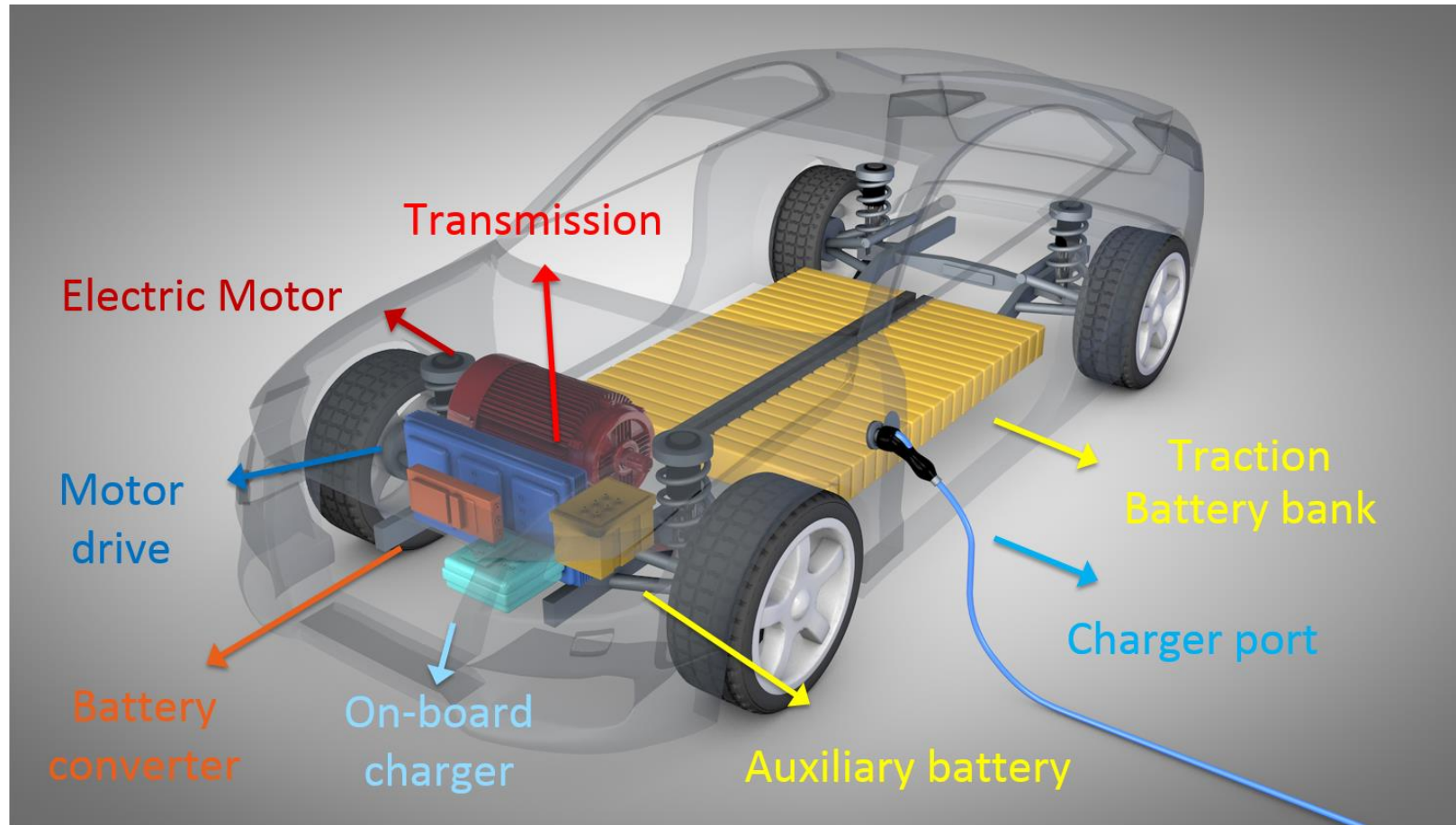
Electric vehicles

- Electric vehicles (EVs) are vehicles that are powered by electricity, rather than gasoline or diesel fuel.
- They use an electric motor to drive the wheels and are powered by rechargeable batteries.
- EVs come in a variety of forms, from fully-electric cars that can travel hundreds of miles on a single charge, to hybrid vehicles that combine electric and gasoline power.



- Electric vehicles operate on the principle of converting electric energy into mechanical energy, which is then utilized to generate kinetic energy and enable vehicle mobility
- EVs use an electric motor rather than a traditional gasoline engine. Electric energy, therefore, replaces traditional fuel (petrol/diesel). Electrical energy is converted into mechanical energy by the electric motor.
- In simple terms, an automobile that operates on traditional gasoline (petrol/diesel) has fundamental components such as an engine, gearbox, fuel tank, and so on. The engine in an electric vehicle has been replaced by an electric motor, and a battery pack has replaced the gas tank. The transmission stays the same, however, all-electric cars have a simplified gear system.

Components of electric vehicles



- **Battery pack:** It stores electrical energy that is used by the vehicle's electric motor and other components.
- **Charging port:** This is a port that allows you to connect the EV to an external power source to charge the battery pack.
- **Cooling system:** An EV's cooling system is analogous to a radiator in a traditional automobile. The cooling system assists in keeping the battery pack, electric motor, power controller, and other powertrain components at optimal operating temperatures
- **DC-to-DC converter:** This device transforms the high-voltage electrical current from the battery pack to a low-voltage current that may be used to replenish the auxiliary battery. The converter is also utilized to power various car accessories/components.
- **Electric Motor:** The electric motor is the core of the electric powertrain, converting electrical energy from the battery pack to mechanical energy. The gearbox, which drives the wheels, is linked to the motor.

- **Auxiliary battery:** An EV, like a petrol or diesel engine-powered automobile, has a 12-volt battery to power the lights, horn, accessories, and other vehicle components. The battery is powered by the energy stored in the main battery pack.
- **Transmission:** Usually known as a gearbox, it distributes mechanical energy from the motor to the wheels. The gearbox in EVs is automated, and the gear configuration is simple in comparison to traditional automobiles.
- **Power Electronics Controller (PEC):** This is a controller that controls the flow of electrical energy from the battery pack. In turn, it regulates the power and torque output of the electric motor

Working of electric vehicles

- The Power Electronics Controller (PEC) regulates the flow of electrical energy to the motor when you push the accelerator pedal.
- The amount of current required to power the motor changes based on the amount of pressure applied to the accelerator pedal.
- When the motor is powered up, the rotors begin to spin and generate mechanical energy.
- The mechanical energy generated by the motor begins to rotate the gears or transmission.
- The mechanical energy is transferred to the wheels via the gearbox, which moves the vehicle forward.

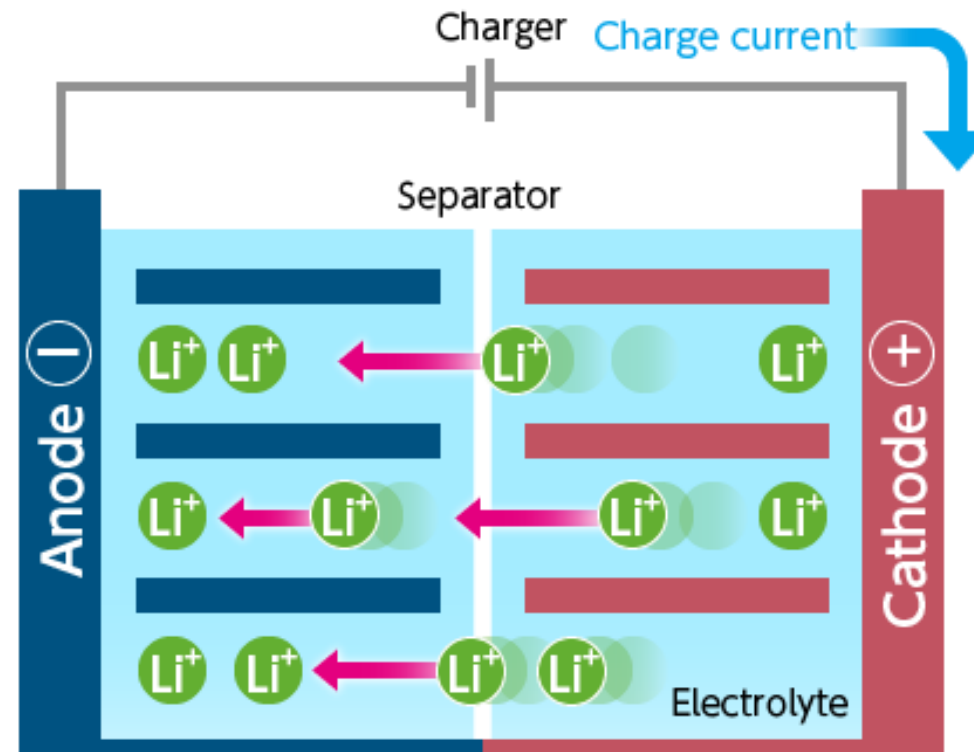
Batteries and Energy Storages

- Batteries and energy storage systems are devices that store energy in a chemical or electrical form and then release it as needed.
- Batteries work by converting chemical energy into electrical energy. They consist of two electrodes, a positive and a negative, immersed in an electrolyte. When a circuit is completed between the electrodes, a chemical reaction occurs, generating an electric current.
- There are many different types of batteries, the most common type of battery is the lead-acid battery, other types include lithium-ion, nickel-metal hydride batteries, etc.

Lithium iron (Li-On) batteries

- Lithium-ion batteries are lightweight, high-energy-density batteries that are widely used in portable electronics, electric vehicles, and energy storage systems.
- They are popular due to their high energy density, which means they can store more energy in a smaller space compared to other types of batteries.
- They also have a long lifespan and can be recharged hundreds of times.

- Lithium-ion batteries work by using a lithium-ion electrolyte to move lithium ions between two electrodes, typically made of graphite and lithium cobalt oxide. The movement of the ions generates an electric current.

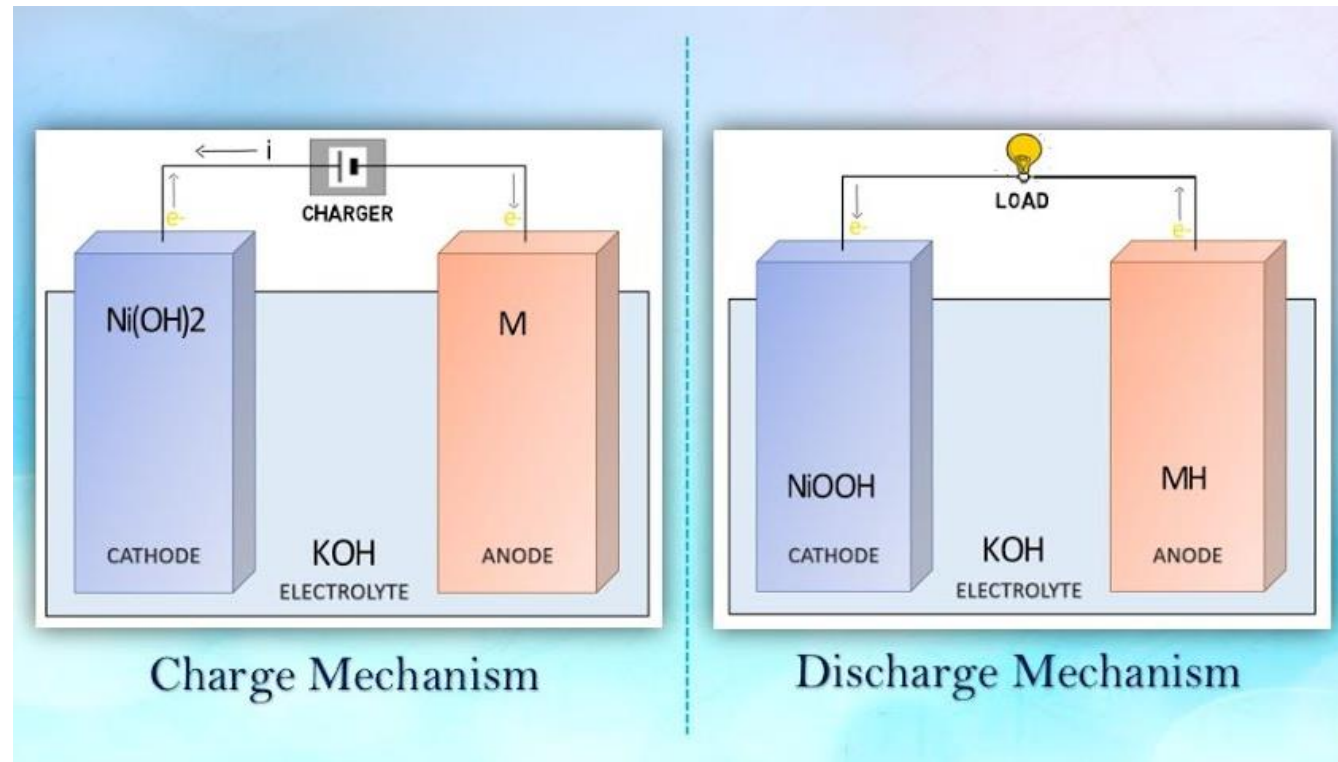


Nickel-Metal Hybrid (NiMH) batteries

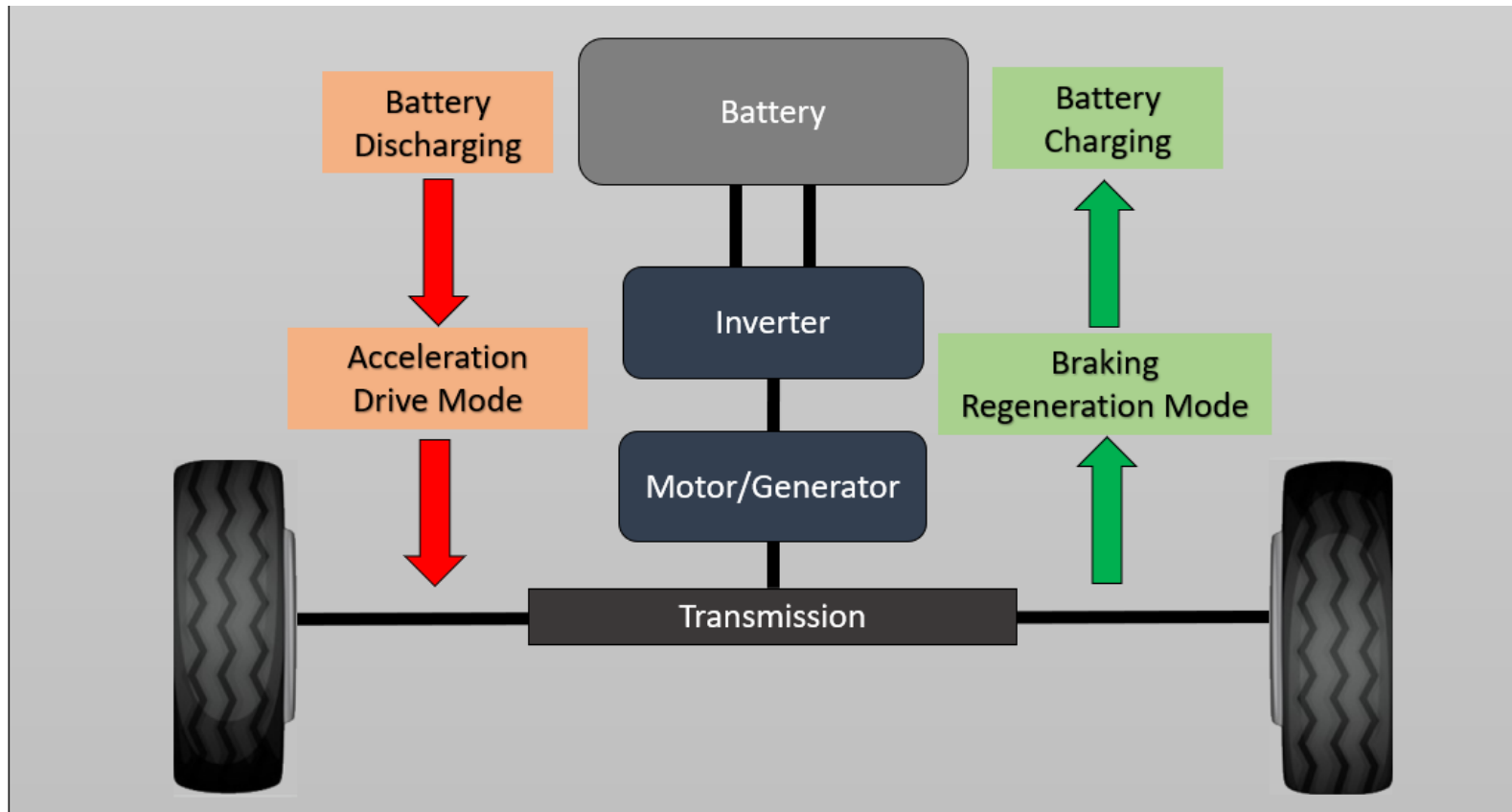
- Nickel-Metal Hybrid batteries, on the other hand, are less common than lithium-ion batteries and are primarily used in hybrid electric vehicles.
- They have a lower energy density than lithium-ion batteries but are more durable and have a longer lifespan.

NiMH batteries consist of a positive electrode made of nickel oxyhydroxide, a negative electrode made of a hydrogen-absorbing alloy, and a potassium hydroxide electrolyte.

The movement of the hydrogen ions between the electrodes generates an electric current.



Regenerative Braking system



- Regenerative braking is a system used in some hybrid and electric vehicles to capture energy that would otherwise be lost during braking and use it to recharge the vehicle's battery.
- When a conventional vehicle brakes, the kinetic energy of the vehicle is converted into heat through friction between the brake pads and the brake rotors, and this energy is lost as heat to the environment. However, in a regenerative braking system, the electric motor acts as a generator, and the kinetic energy of the vehicle is converted into electrical energy as the motor slows down the vehicle. This electrical energy is then used to recharge the battery
- Regenerative braking systems can help **improve the energy efficiency** of hybrid and electric vehicles. They can **increase the range of electric vehicles** by providing additional energy for the battery, and they can **reduce the amount of energy** required from the battery during normal driving, which can help **extend its lifespan**

Hybrid Electric Vehicles (HEV)

- Hybrid electric vehicles (HEVs) are vehicles that combine an internal combustion engine (ICE) with an electric motor and battery.
- The ICE and electric motor work together to power the vehicle, with the electric motor providing additional power and improving fuel efficiency.

Types of HEVs

HEVs can be classified into different types based on how the electric motor and ICE work together.

- The most common type is the **parallel hybrid**, where both the ICE and electric motor can power the vehicle independently or in combination.
- Another type is the **series hybrid**, where the ICE is used solely to generate electricity to power the electric motor and charge the battery.

Advantages of EV

- **Environmental benefits:** EVs produce zero emissions and are therefore better for the environment than traditional gasoline-powered vehicles.
- **Reduced operating costs:** EVs have lower operating costs than traditional vehicles because they require less maintenance and fuel costs are lower.
- **Improved performance:** Electric motors deliver instant torque, which provides better acceleration and responsiveness than traditional engines. EVs are also quieter and smoother to drive.
- **Energy independence:** EVs can be powered by renewable energy sources such as solar or wind power, which can help reduce reliance on fossil fuels

Challenges in EV

- **Range anxiety:** The driving range of an EV is dependent on several factors such as the size of the battery pack, driving style, temperature, and use of accessories. To address this challenge, automakers are continuously improving battery technology, increasing the number of charging stations, and providing more accurate range estimations
- **Battery cost and performance:** The cost and performance of the battery pack are a significant factor in the overall cost and performance of an EV.
- **Charging infrastructure:** The availability of charging stations is a critical factor in the adoption of EVs

Plug-in Hybrid Electric Vehicles (PHEVs)

- In a plug-in hybrid, the electric battery is the primary power source for the car. When the battery runs down, the internal combustion engine takes over. In a full hybrid, the battery only provides enough power for driving the car at slower speeds
- PHEVs have a larger battery pack than conventional hybrids and can operate in electric-only mode for a limited distance before switching to the gasoline engine.
- This allows PHEVs to offer the benefits of electric vehicles while also providing the extended range of traditional gasoline-powered vehicles

Emission control in Automobile

- Emission control refers to the process of reducing or eliminating harmful emissions produced by vehicles, industries, and other sources of pollution.
- The primary objective of emission control is to mitigate the negative impact of pollutants on human health and the environment
- It involves the use of technologies such as catalytic converters, exhaust gas recirculation (EGR) systems, and diesel particulate filters (DPF) to reduce the amount of harmful gases and particulate matter released into the atmosphere

Types of emissions produced by automobiles

- Hydrocarbons (HC): Hydrocarbons are compounds made up of hydrogen and carbon that are released during the incomplete combustion of fuel. They are a major contributor to the formation of ground-level ozone, which is harmful to human health and the environment
- Carbon Monoxide (CO): Carbon monoxide is a colorless, odorless gas that is produced during the combustion of fuel. It is toxic to humans and can cause headaches, dizziness, and other health problems
- Nitrogen Oxides (NO_x): Nitrogen oxides are compounds produced when nitrogen and oxygen react at high temperatures, such as in the combustion chamber of an engine. They contribute to the formation of acid rain and smog, which can cause respiratory problems and other health issues

- Particulate Matter (PM): Particulate matter refers to tiny particles of solids and liquids that are released into the air during combustion. These particles can be inhaled into the lungs, causing respiratory problems and other health issues.

BS4 and BS6

- BS4 and BS6 are two different emission standards that have been implemented in India by the government to control air pollution caused by automobiles
- **BS4**, also known as Bharat Stage 4, is an emission standard that was introduced in India in 2010. It required all new automobiles to meet certain emission standards for hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM). BS4 emission standards allowed for a maximum of 50 parts per million (ppm) of sulfur in diesel fuel.

- BS6, also known as Bharat Stage 6, is a stricter emission standard that was introduced in India in 2020. It requires all new automobiles to meet even more stringent emission standards for HC, CO, NOx, and PM. BS6 emission standards allowed for a maximum of 10 ppm of sulfur in diesel fuel, which is a significant reduction from the 50 ppm allowed under BS4
- The main difference between BS4 and BS6 is the level of pollutants that are allowed to be emitted by new automobiles. BS6 has much stricter limits on the amount of pollutants that can be emitted, which means that vehicles need to be equipped with more advanced emission control systems to meet these standards. As a result, vehicles that comply with BS6 standards are generally considered to be cleaner and more fuel-efficient than those that comply with BS4 standards

Indian motor vehicle Act

- The Motor Vehicles Act (MVA) is an important piece of legislation in India that governs the registration, licensing, and use of motor vehicles on Indian roads.
- The Act has been amended several times over the years to keep up with changes in technology and road safety requirements
- The Act lays down various rules and regulations for the safe and efficient operation of motor vehicles on Indian roads.
- It mandates that all motor vehicles must be registered with the local transport authorities and that drivers must have a valid license to operate a vehicle.
- The Act also sets standards for vehicle safety, including mandatory use of seat belts and helmets, and requires manufacturers to meet certain safety standards for their vehicles

- One of the most significant recent changes to the MVA was the increase in penalties for traffic violations, which were raised substantially in 2019.
- These penalties are now among the highest in the world, and are aimed at promoting better compliance with traffic rules and improving road safety
- Overall, while the Motor Vehicles Act has played an important role in regulating the use of motor vehicles on Indian roads, there is a need for ongoing efforts to improve road safety and reduce pollution through better policies and more effective enforcement.

