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The promise of lightweighting

Shining a light on global challenges and solutions for lighter, more efficient vehicles

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Introduction: changing times, changing needs

You may remember a time when cars were designed primarily to get people to their destinations without breaking down. People weren’t even thinking about in-car Wi-Fi, inductive charging mats and vented seats.

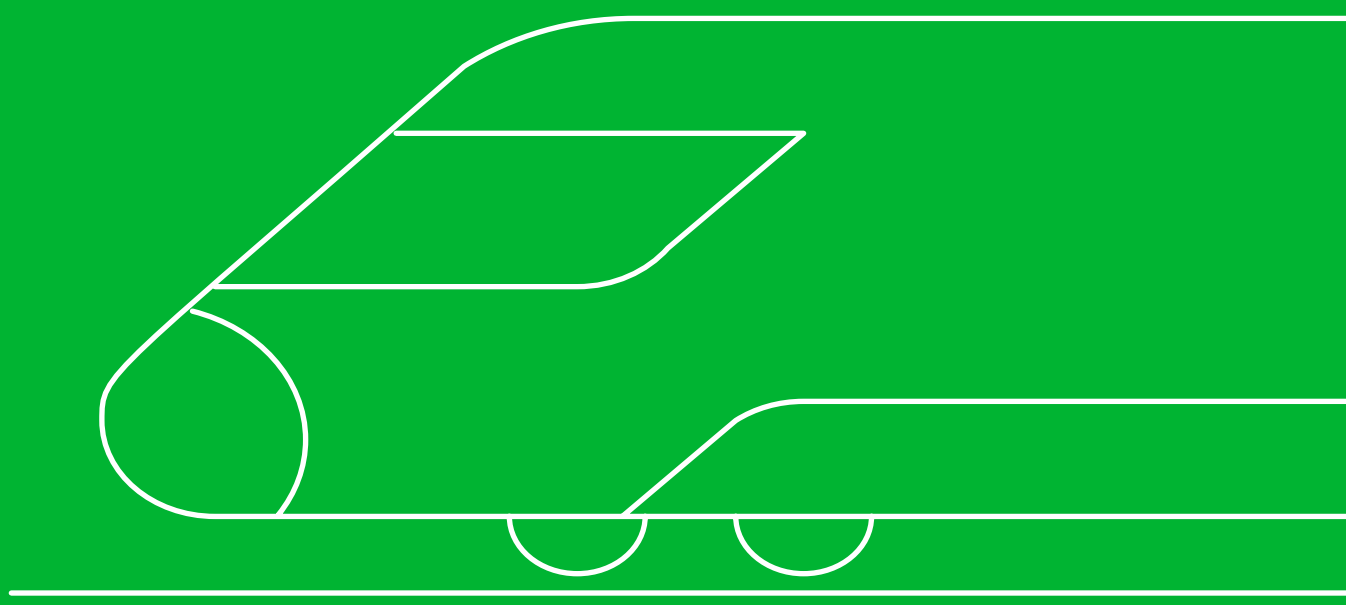
Those features — plus powerful engines, increased safety, passenger comfort, better climate control and less road noise — undeniably add weight to vehicles.

The big challenge

Car owners want better gas mileage, and many governments are pushing for fuel efficiency and better air quality from lower emissions.

That’s a big challenge for design and process engineers in the transportation industry — continually increasing efficiency and lessening emissions, while still keeping drivers and riders happy, safe and comfortable.

There are a few paths to more climate-friendly solutions: alternative fuel sources, more efficient engines, optimized aerodynamics of auto bodies and lower-weight components inside and outside the vehicle.



How the landscape is changing

Both consumer demands and evolving manufacturing technologies are driving change at a faster and faster pace.

As electric vehicles become more common and autonomous cars become more possible, we continue to look for the next big thing — maybe solar and wind-powered cars, micro-transit or even a hyperloop. Regardless of the method of transportation, lightweight materials and efficiency of both vehicles themselves and their production will be two key issues.

“In any form of transportation, whether it’s a car, a plane or a hyperloop pod, lighter is better. It’s one of the first considerations when designing a vehicle.”

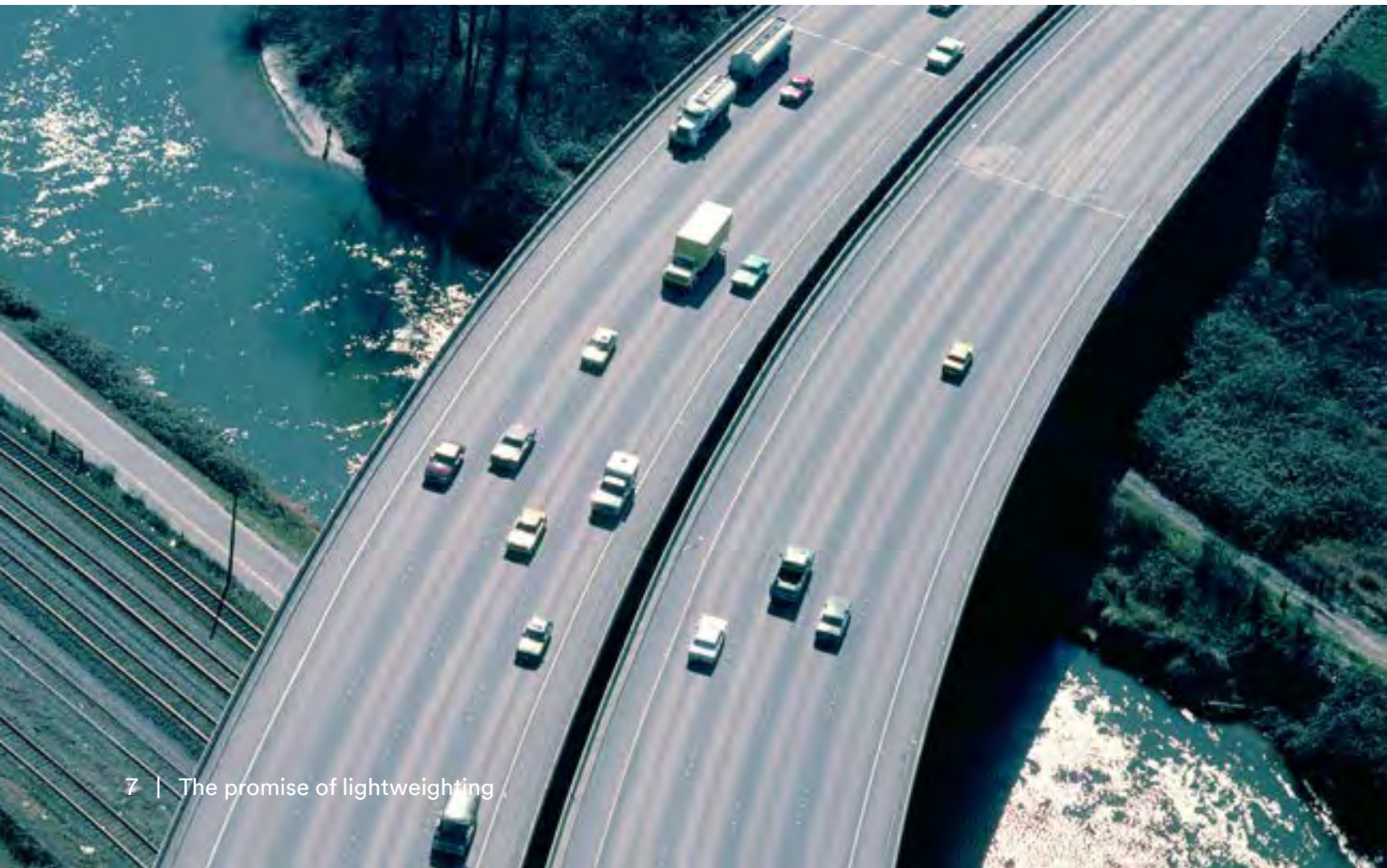
–Cody Schwartz, structural team lead for Badgerloop, University of Wisconsin-Madison

The drive behind lightweighting: global megatrends

For automakers, the push to reduce weight in passenger vehicles is primarily driven by government regulations and standards. All areas of the globe are impacted by emissions, and some countries and regions are pushing harder to implement stricter regulations.

To offset climate risk, many governments have passed legislation to reduce emissions causing greenhouse gases, especially carbon dioxide, or CO_2, which causes 63 percent of global warming issues. The Paris Agreement is an international agreement reached in 2015 to address the threat of global climate change. Countries agreed to set their own targets for reducing carbon emissions.

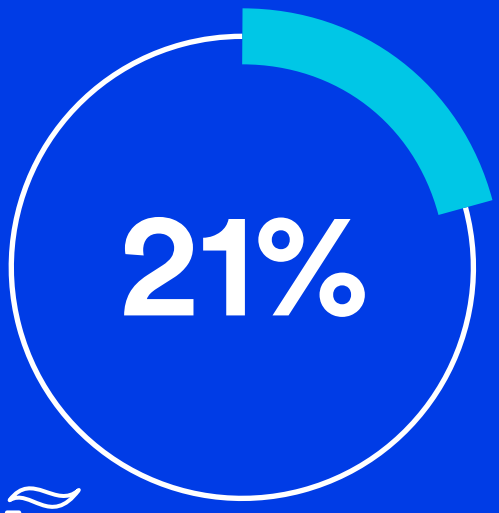
Energy is the largest contributor to CO_2 emissions globally, particularly from combustion of fossil fuels. The transportation sector is responsible for 27 percent of greenhouse gas emissions in the U.S. and about 14 percent globally, according to the Environmental Protection Agency. The European Union sees 24 percent of CO_2 emissions coming from transportation, with 20 percent of the total from road transport, according to the EU Commission.



Global Greenhouse Gas Emissions by Economic Sector

Electricity and Heat Production

Agriculture, Forestry and other Land Use



Industry

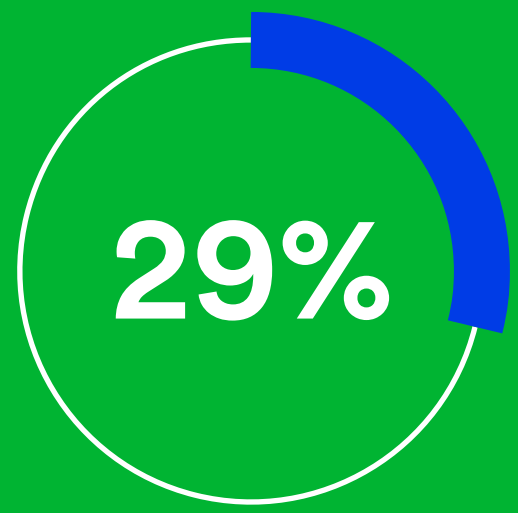
Transportation

Other energy

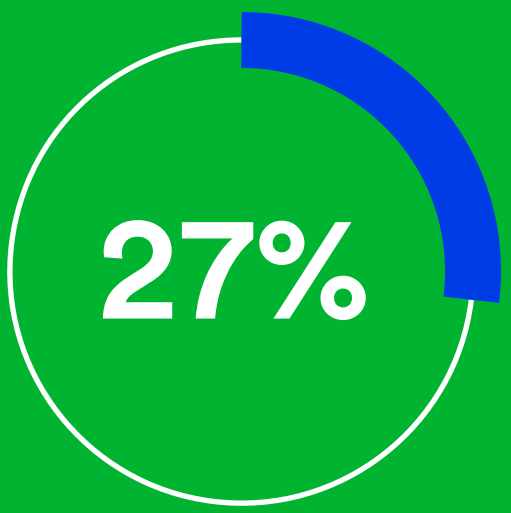
Buildings

Source: IPCC (2014). Based on global emissions from 2010.

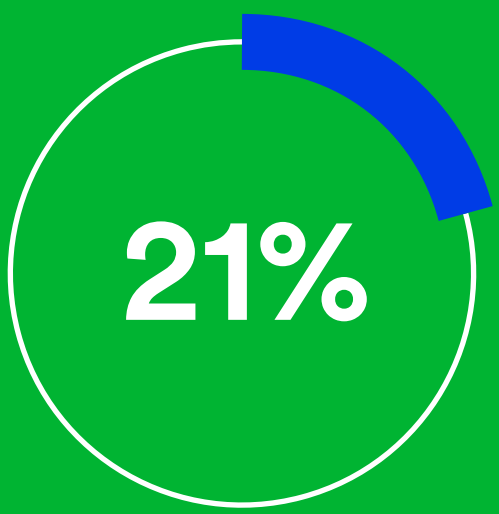
Total U.S. Greenhouse Gas Emissions by Economic Sector



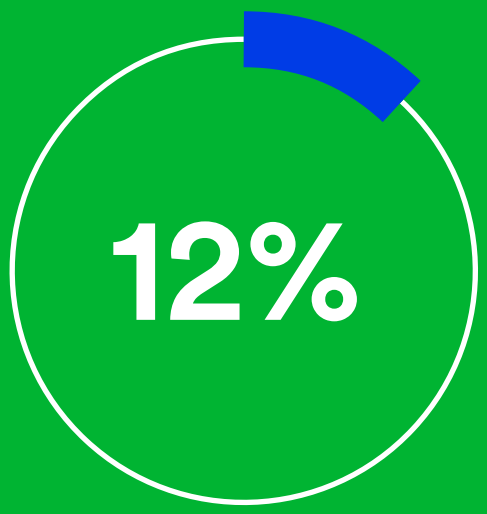
Electricity



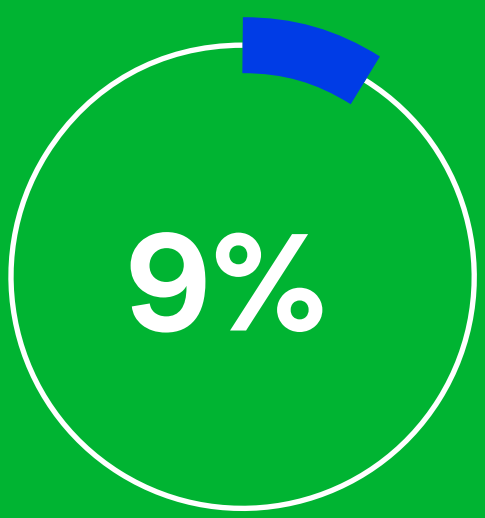
Transportation



Industry



Commercial & Residential



Agriculture

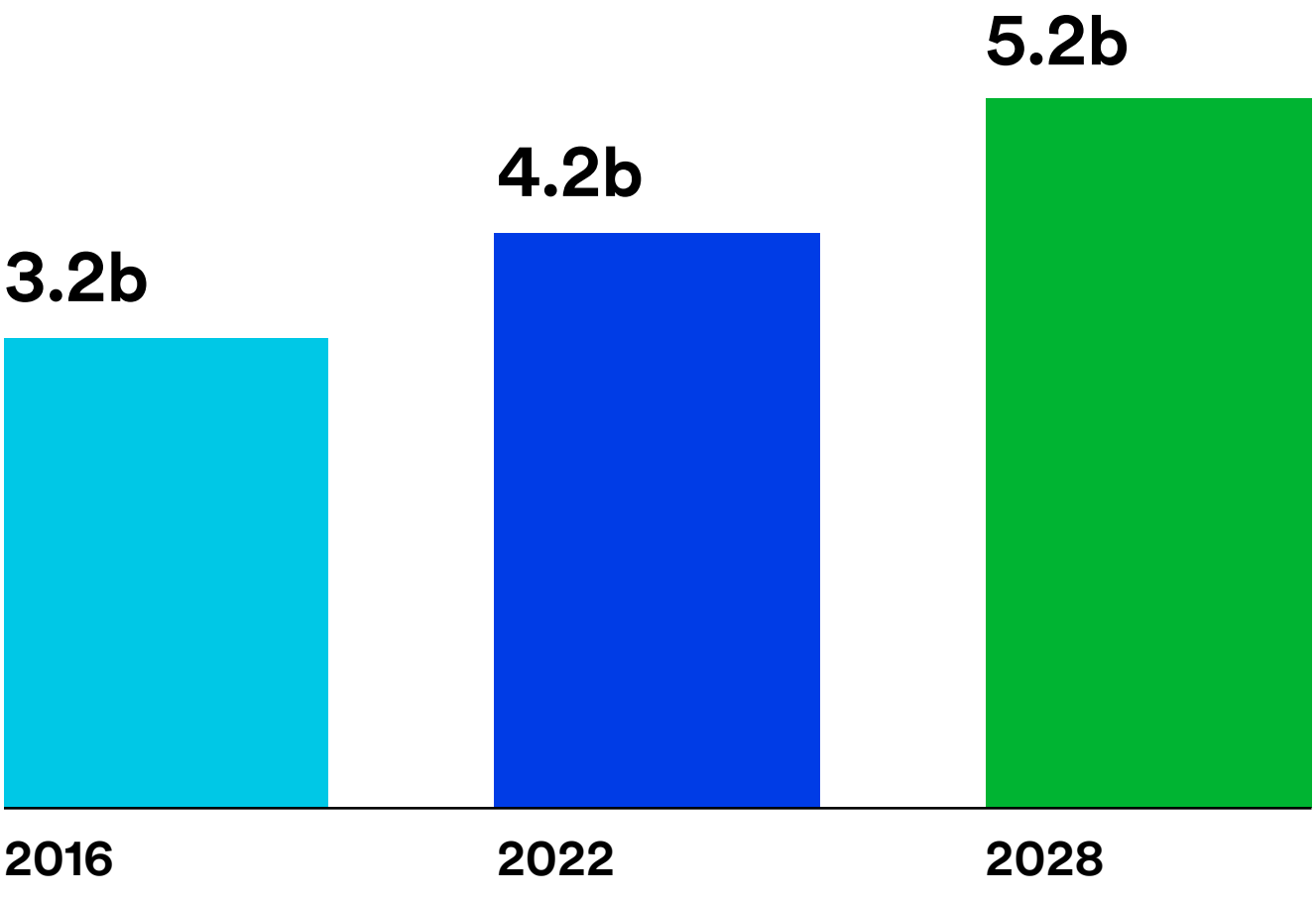
Source: IPCC (2014). Based on global emissions from 2010.

Why the push for legislation?

Regulations are due partly to global megatrends, including urbanization and growing economies. Urbanization is affecting every region in the world, but developing countries will see the biggest impact. More and more people are living in cities, and this trend is only expected to increase. According to UN.org, about 54 percent of people currently live in an urban area, and the trend toward urbanization is expected to continue.

Emerging economies and a rising middle class, especially in Asia, are also leading to an increase in travel and specifically the purchase of passenger vehicles.

A growing global middle class globally



Source: Brookings.edu

Regulations and legislation

The Group of 20, or G20, countries — the world's 20 leading industrialized and emerging economies — have adopted policies to reduce fuel consumption, air pollution and carbon emissions.

These 20 countries account for 80 percent of global energy demand and about 90 percent of new vehicle sales, according to the International Council on Clean Transport.

Key energy targets and emissions reduction regulations in the European Union

The European Union (EU) has set a target to reduce carbon dioxide emissions – across all sectors including transportation – with progressive goals until the year 2050.

The 2020 climate package put legislation in place to ensure climate and energy targets are met by the year 2020. The EU intends to cut greenhouse gas emissions from 1990 levels by 20 percent. The EU intends to cut by 40 percent by 2030.

"We want the European automotive industry to get back in the race for global leadership on clean vehicles."

–Miguel Arias Cañete, EU Climate Commissioner

Source: Reuters: EU plans credits, fines to boost low-emission car production

Specific targets are in place for multiple areas of transportation. Transportation accounts for about one quarter of Europe's overall greenhouse gas emissions. Separate targets are specified for road transport, fuel quality, shipping and aviation.

According to the European Commission, cars are responsible for about 12 percent of total EU emissions of CO_2.

In November 2017, the European Commission unveiled new proposals for limits on emissions. The new standards would push manufacturers to cut emissions from new passenger cars and light commercial vehicles to be 30 percent lower in 2030 compared to 2021.

The standard would apply to the manufacturers' entire fleet of vehicles, so they can still produce some heavy-duty trucks and SUVs as long as they have enough low-emission vehicles to create the balance they need. SUVs are increasing in popularity. 22.4 percent of vehicles sold in Germany are SUVs, while only 0.7 percent of all vehicles sold there are electric, so there is still a challenge to get the right mix available to consumers and out on the street.

The commission is also continuing to work on strategies to address emissions solutions for freight and passenger transportation.

The European Union and the United States have some of the most stringent standards already in place for emissions and fuel economy.

Source: Pace Consulting: The CO_2 Emission Challenge

Major fuel efficiency standards in the United States

The United States government has been pushing to make passenger vehicles more fuel efficient for decades. The U.S. corporate average fuel economy — or CAFE — standards were originally enacted in 1975, largely to reduce dependence on oil imports. U.S. efficiency standards are regulated through the National Highway Traffic Safety Administration (NHTSA).

CAFE standards are focused on fuel efficiency and have a positive impact on emissions, but don't directly regulate them. Greenhouse gas emissions have been regulated under the Clean Air Act by the Environmental Protection Agency (EPA) since 2007.

The United States is second only to China in the number of cars on the road.

Currently there are approximately **300 million** in China, versus **270 million** in the United States.

These two organizations, NHTSA and the EPA, have worked together to develop standards since 2010. This joint effort gives automakers a set of national regulations.

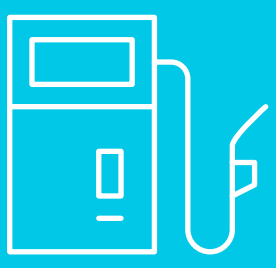
The targets for corporate standards are different for each auto maker, since they hinge on the average output and vehicle mix of each fleet.

Targets are refined annually and they apply to the average efficiency of the cars the manufacturer sells each year. The regulations are designed to push manufacturers to make more fuel-efficient cars and trucks without putting too much pressure on them to sell a specific mix of vehicles.

U.S. fuel economy standards

In the year 2025

The fleetwide average will be

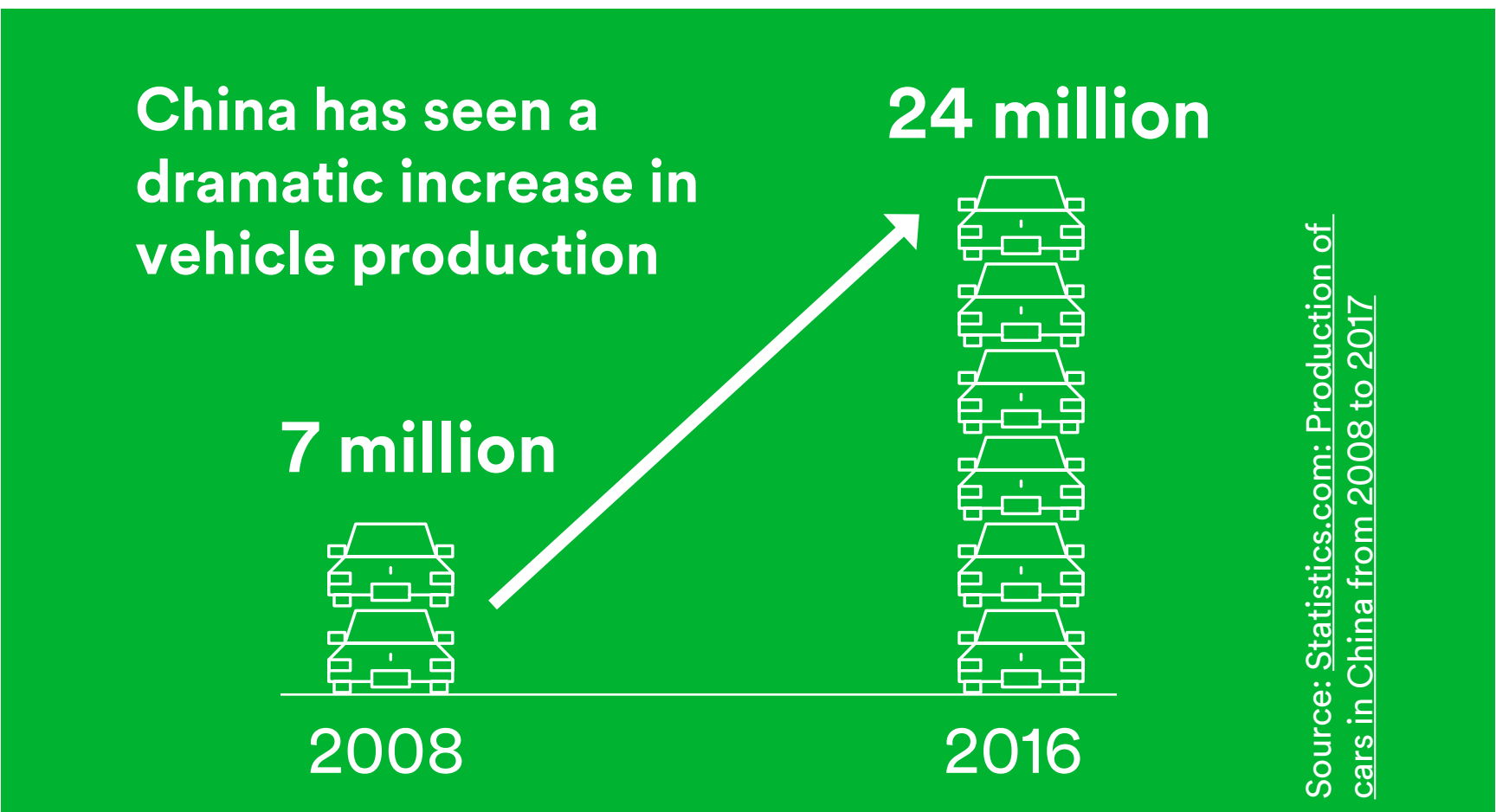


54.5 MPG

What are China’s standards?

China’s first fuel-consumption standards for passenger vehicles were established in 2004. The regulations were drafted by multiple agencies of the Chinese government. The Corporate Average Fuel Consumption standards — CAFC — have been updated in phases. The most recent version, Phase IV, sets a fleet average target of 5.0 liters per 100 kilometers for vehicles sold in 2020. This is a reduction from the Phase III target of 6.9 liters per 100 kilometers set in 2015.

China is also looking at ways to use alternative energy vehicles. In 2013, China adopted the “Made in China 2025” initiative. Part of the plan calls for innovation-driven manufacturing to achieve quality and green development.



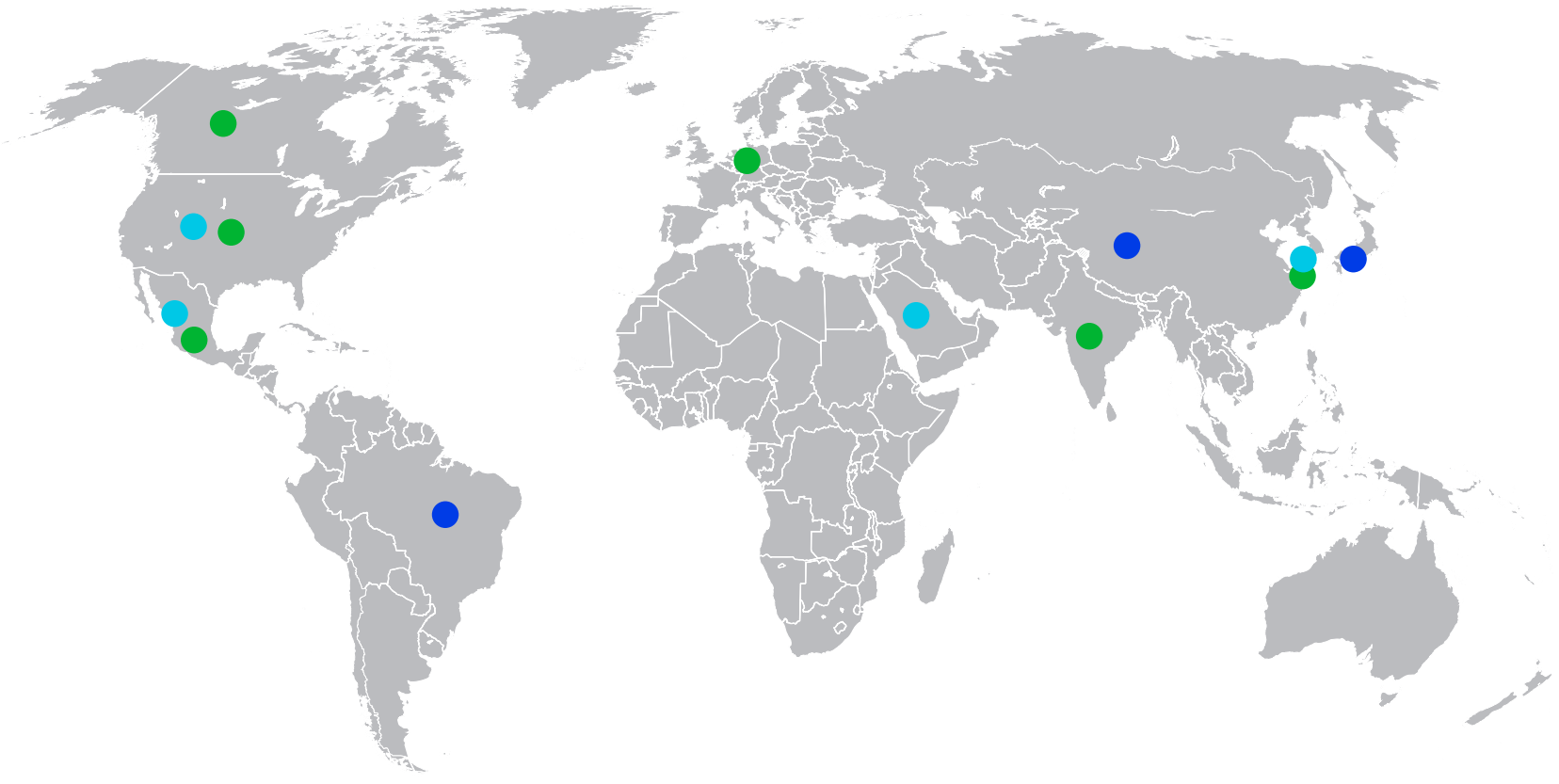
Regulations around the world

Regulations — and how they are measured and enforced — vary widely by region and country.

India and **Canada**, like the **European Union**, have standards to reduce emissions. India and the EU focus on CO_2, and Canada has restrictions on all greenhouse gas emissions.

Other countries — **Brazil, Japan** and **China** — focus on fuel economy and fuel consumption. **Mexico**, like the **U.S.**, looks at both fuel economy and greenhouse gases and in **South Korea**, manufacturers can choose which of the two standards they will meet.

Regulations for passenger cars



Energy/Fuel Consumption

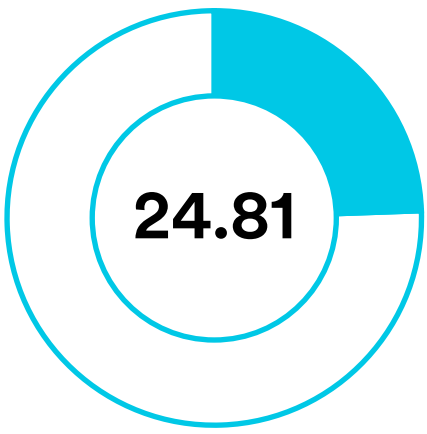
Fuel economy

Emissions

Source: ICCT Global Standards 2017

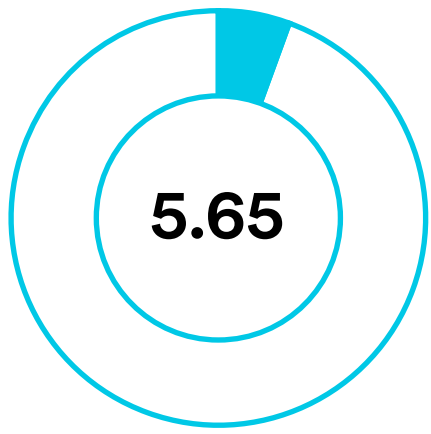
Passenger car production in selected countries

In 2017, by country (in million units)



China

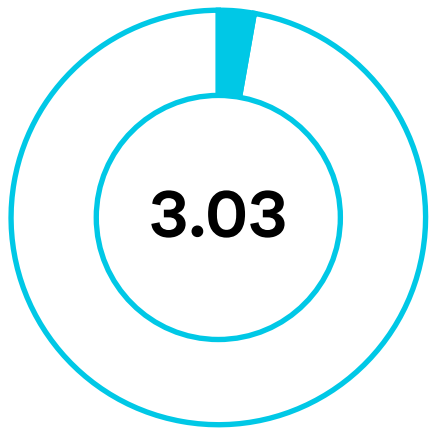
Japan



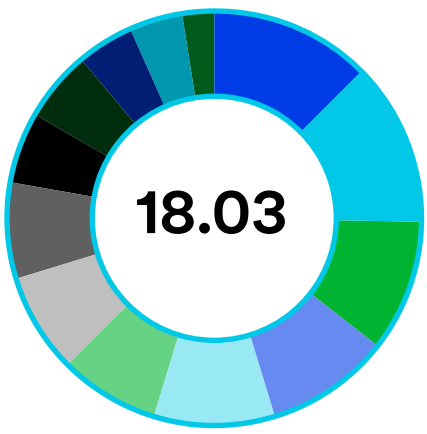
Germany

India

S. Korea



U.S.



Other countries

- Spain: 2.29
- Brazil: 2.27
- Mexico: 1.9
- France 1.75
- UK: 1.67
- Iran: 1.42
- Czech Republic: 1.41
- Russa: 1:35
- Slovakia: 1
- Indonesia: 0.98
- Thailand: 0.82
- Canada: 0.75
- Malaysia: 0.42

Source: www.statista.com

What are the penalties and credits?

The goals set in place by governments vary by country, and enforcement also varies widely. Many governments have complex rules about the enforcement of these emissions and fuel efficiency targets.

Typically, there are penalties for not meeting targets, and often, these are balanced by credits automakers can earn for environmentally friendly practices. This helps the manufacturers maintain a balance of different types of vehicles in their fleets and gives them more options to avoid excessive fines.

European Union: penalties

Penalty payments are assessed if the average CO_2 emissions of a manufacturer's fleet exceeds the limit. They have to pay an excess emissions premium for each car registered. This premium escalates exponentially for each gram per kilometer the car is beyond the target.

Penalty payments

€ 5	for the first g/km of exceedence
€ 15	for the second g/km of exceedence
€ 25	for the third g/km of exceedence
€ 95	for each subsequent g/km of exceedence

From 2019, the cost will be €95 from the first gram of exceedance onwards.

Source: European Commission: Reducing CO_2 emissions from passenger cars

EU: credits

Vehicle manufacturers have incentives to try new technologies that can help cut emissions. They may be granted emissions credits if they can provide independently verified data.

Super credits:
Manufacturers have additional incentives to produce vehicles with extremely low emissions (below 50g/km).

Each low-emitting car is counted as

- 3.5 vehicles in 2012 and 2013
- 2.5 in 2014
- 1.5 in 2015
- 1 from 2016 to 2019

Source: European Commission: Reducing CO_2 emissions from passenger cars

The United States: penalties

Regulations in the U.S. give manufacturers credits for using certain technologies, like selling flex-fuel and electric cars or vehicles with more efficient air conditioners. These credits can be banked for future years or sold to other automakers.

Automakers can carry credits for up to three years forward and backward. They can also trade credits with each other and transfer credits between their own vehicle fleets.

They can also pay a penalty if they fail to meet the average fuel economy target, and some auto manufacturers build this into their fiscal plan.

Source: The ICCT: Credit Trading in the US CAFE Standard

China: penalties and credits

In China, regulators have set sales targets for new-energy vehicle credits. Car makers need to amass credits equivalent to 10 percent of annual sales by 2019 for electric plug-in and hybrid vehicles. The government would like to have electric and hybrid cars make up at least one-fifth of sales by the year 2025.

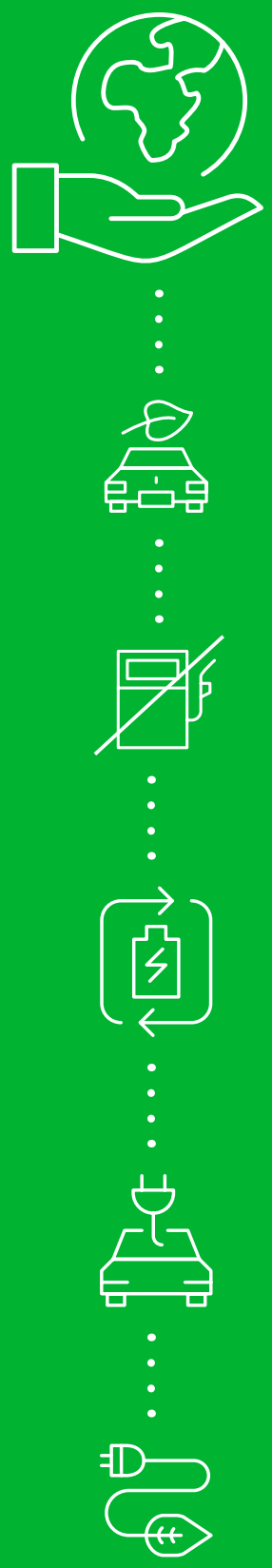
The quotas apply to both domestically produced and imported vehicles. Because a single vehicle can generate multiple credits, the volume of new-energy vehicles sold would most likely be lower than the target rate for each year.

Sources:
The ICCT: Policy Update October 2016
Fortune.com: China Gives Carmakers an Extra Year to Hit Green Sales Targets

Ambitious goals: Can we get to zero emissions?

Some countries are planning to forego gasoline-powered cars altogether and shoot for zero emissions on new cars. More than a dozen countries, including China, and several states in the U.S. have set targets for selling electric cars. India aspires to sell only electric cars by the year 2030.

These countries have plans drafted to go to zero emissions:



U.K.

No sales of gasoline or diesel cars by 2040 and all cars on road at zero emissions **by 2050**.

France

End sales of gas and diesel vehicles by 2040. Use electricity or other cleaner power. Hybrid cars will be permitted.

India

Every vehicle sold by 2030 should be powered by electricity.

Norway

All passenger vehicles should be zero-emission by 2025. Currently, about 40 percent of all cars sold are electric or hybrid.

About 10 other countries also have some type of target for electric vehicles.

Source: CNN: These countries want to ditch gas and diesel cars

“We can’t carry on with diesel and petrol cars. There is no alternative to embracing new technology.”

–Michael Gove, U.K. environment secretary

Finding the balance: the weight of consumer expectations

What are consumers' expectations?

Consumers continue to want and expect more amenities in their cars — heated and vented seats, panoramic sunroofs and Wi-Fi connectivity.

Car buyers want vehicles that have powerful engines and are still fuel efficient. They also want — above all else — cars that are safe. And they are only willing to pay so much.

How can carmakers balance these customer expectations, meet government regulations and still manufacture cars that are profitable for them? It's a balancing act.

What consumers want

According to Jay Baron, former CEO and director of manufacturing for Center of Automotive Research (CAR), vehicles are mostly sold on content — the features and characteristics of the car — including drivability, noise, acceleration. “It’s a consumer product,” he says. “Fuel economy is driven more by regulations than by the consumer. Companies that are successful increase fuel economy and reduce weight without reducing content.”

Cars drive better, are safer and are more comfortable than they were 30 years ago. At the same time, lighter-weight materials have been used in cars to mitigate the poundage of added features, keeping the weight of cars relatively flat.

“Auto manufacturers are using higher strength steel, aluminum and magnesium for lightweighting. However, the weight of the fleet has been constant in the last 15 years, while horsepower and fuel economy have gone up. Manufacturers will have to increase lightweighting efforts or reduce performance, which is not what the market wants.”

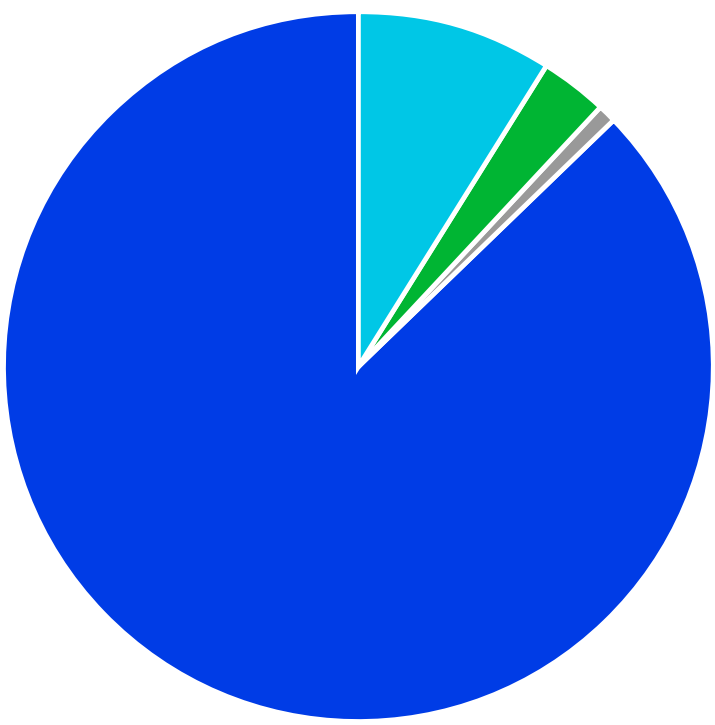
–Shashank Modi, research engineer, CAR

Shifting the weight of a car from the body to the experience

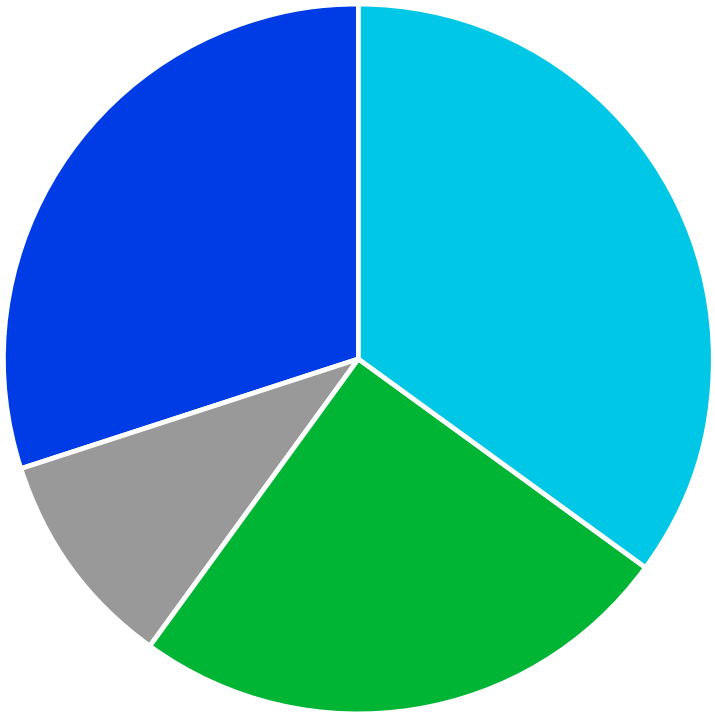
Passenger car & feature mass 1975–2010

Mass of passenger cars 1975–2010 and weight attributed to safety, emissions, and comfort/convenience features

1975



2010



Base car
Emissions
Safety
Comfort/convenience

Source: CAR: Identifying Real World Barriers to Implementing Lightweighting Technologies and Challenges in Estimating the Increase in Costs

What consumers expect: safety and fuel economy

Connectivity, safety and fuel economy are the features car buyers most want, according to the Boston Consulting Group, and they're willing to pay for innovation in these areas.

Safety is also the top priority for car makers and legislators. More than 50 percent of car buyers think active safety — technology that helps prevent a crash — should be prioritized.

A bit further down the list, but still important, is fuel economy. These two requirements may seem contradictory, but with lightweight materials and advances in both construction technology and in driver-assist features, it's increasingly possible for cars to be light and safe.

"Car manufacturers have always had to look at safety, cost and fuel economy. However, due to increasing legislation, finding the right balance has become more of a challenge."

–John Woodhouse, 3M National Key Account Manager

Safety and fuel economy: how to get there

Advanced safety features are already available and include technology behind self-driving vehicles. Drivers can get help with lane-drift detection and collision-avoidance braking.

While many drivers aren't yet comfortable with the idea of autonomous cars, they are eager to utilize safety features that help them avoid crashes.

Cars can also be designed to be lighter by using newer technology within the car body. Many automotive parts can be made lighter by using advanced material additives, like high-strength glass bubbles, or materials bonded with super durable tapes can help lighten vehicles and help them maintain their physical integrity.

Innovations in the race to cut weight

Accelerating innovation in manufacturing

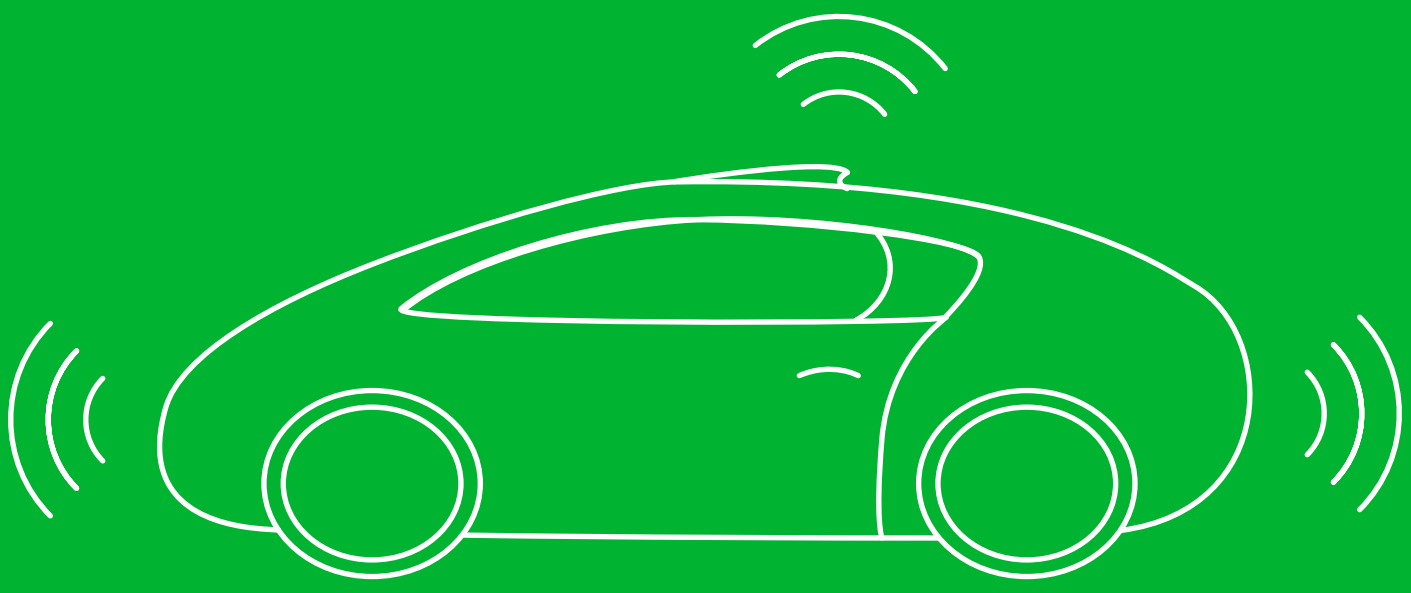
Automakers continue to accelerate innovation through new technologies and changing business models. To meet consumer needs and legislation requirements, and still keep costs manageable, manufacturers are looking at materials, parts and processes in new ways.

The auto industry has worked for decades on perfecting processes for working with different materials and solutions. From fabrication to joining parts and painting, manufacturers have built solid expertise in the art and efficiency of creating the perfect machine.

The shift to make lighter parts — parts that can also be recycled at the end of the car life — impacts many steps in the manufacturing process.

Jay Baron of CAR says that, with pressures for both lightweighting and recycling, manufacturing processes and technologies have become much more complex. Automakers are having to add more suppliers to provide niche materials for every part. Adding more suppliers and steps is the opposite direction of where they want to go.

“The manufacturers will tell you that this is out of their comfort zone,” he says. What does he think is the logical next step? Possibly finding tier one suppliers to build some of the components.



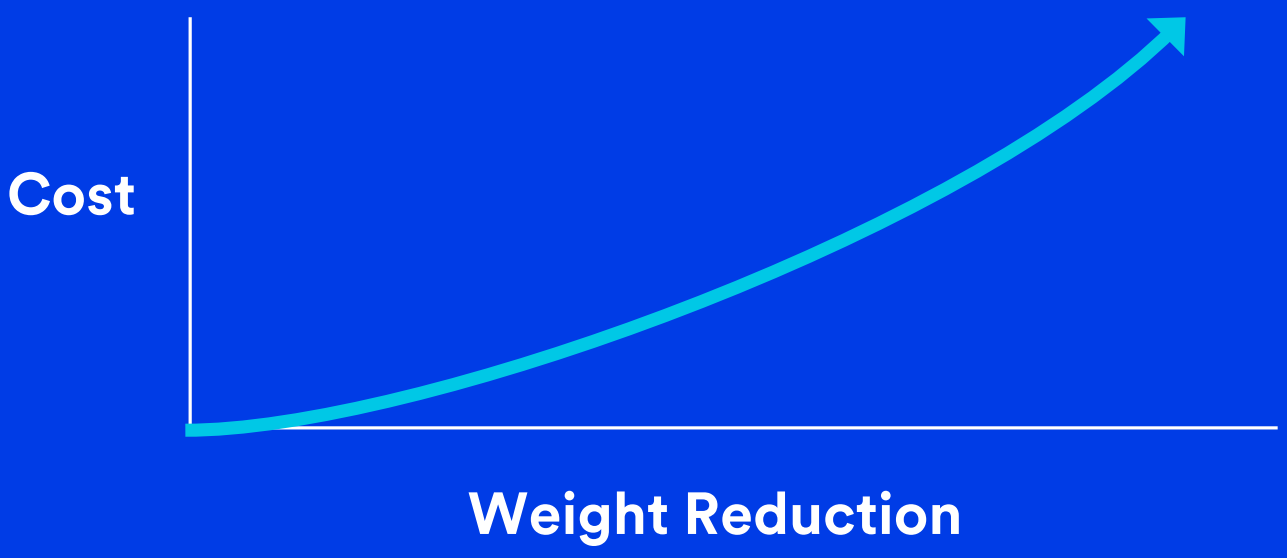
The cost of lightweighting

Engineers design components with multiple, and often competing, objectives. One of the top objectives? Avoiding risk. Since vehicles are mass-produced, the consequences that can come from parts failing can be catastrophic. Automotive design engineers work diligently to ensure that parts are tested and retested to meet this number one objective.

Making lightweight components is also on the list of objectives — after meeting the needs for safety and performance. This is where another objective comes into play: cost.

Manufacturers can meet the needs for safety, performance and lightweighting, but it comes with an increase in cost.

Manufacturing cost for lightweighting vehicle



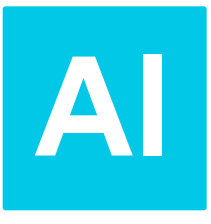
Source: CAR: Identifying Real World Barriers to Implementing Lightweighting Technologies and Challenges in Estimating the Increase in Costs

Materials in the mix

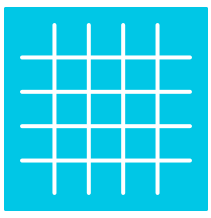
To meet needs for safety and lightweighting, automotive manufacturers are using more materials with higher strength-to-weight and stiffness-to-weight ratios. Many advanced materials are in play throughout the car.

Steel is still the most common material used in cars. It's strong, cheap and easy to work with, and automakers have built up expertise and processes to work with it. It comes in multiple grades and thickness. Advanced high-strength steel and ultra high-strength steel have thinner-gage sheeting, so it's lighter but not as easy to work with. The strongest steel is typically used where the most reinforcement is needed, like protecting the cockpit for crash-resistance.

Which materials are best?



Aluminum is another favorite material — and growing more popular each year. It's light, strong and rust-resistant, and it is often used in hoods, trunk lids and doors. It can reduce the weight of a component by up to 60 percent, according to energy.gov. It adds significantly to the cost of the vehicle, because it's a more expensive material and more challenging to work with. It has limits on formability and can be difficult to join to other materials. More expensive cars tend to use more aluminum, and lower cost cars tend to use more steel.



Carbon fiber is half the weight of steel and four times stronger, according to energy.gov, and it can potentially reduce the weight of a car by up to 70 percent. The barriers? High cost, low availability and difficulty in joining. It is also more complex to recycle than steel and aluminum.

Carbon fiber is more commonly used in aviation, and is becoming increasingly popular in premium cars for passenger enclosures, hoods and frames.

Finding the best material mix

Magnesium has the lowest density of metals used in cars and is currently used primarily in the powertrain. It was used in the 1970s, and, because it's easier to work with than other lightweight materials, it could see a resurgence in use. However, it is expensive, lacks crashworthiness and is not readily available in large quantities.

Titanium is used in some parts like exhaust systems and can withstand heat well. It has high strength, but is costly.

Plastics are used throughout the interior of the car and in areas like the bumpers. It's tough, lightweight and cost-effective. High-strength glass bubbles can be added to plastic car components and make it even lighter without sacrificing performance.

"There is no generic approach to lightweighting. It's all about the material mix."

–Daniel Suttor, 3M Global Key Account Manager

What other materials could be used?

Other materials will likely come into the mix. Researchers are working hard to look at other alloys and composites. Titanium alloys, nickel-based alloys and metal matrix composites all look promising and have qualities that other materials can’t match.

When automakers find a way to make them work in mass-production, they may have additional options to fit into the already complex manufacturing process.

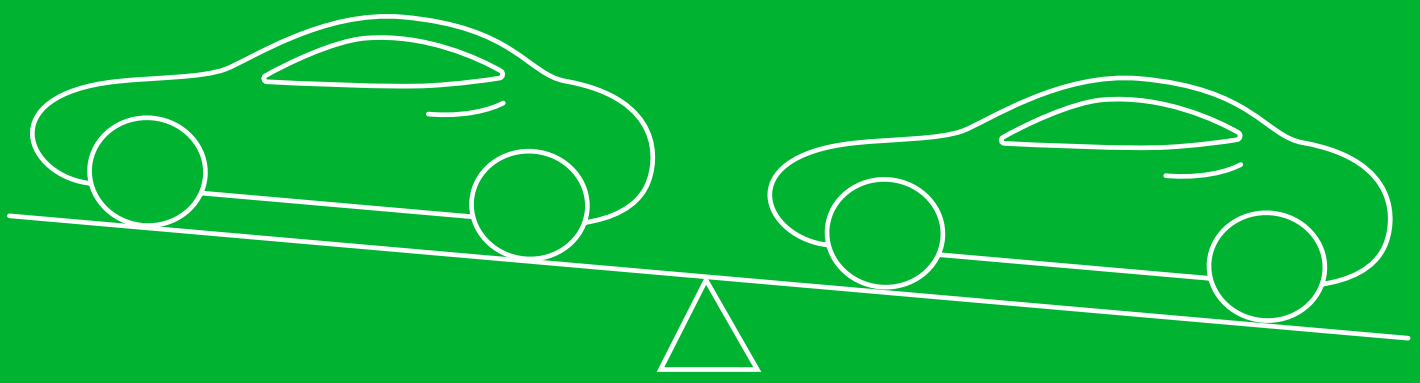
Sources:

Automotive World: The quest for the ideal automotive material mix
Energy.gov: Timeline: A Path to Lightweight Materials in Cars and Trucks
Carwow: Car materials explained

How much difference does it make?

The types of materials used can make a huge difference in the weight of each component and in the overall weight of the car.

Lightweight materials **vs.** **Traditional materials**



Magnesium 30–70% lighter

Carbon fiber composites 50–70% lighter

Aluminum & AL Matrix composites 30–60% lighter

Titanium 40–55% lighter

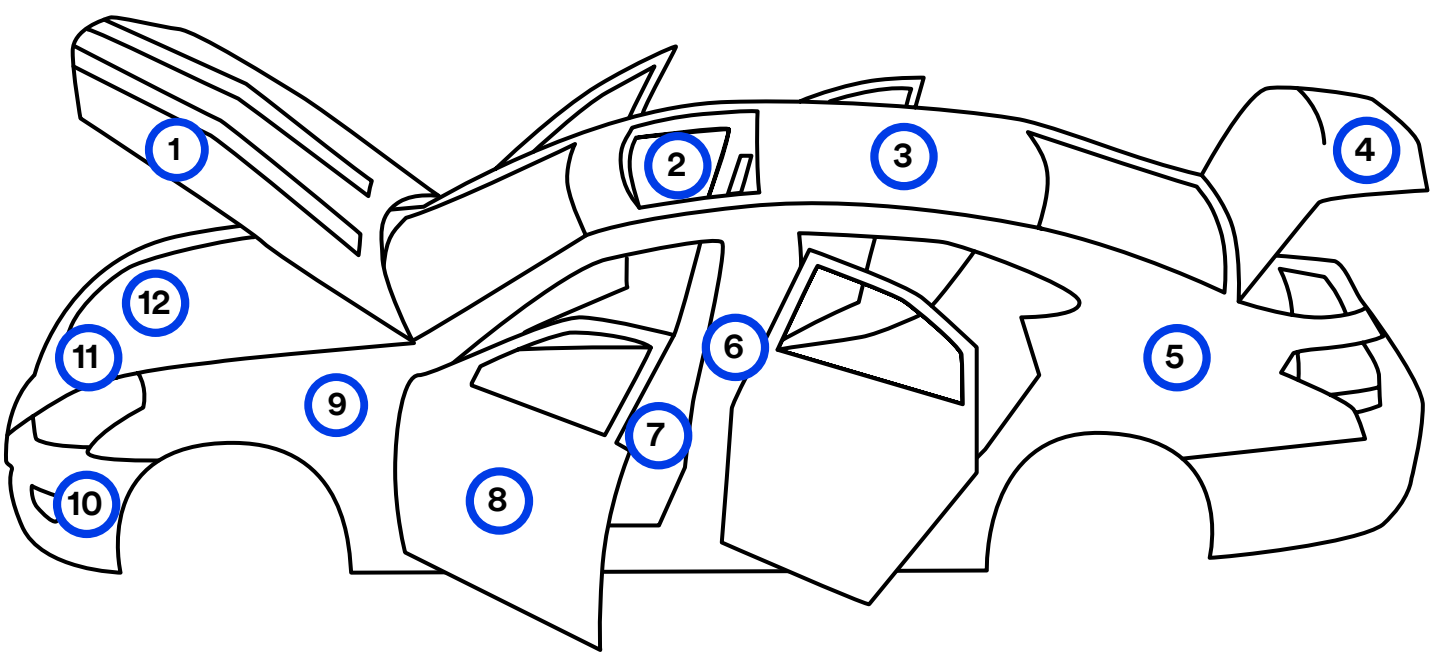
Advanced high-strength steel 15–25% lighter

Source: Energy.gov: Timeline: A Path to Lightweight Materials in Cars and Trucks

Where are they used?

Automotive engineers use different materials in different components of the car. This is where each material is most commonly used in vehicles currently on the road.

1. **Hood:** Aluminum
2. **Sunroof:** Polycarbonate
3. **Roof:** Mild Steel
4. **Decklid:** Mild Steel
5. **Body Side Outer:** Mild Steel
6. **A Pillar:** Steel 1000-1500 MPa Tensile/Hotformed
7. **Floor:** Mild Steel
8. **Door Outer:** Bake hardened Steels
   Door Inner: Mild Steel
9. **Fender:** Mild or Bake Hardened Steels
10. **Bumper Fascia:** Plastic
    Bumper Structure: Steel 980-1200 MPa or Aluminum
11. **Engine Cradle:** HSLA 350-700 MPa
12. **Motor Compartment Rail:** HSLA/AHSS



Source: CAR: Technology Roadmaps

How will it change?

According to CAR, the use of mild steel in the body-in-white, or the unpainted shell, is predicted to shrink in usage from 55 to 5 percent. What will take its place? Increased use of high-strength steel, aluminum, plastics and polymer composites. Magnesium will replace mild steel.

Material distribution in the U.S. fleet, 2010-2040

Mild Steel	↓
High-strength low alloy	↓
High-strength steel	↓
Advanced high-strength steel	↑
Ultra high-strength steel	↑
Boron/Martensite	↑
Aluminum 5000/60000	↑
Aluminum/High-strength	↑
Magnesium	↑
Reinforced plastic/Composites	↑

Source: CAR: Technology Roadmaps

Challenges of new materials

Using mixed materials can lead to significant challenges, like joining dissimilar materials, corrosion from moisture and differences in process cycle time.

Mixed-material joining

Difference in melting point between materials

Corrosion

Relative placement in the galvanic series and exposure to moisture

Thermal expansion

Differences in coefficient of linear expansion (CLTE) cause materials to expand differently in the paint oven

Cycle time

Automotive industry needs process cycle times to match line speed, which is approximately one unit a minute for mass production

Cost

Meeting regulations while testing and implementing new materials to the mix can be costly to manufacturers

Source: CAR: Technology Roadmaps

Supply chain

Automakers are shifting towards global platforms. The availability of material across the world from multiple suppliers is critical

End-of-life recycling

Most materials used in automobiles should be easily recyclable for environment reasons and to meet regulatory requirements

Repair

A hard-to-repair vehicle will have increased insurance cost and in turn will affect sales

Talent gap

Engineers and plant workers need to be retrained to work with new materials and processes

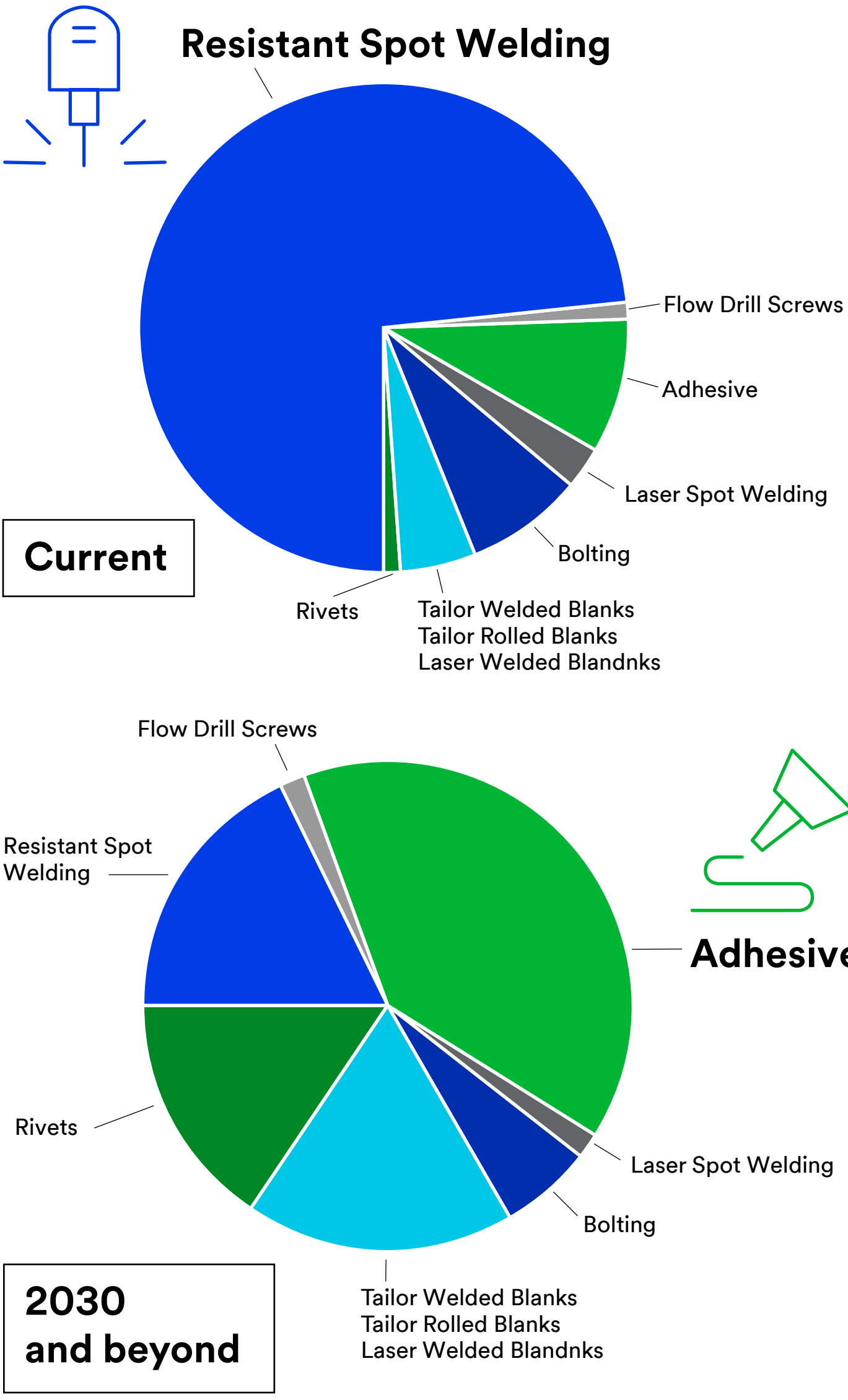
Source: CAR: Technology Roadmaps

Creating a powerful bond

As mixed materials are used more in vehicles, one of the biggest issues engineers deal with is bonding them together.

According to Shashank Modi, a research engineer at the Center for Automotive Research, certain car models used 30 linear feet of adhesive in 2001. Today, those same models contain more than 400 linear feet of adhesive. Welds, screws and rivets are still used, but mixed materials are increasingly held together with adhesives.

How adhesives are becoming more common



Source: CAR Research, Lucintel

Why use adhesives?

How do you marry a steel component to an aluminum or carbon fiber composite part? You probably use adhesives.

Adhesives solve a lot of issues when welding won’t work to join dissimilar materials. Bolts or rivets add weight or open materials up to corrosion, where adhesives can add a tighter seal. The right adhesive can create a stiff seam that strengthens the entire structure.

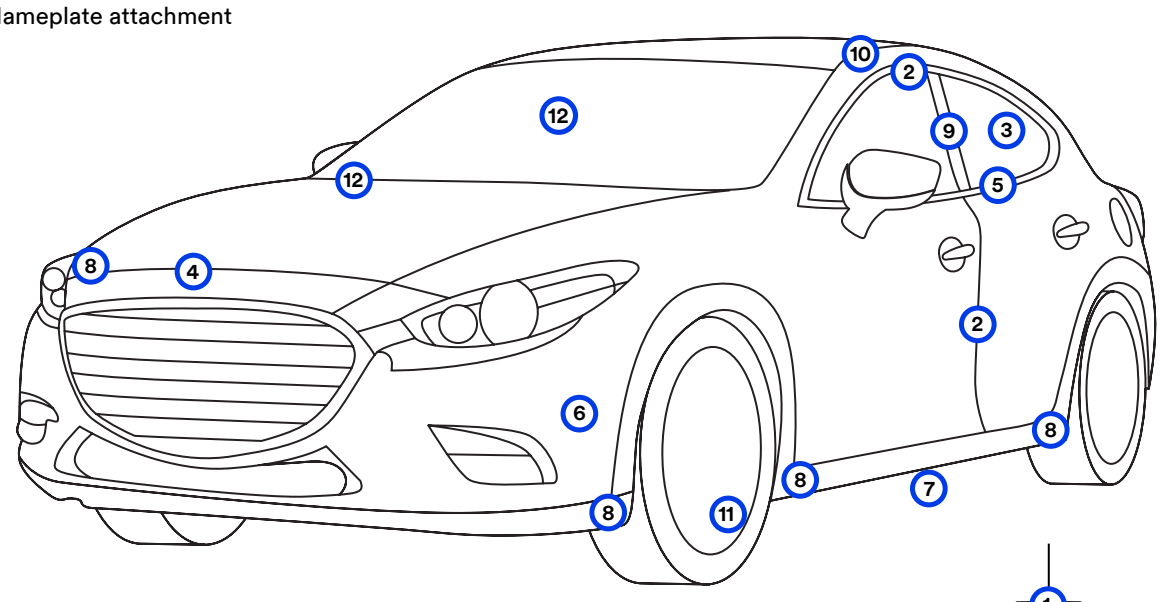
The adhesive can also seal gaps, reducing noise, vibration and harshness inside the vehicle.

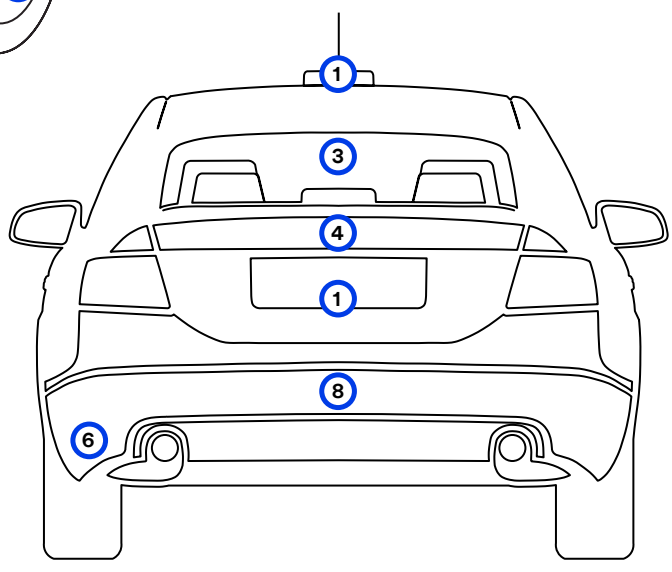
What's the right adhesive?

Just as different metals, alloys and composites work best in different parts of the vehicle, there are a wide variety of adhesives and tapes. Automakers may want to connect an aluminum panel to a steel panel, or they may want to attach a mirror to the inside of the windshield.

There are many types of liquid adhesives, double-sided tapes, epoxy film adhesives and heat curable tapes for different applications.

1. **3M™ Acrylic Foam Tape for exterior trim attachment**
   Moldings, sensor brackets, B pillar appliqué
2. **3M™ Acrylic Foam Tape for Sealing and Weatherstrip**
   Body, door, trunk and deck lid seals
3. **3M™ Auto Glass Film**
   Side and rear glass
4. **3M™ Die-Cuttable Acrylic Foam Tapes**
   Nameplate attachment
5. **3M™ Exterior Trim Film**
   Belt line moldings
6. **3M™ Glass Bubbles in Plastic Parts**
   Sheet molded composite panels, hood, trunk lid, engine cover
7. **3M™ Glass Bubbles in Sealants**
   Seam sealers, underbody coatings
8. **3M™ Paint Protection Film**
   Hood, bumper, trunk ledge, rocker panels
9. **3M™ Paint Replacement Film**
   Door pillars, sashes and moldings
10. **3M™ Structural Bonding Tape**
    Roof ditch molding clips
11. **3M™ Wheel Weights**
    Lead-free wheel balancing
12. **Tape-Attached Hardware**
    Mirror buttons, sensor brackets, locator pins





[Explore 3M Lightweighting Solutions]

What does the future hold?

In many ways, the future is already here.

Electric vehicles, car-sharing and autonomous driving features are already available. Bigger changes will come when people's comfort level catches up with existing technology and when cities and roadways can provide the needed infrastructure to manage it safely.

“We’re working with the mobility ecosystem – not only what we’re doing on the car – we’re working with the traffic safety team to make sure that the infrastructure is the right one for safety and to improve lives around the world.”

–Ray Eby, VP of 3M Automotive Electrification

Electric vehicles

Electric vehicles may seem like the obvious solution to move directly to zero emissions and eliminate dependence on gasoline. Many countries and manufacturers are focusing their energy on that end.

This strong commitment will need to drive market acceptance to a point where people will be willing to purchase them. Right now, many experts believe that market acceptance is lagging behind the commitment of government expectation. The range of battery electric vehicles, paired with the amount of time needed to recharge them, makes ownership less than desirable for most consumers.

Hybrid vehicles

The path to fully electric is filled with hybrid options. Many new vehicles come with options that rely on some gasoline. And, regardless of the mix of electric and gasoline, lightweight solutions become even more important.

Hybrids have all the benefits of both gasoline and electric vehicles — efficient acceleration from the electric battery and the ability to drive long distances without a charge. And hybrids have the added cost and weight that comes with carrying two propulsion systems.

What’s next for autonomous vehicles?

Autonomous vehicles are also on the near horizon, with many vehicles already using some smart car technology. Most experts predict we’ll have to wait more than 10 years for fully autonomous vehicles, but you can get some help with parking, blind-spot monitoring and lane correction already.

The three primary technology features of autonomous vehicles are sensors, connectivity and software. Sensors, such as cameras and light-detection systems, are already in place in some cars and are needed to help the car navigate.

When your car is your office

Connectivity is required to monitor conditions like traffic, construction and weather. Software will use the data captured to make decisions about braking, steering and navigation.

The sensors, connectivity and displays needed to guide autonomous cars add weight — about 300 to 400 pounds, according to some estimates.

And the entire architecture of the interior will likely change with a demand for more entertainment features like displays and swivel seats.

“There will be a stronger focus on comfort and connectivity that goes with autonomous vehicles. The driver will treat it like an office or a living room.”

–Stefano De Bernardi, 3M Global Automotive Key Account Manager

What’s next in autonomous?

Some technologies to warn and assist drivers are already available, and more are coming in the next few years, according to CAR.

Timeline for launches of advanced driver assistance systems and automated driving features

2014

- Pedestrian avoidance
- Lane keep assist

2010

- Drowsiness alert

2008

- Forward-collision assist

2007

- Surround view systems

2006

- Automatic parking
- Adaptive front lights
- Blindspot detection
- Driver monitoring

2004

- Lane departure warning

2002

- Park assist
- Rear camera

2000

- Forward collision warning
- Night vision

1999

- Adaptive cruise control

Source: CAR: Technology Roadmaps

Solar cars: How soon?

Solar cars combined with another power source may be available for sale in some countries in a few years. Hanergy Holding Group, a maker of solar panels, announced plans to build solar vehicles and showed off four prototypes, which have yet to hit the market.

Realistically, in the near future, solar will probably play only a small role in powering the vehicle. Several car companies have created hybrid concept cars that use solar power to charge the battery or accessories in the car including lights and audio systems. Energy companies are also producing solutions to power electric cars with charging stations that draw their power from rooftop solar panels.

If you don't want to wait, you always have the option to build a solar car.

“Cars have always been my pride and joy. Times change. For the younger generation, a car is just a tool to get them from A to B. It’s changing the business model.”

–Abs Master, 3M Global Automotive Key Account Manager

Mobility services: focusing on the traveler

In the past several years, emerging technologies and connectivity have made travel options more flexible and convenient for many people. The focus has shifted from the mode of transportation to the needs of the traveler.

Known collectively as mobility services or shared-use mobility, these forms of transportation include carshare, rideshare, bikeshare and more.

The impact of mobility services

Automakers are keeping a close eye and the rapid growth of mobility services. As fewer individuals look to buy their own cars, they are looking to part of the ridesharing economy, and many are looking at developing their own services. They also realize that this new model makes a need for longer-lasting vehicles even more acute.

“If you are using a car for 50 percent of the time instead of 5 percent, you need more durability.”

–Shashank Modi, Research Engineer at CAR

Do I need my own car?

Experts predict that carsharing will grow in urban areas and even expand to smaller communities as it gains more acceptance and grows in popularity. For many, it will become easier to access a car without the cost of ownership.

Projected growth of car sharing programs

North America
2010
.51 million users
2021
3.81 million users

Worldwide
2010
1.16 million users
2021
29.58 million users

North America
2010
10.4K vehicles
2021
50.8K vehicles

Worldwide
2010
32K vehicles
2021
610.6K vehicles

Source: CAR: Technology Roadmaps

The shift to mass transit

We may have to wait a few years for our own autonomous car, but you don't have to wait to try one out. Shuttles and buses are already making use of driverless technology in many cities. Paris launched a driverless bus to shuttle passengers between train terminals. Many parks and museums use driverless vehicles to transport visitors within the confines of their grounds. Minneapolis, Minnesota, recently tested a driverless shuttle in cold and snowy conditions.

Another exciting option? Students, including Wisconsin's Badgerloop team, are working on the newest form of transportation — a hyperloop. They are designing pods that could one day transport you via vacuum tubes to another city at a high rate of speed.

What’s next?

The future of transportation is both exciting and challenging to predict. Regardless of the mode of transportation — whether an electric vehicle, a pod hurtling through a tube or an old-fashioned gasoline-powered car — finding solutions for lightweight transportation will continue to be top of mind for design engineers and other transportation professionals.

More information

For more information on 3M solutions for lightweighting visit:

3M.com/autolightweighting

Also visit these sources for more on the topic of lightweighting:

Center for Automotive Research (CAR)
www.cargroup.org

Environmental Protection Agency (EPA)
www.epa.gov

International Council on Clean Transportation (ICCT)
www.theicct.org

Energy.gov
www.energy.gov

European Commission
www.ec.europa.eu/commission/priorities/energy-union-and-climate_en

Automotive World
https://www.automotiveworld.com/analysis/manufacturing-logistics-analysis/

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3M Center
Saint Paul, MN 55144-1000

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