FUTURE AHoy!
An Infographic Novel About Sustainable Transport
DEAR READERS,

Since releasing "12 Insights into Sustainable Transport" in 2017, Agora Verkehrswende has published more than twenty studies detailing the essential building blocks of climate-friendly mobility.

This publication marks a significant departure from our previous work on sustainable transport. For one, it's filled with cartoons and colorful illustrations. For another, it does not contain any new findings. Why did we decide to take a different approach?

The term "Verkehrswende" ("transport transformation") and the broad range of topics it encompasses have gained enormous polarity over the past three years in Germany. But there has been little progress in implementing policies that will make sustainable transport a reality in Germany or other parts of the world, although it is becoming increasingly clear that the transport sector is one of the biggest challenges in climate protection.

So instead of another expert report, we have sought to reach a wider audience with an innovative genre: the "infographic novel." Part infographic, part graphic novel, it draws on our previous insights but re-packages them in a fun and accessible format. Its purpose is to raise public awareness of the problems that the transport sector poses for the climate while pointing to real solutions that can help fight global warming. In realizing this ambitious project, we enlisted the help of Ellery Studio, a group of young designers, researchers, illustrators, and go-getters dedicated to making climate change understandable and illuminating prudent paths forward. We spent many gratifying hours with the Ellery team last year hatching ideas and storylines for this novel form of science communication. It was new territory for everyone.

"Future Ahoy!" is the result of our collaboration. We hope that it entertains, enlightens, and ultimately inspires. Its overriding message is that sustainable transport is a collective endeavor. If it is to succeed, each and every one of us must embrace a common purpose.

Christian Hochfeld and Marena Pützschler
Agora Verkehrswende
WHAT THE HAY?
IS THIS AN INFOGRAPHIC OR A GRAPHIC NOVEL?

TO BE HONEST, I'M SKEPTICAL! IT'S A NATURAL INSTINCT FOR GERMAN BREEDS.

IT'S BOTH!

IMPORTANT FACTS AND INFOGRAPHICS APPEAR IN BRIGHT PINK.

THE CONTEXT EXPLAINS THE BEST.

WHY IT IS NECESSARY

P. 6

HOW IT CAN SUCCEED

P. 20

ALL'S WELL THAT ENDS WELL

P. 64

WE CAN MAKE TRANSPORT SUSTAINABLE.

THIS INFOGRAPHIC NOVEL EXPLAINS HOW IT CAN BE DONE.

1. SUSTAINABLE TRANSPORT HAS BEEN A HUGE TOPIC FOR US RECENTLY.
   I WAS EXTREMELY DOUBTFUL AT FIRST.
   I DEFINITELY PREFER THINGS TO STAY THE SAME.

2. GRAMPS

3. DAUGHTER

4. DAD

5. NEWEST MEMBER OF THE FAMILY

HERE I AM WITH MY FAMILY.

A CUTE COUPLE, DON'T YOU THINK?

I'M SKEPTICAL!

(IT'S A NATURAL INSTINCT FOR GERMAN BREEDS.)

HERE I AM WITH MY FAMILY.

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CHAPTER 1

WHY WE NEED SUSTAINABLE TRANSPORT
It was hard to imagine thirty years ago! But now we have a healthy planet and a prosperous, emissions-free economy.

This could be the world of the future, but only if we manage to stop global warming!
In 2021, climate change continues to gain steam. 32 billion tons of CO₂ are released each year globally.

The earth has already warmed by 1°C. If this trend continues, we are headed for big trouble! We have to take action now to avoid causing catastrophic damage to the climate, to nature, and to ourselves.

I’ve always dreamt of being an astronaut! … But our planet seems so fragile from way up here.

TODAY

The world needs to act now! The focus of this book!

In 2015 the nations of the world signed the Paris Agreement, which calls for global warming to be kept below 2°C, and, if possible, below 1.5°C. The world needs to act now!

Germany has adopted ambitious targets and is seeking to reduce emissions in all areas of the economy.

Which areas of the economy are responsible for emissions? And how much carbon can be released in 2030?

(Figures in million tons of CO₂ equivalents*)

<table>
<thead>
<tr>
<th>Year</th>
<th>Agriculture</th>
<th>Buildings</th>
<th>Transport</th>
<th>Industry</th>
<th>Energy economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>&lt;81</td>
<td>&lt;72</td>
<td>&lt;28</td>
<td>143</td>
<td>343</td>
</tr>
<tr>
<td>2030 goal</td>
<td>&lt;81</td>
<td>&lt;72</td>
<td>&lt;28</td>
<td>143</td>
<td>183</td>
</tr>
</tbody>
</table>

*Definitions can be found on page 76.
GERMANY'S GOAL IS TO REDUCE EMISSIONS IN TRANSPORT BY 40-42% RELATIVE TO 1990. IT WANTS TO REACH THIS TARGET BY 2030.

DAMN! I'M LATE FOR MY MEETING! I'LL TAKE THE CAR TODAY. OTHERWISE I WON'T ARRIVE ON TIME.

LAST NIGHT I DREAMT AGAIN I WAS AN ASTRONAUT...

GRANDPA, DID YOU KNOW THAT ALMOST 20% OF ALL EMISSIONS IN GERMANY COME FROM TRANSPORT? I JUST HEARD IT ON THE NEWS!

WOULD YOU LIKE A RIDE TO SCHOOL, SWEETHEART?

NO THANKS, DAD

I'D RATHER RIDE MY BIKE - IT'S MUCH HEALTHIER!

HMMM

A STRIKE! MORE CLIMATE HYSTERIA!

Experts: Climate change,opping

GOOD OLD DAYS? OK BOOMER...

IN THE GOOD OLD DAYS THE SITUATION WASN'T AS SERIOUS.

KIDS ON STRIKE! THAT NEVER HAPPENED IN THE GOOD OLD DAYS!

ANYWAY, SCHOOL IS CLOSED FOR A CLIMATE STRIKE!

IT'S MUCH HEALTHIER!
Cars and trucks cause more emissions than all other modes of transport combined...

According to established standards for calculating emissions, international air and maritime traffic originating from Germany does not count toward national emissions.

But these aren’t the only sources of global warming.

...and the amount of CO₂ emitted since 1990 has risen rather than fallen!

One thing is clear: Making road transportation climate neutral by 2050 will require radical change.

1990

163 Mt CO₂ equivalents

2017

168 Mt CO₂ equivalents

<table>
<thead>
<tr>
<th>Other</th>
<th>TOTAL EMISSIONS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail transport</td>
<td>1 Mt</td>
</tr>
<tr>
<td>Costal and inland ships</td>
<td>2 Mt</td>
</tr>
<tr>
<td>Domestic air travel</td>
<td>2 Mt</td>
</tr>
<tr>
<td>Road traffic</td>
<td>162 Mt</td>
</tr>
</tbody>
</table>

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<tr>
<td>Domestic air travel</td>
<td>2 Mt</td>
</tr>
<tr>
<td>Road transport</td>
<td>30.7 M</td>
</tr>
<tr>
<td>Commercial trucks</td>
<td>1.4 M</td>
</tr>
<tr>
<td>Domestic air travel</td>
<td>45.8 M</td>
</tr>
<tr>
<td>Domestic air travel</td>
<td>121 HP</td>
</tr>
</tbody>
</table>

But these aren’t the only sources of global warming.

Cars and trucks cause more emissions than all other modes of transport combined...

According to established standards for calculating emissions, international air and maritime traffic originating from Germany does not count toward national emissions.

5 MINUTES LATER...
Traffic injuries in 2018: 399,293 (including 3,275 fatalities)

Nearly 5 million Germans regularly lose sleep because of traffic noise.

Tailpipes release nitrous oxide, a harmful compound that causes respiratory problems. 61% of dangerous emissions in German cities are caused by road traffic.

Conventional vehicles are almost totally dependent on petroleum, which has to be imported from abroad.

Less than 25% of land in Germany is unspoiled by a road or railway within a 5 km radius. Road and rail infrastructure disturbs ecosystems and eliminates areas for enjoying nature.

The external costs of road traffic to the environment and human health are estimated at $2 billion.

These costs are not borne by the individuals who cause them but by society as a whole.

Can’t get me now!

What the...?

Thank you... That game is so last century.

Reason #2 for sustainable transport: to improve quality of life
Creating sustainable mobility encompasses a range of measures – including efforts to reshape attitudes and beliefs – that will encourage people to use more public transport, rely less on privately owned vehicles, and make more trips by foot or bike. It also involves shifting some freight from roads to rail and waterways.

To be sustainable, the transport sector must rely primarily on electricity for power and phase out combustion engine vehicles. Furthermore, the electricity for e-vehicle fleets has to come from renewable sources. Creating a sustainable transport system requires moving at full speed towards a clean-energy-based power sector.
SUSTAINABLE MOBILITY

Sustainable transport rests on two pillars. This section is about the first.
THE TRANSITION TO SUSTAINABLE MOBILITY WILL BEGIN IN CITIES.

According to a study by the German Federal Environment Agency, over 90% of people believe that quality of life would improve if regional and urban planning sought to diminish dependency on cars.

And new ways of thinking are a crucial first step.

In which city would you rather live?
The decisions of urban planners in the 1950s and 60s are why cars continue to dominate cities today.

Many cities are reaching the breaking point...

...because cars foul the air and ruin the climate...

...they take up more space than any other mode of transport...

Street space required for the transportation of 15 people using various means of transport (based on the shared apartment analogy).

<table>
<thead>
<tr>
<th>Mode of Transport</th>
<th>Space Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>30 m²</td>
</tr>
<tr>
<td>Bicycle</td>
<td>18 m²</td>
</tr>
<tr>
<td>Car</td>
<td>77 m²</td>
</tr>
</tbody>
</table>

Modal share* of journeys made in Germany with over 100,000 inhabitants

12% of journeys are travelled with public transport

50% with a car

14% with a bicycle

And by foot 24%
...cars take up a lot of space even when they are not being used...

On average, private vehicles are used just 1 hour a day.

...the car pays significantly less than other users of urban space...

I pay 40 times as much per square meter for an apartment as a car pays for a parking spot.

WHY AM I BEING TREATED SO UNFAIRLY?

I HEARD HE EVEN KILLED AN OLD LADY CROSSING THE STREET.

...and...

CHILLING CAN GET PRETTY BORING, HOWEVER.

Improving the quality of urban life is easy. We simply have to set new priorities.

I HEARD HE EVEN KILLED AN OLD LADY CROSSING THE STREET.

BUT I USED TO BE A VIP!
MY CAR SHARING APP SAYS THERE ARE 32 CARS AVAILABLE.

BUT I WANT TO DRIVE MY OWN CAR.

ALWAYS MINE, MINE, MINE!

WHAT ABOUT SHARING INSTEAD?

THERE ARE SO MANY ALTERNATIVES TO OWNING YOUR OWN CAR!

AND THEN MIX IN SHARING AND POOLING SERVICESarp of Foot Traffic, and then mix in sharing and pooling services.

Many people have difficulty changing their daily routines. This is where policymakers can help.
Policymakers need to create incentives to make sustainable mobility a reality.

**PUSH**

"Push measures" should be enacted that make car ownership less appealing.

- Higher fees
- Strict enforcement of violations
- Reduce the number of parking spots
- Reduce speed limits
- Create more ultra low emissions zones
- Reallocation of road space to other public uses
- Tax transport that harms the climate

**PULL**

"Pull measures" are designed to make other forms of transport more attractive.

- Improve public transport
- Encourage sharing and pooling solutions
- Interlink different modes of transport
- Promote ecomobility
- Expand bike paths and make them safer
- Create pedestrian friendly areas

**CITIES**

We can’t do everything that is necessary at the local level! The federal government needs to help.

**FEDERAL GOVERNMENT**

If we only had access to the right tools!
Our roads are becoming ever more congested with people and goods. The delivery of goods is essential for daily life, supplying us with food and other necessary items. However, delivery vehicles compete with cars, buses, and cyclists for scarce road space. Cities will face numerous challenges in this sector in the coming decades.

Despite the problems, we rely on deliveries more than ever before, as the following figures show:

Number of daily deliveries (trips) and shipments (dispatched goods) per business (in Wuppertal, Germany)

<table>
<thead>
<tr>
<th>Business</th>
<th>Deliveries</th>
<th>Shipments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retailer</td>
<td>7.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Coffee shop</td>
<td>15.5</td>
<td>25.5</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>6.5</td>
<td>12.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>46.5</td>
<td><strong>46.5</strong></td>
</tr>
</tbody>
</table>

Households are also ordering more online than ever before.

Average number of packages received per person each year.*

*Courier, express, and parcel services

<table>
<thead>
<tr>
<th>Year</th>
<th>Packages per Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>15</td>
</tr>
<tr>
<td>2018</td>
<td>23</td>
</tr>
<tr>
<td>2023*</td>
<td>29</td>
</tr>
</tbody>
</table>

*Forecast
Parcel shipping volumes are on the rise. The use of heavy trucks is also increasing. The carbon emissions of the entire branch are thus expected to grow rapidly.

**Automated Sustainable Mobility?**

Self-driving cars could revolutionize transportation.

- **Federal Government**
  - Cities should take an active role in managing urban freight traffic.
  - Cities should create more delivery zones while reducing parking spots.
  - We need to establish greater incentives for cargo bikes and electric vehicles in urban freight transport.

- **Firms**
  - But they can’t do it all by themselves.
  - We should develop freight hubs close to city centers to allow bundled last-mile delivery.

- **States**
  - Unregulated growth is more harmful to the industry than beneficial.
  - We need to establish greater incentives for cargo bikes and electric vehicles in urban freight transport.

- **Cities**
  - Thank God it’s a convertible.
  - I just ordered it by app.
  - Cheers!
  - I’ve seen a few things in my day...
  - These self-driving cars can already drive better than me!

**Nico Rosberg, Formula 1 Racer**

- These self-driving cars can already drive better than me!
- That’s well and good for Nico Rosberg... but are self-driving cars also good for the environment?
Self-driving cars could create heaven on earth...

...if they are integrated into public transport, particularly for the first and last mile...

...and if they are shared for the transportation of numerous passengers...

...then we could reduce the size of the vehicle fleet by 97% without limiting personal mobility. This would free up the massive amounts of space currently used to park vehicles while also slashing energy consumption and emissions.

...or they could unleash infernal forces...

...if everyone wants to own their own car...

...if long-distance trips become more frequent because people can read or sleep while travelling...

...and if we let self-driving vehicles drive on their own, in order to avoid paying for expensive parking spots...

...then there will be more vehicles on the road and less public space for non-vehicle related uses. Furthermore, distances travelled, energy consumption, and emissions will continue to rise.
Nearly one quarter of Germans live in rural areas.

German population (2015): 34.2 M in suburbs and towns, 29.3 M in rural areas.

THE TRAIN IS PACKED AGAIN...

30,000 daily commuters in Stuttgart.

THE COUNTRYSIDE IS SO IDYLLIC!

THE BEST OPTION IS TO GO BY CAR.

Modal share in villages and small towns in Germany (2017):

- Car: 70%
- Bike: 7%
- Public transport: 5%
- Walking: 17%

As a result, the share of trips taken with a car is twenty percentage points higher in rural areas.

People living in rural areas are much more dependent on cars than city dwellers... because public transport is often inconvenient or unavailable.

OH GREAT... NOW WE'RE STUCK IN A TRAFFIC JAM. MAYBE WE SHOULD HAVE TAKEN THE TRAIN?

JUST TO GET TO THE TRAIN STATION, YOU HAVE TO TAKE A BUS TO THE NEXT VILLAGE.

...but infrequent trips mean low availability.

WHAT? THE NEXT BUS DOESN'T COME FOR AN HOUR!

...frequent trips mean very few passengers per vehicle.

LOW OCCUPANCY

Car: 70%

Bike: 7%

Public transport: 5%

Walking: 17%

THAT'S THE COST OF DATING A COUNTRY BUMPKIN!

...frequent trips mean very few passengers per vehicle.

...but infrequent trips mean low availability.

THE TRAIN IS PACKED AGAIN...

THE COUNTRY IS SO IDYLLIC!

THE BEST OPTION IS TO GO BY CAR.

Modal share in villages and small towns in Germany (2017):

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Private cars will remain important for the foreseeable future. What matters is that they are electric.

With ambitious investment and new mobility services, public transport in rural areas can be made more convenient.

Encouraging a shift to different modes of transport is possible in rural areas as well as in the city.

**29%** of commuters travel less than 5 km to work.

**20%** of commuters travel 5-10 km to work.

Even distances of up to 15 km are no problem! What is needed to make cycling more appealing:
- Good bike paths
- "Expressways" for cyclists
- Parking infrastructure
I loved model trains when I was little.

I did too! Some things never get old!

When I was little, I did too! Some things never get old!

...Why don’t we travel more often by train?

It would be much better for the climate!

Everyone used to take the train, but then the world went car crazy.

Today, most trains run on electricity instead of diesel. As renewables generation rises, rail becomes increasingly climate friendly.

87% of rail traffic is electric.

Rail transport is climate friendly...

Trains emit much less carbon than cars.

Passenger transport

139 Car

36 Rail

Freight transport

103 Truck

19 Rail

Rail is also much more efficient for freight transport.

Comparison of greenhouse gas emissions between road and rail (in gram CO2 equivalents per passenger or ton kilometer, 2017)

Comparison of energy consumption between road and rail (in megajoules* per passenger or ton kilometer*, 2017)

Rail requires significantly less energy...

...in part because of lower wheel friction and improved aerodynamics in relation to cars and trucks.

Energy sources in rail transport (2017)
Since rail travel is very climate friendly, the government aims to double the number of train passengers in Germany by 2030.

**BUT HOW?**

An innovative timetable system and better coordination between regional trains can dramatically improve the efficiency of the rail network. Travellers will be able to get anywhere they want with greater ease. This will require the expansion of the rail network and the construction of new stations.

**THE KEY TO MULTIPLE MOBILITY IS CALLED INTERMODAL TRANSPORT.**

Because rail is the greenest way to move freight, companies should transport most goods by train. With trucks used only when necessary at the very beginning and end of a journey.

**NEW MOBILE SOLUTIONS MAKE IT EASY TO FIND CONNECTIONS AND DEPARTURE TIMES WHEN PLANNING MULTI-LEG JOURNEYS WITH DIFFERENT MODES OF TRANSPORT.**

**OPTIMIZE THE RAIL NETWORK**

Policymakers must enshrine rail network optimization into law with guaranteed funding. An innovative timetable system and better coordination between regional trains can dramatically improve the efficiency of the rail network. Regional trains can improve coordination between the rail system and better regional integration of transport.

**REFORM THE RAILWAY TOLL SYSTEM**

Rail tolls are ultimately paid by passengers in the form of higher ticket prices. Rail travel would be more competitive if public subsidies were available for rail network operators.

Since rail travel is very climate friendly, the government aims to double the number of train passengers in Germany by 2030.

**CREATE A LEVEL PLAYING FIELD**

If each form of transport was required to bear its own environmental and climate costs, rail would be much more price competitive than other options.

**THE RAILMAP 2030 FROM AGORA VERKEHRSWENDE SHOWS HOW THIS CAN BE DONE.**
Sustainable transport rests on two pillars. This section is about the second.
WE NEED ALTERNATIVES TO GASOLINE AND DIESEL

Even if we change the way we travel and use more bicycles and trains, we won’t be able to do away with cars and trucks entirely. To ensure that the transport sector is environmentally sustainable, we need to power it with renewable energy and create more efficient vehicles.

Transport energy by source in Germany, 2017
94.5% fossil fuels
5.5% electricity and renewables

BI0FUELS ARE NOT THE ANSWER

Why don’t we simply keep our old cars and power them with biofuels, which can be sustainably produced?

Great idea!

There simply isn’t enough land available to grow food for the world’s population...

...and to cultivate crops for conversion into biofuels.

...to protect flora and fauna in natural habitats...

I heard you can even produce biofuels from garbage, like in back to the future 2!

That would be awesome!

Yes, that would be great... but there simply isn’t enough biowaste.

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**SYNFUELS**

**INEFFICIENT AND TOO EXPENSIVE**

I heard you can produce gasoline and diesel using renewable electricity.

I read about that the other day. The problem is that it’s still way too expensive.

What a bunch of hocus-pocus!

How to produce vehicle fuels from renewable electricity, water, and carbon dioxide:

**DIRECT POWER CONSUMPTION IS THE MOST EFFICIENT**

Witches and knights – my kind of story!

Come on! Or are you chicken?

Ay carabba! Synthetic fuels require a lot of wind power!

Indeed! Direct consumption of electricity is far more efficient!

The key to clean-energy transport and the best strategy for cars.

How much energy do various types of vehicles require to travel a distance of 100 km?

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Energy Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery-electric vehicle</td>
<td>15 kWh</td>
</tr>
<tr>
<td>Fuel-cell vehicle</td>
<td>31 kWh</td>
</tr>
<tr>
<td>Conventional vehicle (with power-to-gas)</td>
<td>93 kWh</td>
</tr>
<tr>
<td>Conventional vehicle (with power-to-liquid)</td>
<td>103 kWh</td>
</tr>
</tbody>
</table>

The literary masterpiece ‘Don Nimbyxote’ tells the story of a knight-errant and his squire Sancho SUV-Panza and their desperate fight against the ferocious giants known as wind turbines.

We’re electric vehicles!
BUT... are there enough raw materials for everyone to drive electric vehicles?

WHERE BATTERIES GET THEIR JUICE

LITHIUM

Lithium is available in sufficient quantity for electric vehicles. Lithium reserves are enormous, enough to meet growing demand. Short-term supply bottlenecks could occur, however.

WORLDWIDE LITHIUM RESERVES ARE ENORMOUS, ENOUGH TO MEET GROWING DEMAND

240,000 t annual demand in 2050

14,000,000 t Reserves

LITHIUM MINING IS OFTEN ASSOCIATED WITH POOR LABOR CONDITIONS AND ENVIRONMENTAL DAMAGE.

THAT'S WHY ITS EXTRACTION HAS A BAD REPUTATION.

THIS LOOKS FAMILIAR...

WHERE MINING TAKES PLACE, WE NEED:

• Mandatory due diligence for cobalt (via cobalt’s inclusion in the EU regulation for conflict minerals)
• Partnerships that support sustainable mining
• Collection and recycling targets for cobalt and lithium in the EU’s battery directive

WE SHOULD TRY TO RECYCLE AS MUCH AS POSSIBLE, DESPITE THE LARGE QUANTITIES AVAILABLE. (IN THE FUTURE, I WILL WORK WITH LESS COBALT.)

TO PROTECT PEOPLE AND THE ENVIRONMENT WHERE MINING TAKES PLACE, WE NEED:

COBALT

WORLDWIDE COBALT RESOURCES ARE ALSO ENORMOUS RELATIVE TO ANNUAL DEMAND.

BUT HALF OF ALL COBALT MINING TAKES PLACE IN CRISIS-RIDDEN COUNTRIES SUCH AS THE CONGO.

GO LOOK FOR COBALT SOMEWHERE ELSE!

62,000,000 t Resources

120,000,000 t Resources under the sea floor

14,000,000 t Reserves

25,000,000 t Resources in the ground

40,000 t annual demand in 2050

7,000,000 t Resources

Global raw material deposits (2018) versus demand in 2050

Resources: Total deposits, including those that cannot be extracted economically.
Reserves: Deposits that can be extracted economically using current technology.

40,000 t annual demand in 2030

7,000,000 t Resources in the ground

25,000,000 t Resources in the ground

120,000,000 t Resources under the sea floor
The carbon footprint of an electric vehicle is higher "at birth".

Battery production for electric vehicles consumes a lot of electricity, however. This is particularly troublesome when the electricity is generated using fossil fuels.

In Germany, electric cars are already more climate friendly than their conventional counterparts.

BUT...

aren’t electric cars much worse for the environment than conventional cars during manufacturing?

Inclusions from production!

The carbon footprint of an electric vehicle is higher "at birth".

IT’S A PETROLIUM BABY!

IT’S AN E-BABY!

CO₂ FOOTPRINT 7.5 t

CO₂ FOOTPRINT 13.2 t

Diesel 16% more emissions than an e-car

150,000 km

After the electric vehicle has lower cumulative emissions, however.

After 150,000 km the electric vehicle has lower cumulative emissions, however.

I'VE TRAVELLED 150,000 KM SINCE I WAS BORN!

Including emissions from production!

I WAS DROPPED YEARS AGO.

Gasoline 24% more emissions than an e-car

IT’S A PETROLIUM BABY!

IT’S AN E-BABY!

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BUT aren’t electric cars much worse for the environment than conventional cars during manufacturing?

In Germany, electric cars are already more climate friendly than their conventional counterparts.
The greater the share of renewables in the power system, the more climate-friendly electric vehicles become.

**Power Mix in 2018 & 2050 Goal**

- **2018**
  - Renewables: 36%
  - Others (coal, natural gas): 64%

- **2050**
  - Renewables: 65%
  - Others: 35%

**I’ve been feeling great on this new climate-friendly diet!**

The adventures of Don Nimbyxote continue...

**Policymakers must create incentives that accelerate the switch to electric cars.**

To meet the growing demand for clean electricity in the transport sector without creating shortfalls elsewhere, we need to rapidly expand wind and solar energy.

**Lawmakers must act!**

**Did you hear?**

**We need to make it more expensive to purchase high-polluting vehicles...**

Money is no object when it comes to how I roll!

**Most electric cars today are more expensive than combustion models.**

**Immediate measures should be taken to expand the network of charging stations and ensure nationwide coverage.**

**Where can I water my horse?**

**Policymakers must create a regulatory framework that encourages these changes!**

**My horse needs a drink!**

**Technological advances in clean energy and battery production will continue to reduce the carbon footprint of electric vehicles.**

But these efficiency gains will be lost if cars continue to get larger and heavier.

**Money is no object when it comes to how I roll!**

**At the same time, the government must subsidize purchases of low-emission, high-efficiency vehicles.**

**Yipey!**

**Where can I water my horse?**

56 57
Widespread deployment of electric vehicles in Germany will require the expansion of the power grid. To keep investment costs down, we need flexible charging for electric vehicles in combination with sustainable mobility.

**INFLExIble CHARGING without sustainable mobility:**

- All cars are charged simultaneously at the maximum rate.

**FLExIble CHARGING with sustainable mobility:**

- Flexible charging helps stabilize grid power flows.
- Flexible charging reduces the need for grid expansion.
- Flexible charging prevents the grid from overloading.

We need flexible charging that accommodates current grid capacity and generation levels.

**CHARGING BASED ON GRID CAPACITY**

- Charge as long as I am not overloading the grid. This helps stabilize grid power flows.

**CHARGING BASED ON GRID CAPACITY AND GENERATION LEVELS**

- Charge when output of renewables is high, the price of power falls, and I can charge ahead of time. But those in a hurry receive priority in order to prevent the grid from overloading.

**CHARGING BASED ON GENERATION LEVELS**

- I charge when power is cheap, regardless of the problems it creates.
- I’ll charge to 100% anyway!!!
- I’ll charge to 100% anyway!!!

**WHAT DOES THAT EVEN MEAN?**

- It’s simple: charge me whenever there is an abundance of renewable energy. But don’t charge me so much as to overload the power grid. Does that make sense?

**IT’S SIMPLE:**

- Charge me whenever there is an abundance of renewable energy. But don’t charge me so much as to overload the power grid. Does that make sense?

**HELP, I’M OVERLOADING!**

- I’ll charge to 100% anyway!!!
- I’ll charge to 100% anyway!!!

**NO, I WILL!!!**

**Electricity storage is difficult. The less power that needs storing, the better.**

**One at a time please. Otherwise the grid will overload!**

**THIS KEEPS GRID EXPANSION TO A MINIMUM!**

**D**
HEAVY TRUCKS
EXPERTS ARE STILL DEBATING HOW BEST TO POWER THEM

SYNTHETIC FUELS
POWER-TO-GAS
POWER-TO-LIQUID

TROLLEYTRUCK
ELECTRICITY FROM RENEWABLES

FUEL CELLS
HYDROGEN (∙ H₂)

BATTERY
ELECTRICITY FROM RENEWABLES

A TRUCK TOLL THAT FLUCTUATES BASED ON CARBON EMISSIONS WOULD CREATE INCENTIVES TO REDUCE EMISSIONS IN ROAD FREIGHT AND USE MORE EFFICIENT VEHICLES.

CARBON TAXES ON FUEL

GERMAN CARBON TAXES ON FUEL

IF DIESEL IN GERMANY BECOMES MORE EXPENSIVE, THEN I’LL TANK UP ELSEWHERE.

LARGE SHIPS AND AIRCRAFT
THESE VEHICLES PROBABLY CAN’T BE ELECTRIFIED

YES! SUMMER VACATION IS COMING SOON.

WHAT ABOUT THE CANARY ISLANDS? THE FLIGHTS ARE CHEAP.

I’D PREFER NOT TO FLY.

WHAT ABOUT THE CANARY ISLANDS? THE FLIGHTS ARE CHEAP.

I’D PREFER NOT TO FLY.

WE’RE JUST TOO FAT.

I’M A LIGHTWEIGHT BY COMPARISON.

At some point in the future, we will probably need carbon-free synfuels for airplanes and ships.

GERMAN CARBON TAXES ON FUELS ARE NOT ENOUGH.

MAYBE IN THE FUTURE AIRPLANES AND CRUISE SHIPS WILL RUN ON ELECTRICITY.

THAT’S STILL A LONG WAY OFF.

THAT’S STILL A LONG WAY OFF.

UNFORTUNATELY CRUISE SHIPS ARE ALSO TERRIBLE FOR THE ENVIRONMENT.

IF DIESEL IN GERMANY BECOMES MORE EXPENSIVE, THEN I’LL TANK UP ELSEWHERE.

THIS NEW GIRLFRIEND CERTAINLY SPEAKS HER MIND...

YES! SUMMER VACATION IS COMING SOON.

THAT’S FINE WITH ME. I LIKE HER.

UNFORTUNATELY CRUISE SHIPS ARE ALSO TERRIBLE FOR THE ENVIRONMENT.

THESE VEHICLES PROBABLY CAN’T BE ELECTRIFIED.
What is the CO² footprint of my trip?

(CO² equivalent kilograms)

<table>
<thead>
<tr>
<th></th>
<th>Train</th>
<th>Car</th>
<th>Plane</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISTANbul</td>
<td></td>
<td></td>
<td>German air freight</td>
</tr>
<tr>
<td>(Annual freight volume in billions of tons)</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>2,700 kM</td>
<td></td>
<td></td>
<td>2,700 kM</td>
</tr>
<tr>
<td>97</td>
<td>375</td>
<td>360</td>
<td>BERlIN</td>
</tr>
<tr>
<td>ISTANbul</td>
<td></td>
<td></td>
<td>MunICH</td>
</tr>
<tr>
<td>600 kM</td>
<td></td>
<td></td>
<td>600 kM</td>
</tr>
<tr>
<td>73.9%</td>
<td>10.9%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 22 | 83 | 196 | Destinations of flights originating in Germany (2017)
| 1,000 kM | 1,000 kM | | |
| 36 | 139 | 196 | Paris |
| 4.1% | | | |
| 4.1% | | | AFRICA |
| 73.9% | | | USA |
| 32% | | | ASIA |
| 10.9% | | | AUSTRAliA & OCEANIA |
| 0.4% | | | 0.4% |
| 10.8% | | | OR WE COULD |
| OR WE COULD |
| GO CAMPING! |
| DO I LOOK LIKE A OUtDoOR DOG? |
| I AM A REFINED CITY DOG! |
| WHY DON’T WE vACATIoN MORE OFTEN IN GERMANY? | WHY DON’T WE vACATIoN MORE OFTEN IN GERMANY? |
| YOu ALWAYS SAId YOu WANTED TO GO HIkING IN bA vARIA... | YOu ALWAYS SAId YOu WANTED TO GO HIkING IN bA vARIA... |
| WEll... | WEll... |
| PluS I dON’T GET THROWN INTO THE CARGO HOld IN A SMALL CAGE! | PluS I dON’T GET THROWN INTO THE CARGO HOld IN A SMALL CAGE! |
| I AM TOO HEAvY TO RuN ON bATTERIES. | I AM TOO HEAvY TO RuN ON bATTERIES. |
| GREEN SYNFuElS ARE NOT AvAIlABLE IN SUFFICIENT QuANTITIES. | GREEN SYNFuElS ARE NOT AvAIlABLE IN SUFFICIENT QuANTITIES. |
| Carbon-neutral planes remain a distant dream. For now, the only solution is to fly less. | Carbon-neutral planes remain a distant dream. For now, the only solution is to fly less. |
| SO MuCH FOR FliGHT-SHAMING. | SO MuCH FOR FliGHT-SHAMING. |
| People are flying more than EVER! | People are flying more than EVER! |

Number of passengers, domestic destinations
2000 17.9 M
2017 23.7 M

Number of passengers, international destinations
2000 52.5 M
2017 97.8 M

German per capita CO² emissions are 11 tons annually, and must fall to 1 ton to fulfill emission targets.
CARBON PRICING IS ESSENTIAL FOR SUSTAINABLE TRANSPORT

Polluters should pay for the damage they cause to the environment. By taxing activities that emit carbon, we can discourage pollution while encouraging cleaner alternatives. In this way, carbon pricing can help create climate-friendly transport powered by clean energy.

TODAY’S PRICES DON’T REFLECT THE TRUE ENVIRONMENTAL IMPACT!

CO₂ PRICING

OH NO! I THINK I SEE MYSELF!

TO ENSURE THAT CARBON PRICING IS FAIR, THE REVENUES IT GENERATES SHOULD FLOW BACK TO CITIZENS THROUGH (1) UNIFORM PER CAPITA REDISTRIBUTION, (2) A REDUCTION IN THE ELECTRICITY TAX, AND (3) A HARDSHIP FUND.

THAT’S CALLED ENERGY POVERTY.

A HORROR SCENARIO: A WOMAN WITH LOW-INCOME WHO LIVES IN A POORLY INSULATED HOUSE IN A REMOTE LOCATION, REQUIRING LONG COMMUTES.
The auto industry is facing the greatest upheaval in its history. Manufacturers who resist change will end up losing out. The future belongs to companies that embrace the development of environmentally friendly vehicles and services.

Electric drivetrains are less complex than their conventional counterparts, and hence require less manpower to build. If 40% of new cars are electric in 2030 and 20% are hybrid, the German automotive sector will have 84,000 fewer employees.

In the ‘business as usual’ scenario (continued manufacturing of conventional vehicles), some 87,000 jobs will disappear by 2030 due to greater mechanization and productivity increases.

However, only 20,000 jobs will be lost because of e-vehicles. The other 67,000 jobs will disappear regardless of the types of vehicles we produce, due to productivity improvements and further automation. It is also important to consider that the industry currently employs 840,000 people.

If car and bike sharing enjoys success as a business model in Germany, some 200,000 new jobs could be created. However, this would likely reallocate demand for jobs and skills across regions.

German companies sell more cars abroad than they do at home. Demand for electric vehicles in foreign markets, especially in China, is growing rapidly. If Germany cannot cater to this demand, massive job losses in the German car industry are likely to result.

2016 automobile production and sales figures of Germany car makers

<table>
<thead>
<tr>
<th>Production Type</th>
<th>Production in 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Production</td>
<td>5.7 M</td>
</tr>
<tr>
<td>Foreign Production</td>
<td>10.1 M</td>
</tr>
<tr>
<td>Total Production</td>
<td>15.8 M</td>
</tr>
</tbody>
</table>

Here are 15.8 M cars!

Thanks, we’ll take 13.4 M cars...

Great, we’ll take 2.4 M cars!

But please send us electric vehicles in the future!

WHY SHOULD I CARE ABOUT THE FUTURE?

WHAT DO WE DO NOW?

LAND AHoy!

NO, I’M STEALING YOUR JOBS! Muhahaha!

START

Should we manufacture electric vehicles for climate protection?

YES

NO

THIS DECISION TREE HAS FAR-REACHING CONSEQUENCES! TEST IT FOR YOURSELF.

JOB DESTROYER!

68 69
The German government awards environmentally harmful tax breaks in the transport sector amounting to 28.6 billion euros annually. In purely mathematical terms, the abolition of these tax breaks would be more than sufficient to fund the investment necessary to transform the sector.

Value of environmentally harmful tax breaks, (2017), in euro billions

- Jet fuel is tax free: 11.8 billion
- Tax breaks for company cars: 3.1 billion
- Commuter deductibles: 5.1 billion
- Diesel privilege: 7.4 billion
- Miscellaneous: 4.2 billion
- Big and expensive cars get the highest tax break.
- The cost of driving to work is tax deductible.
- Diesel is taxed at a lower rate than gasoline.

In particular, we should eliminate tax breaks that encourage harmful emissions. Investment in sustainable transport will also allow us to reduce energy expenditures.

We can afford sustainable transport

I read today that Germany spends 43 billion a year on defense alone.

That would be 17 billion a year for sustainable transport!

Yes, but it won’t protect you from a proud dad!

And the money we spend on the transformation will help protect us from the disastrous effects of runaway climate change.

How many bones can you buy for 250 billion?

It’s not much when you consider what we spend on other things.

AndFree!

Climate change

Between now and 2050, investment costs could total 250 billion euros.

250 billion euros?!
SUSTAINABLE TRANSPORT IS GOOD
NOT JUST FOR CLIMATE PROTECTION

WHO SAYS YOU CAN’T TEACH HUMANS A FEW NEW TRICKS!
I THINK THEY’RE CATCHING ON!
NOW THEY JUST NEED TO LEARN HOW TO DRIVE...
...SO WILL ROAD SAFETY!
AIR QUALITY WILL IMPROVE...
...SO WILL ROAD SAFETY!
THERE’LL BE MORE SPACE FOR BIKE PATHS AND OTHER NICE THINGS.

TADA!
THEN IT’LL BE GOODBYE, BIG OIL!
ONCE WE ARE NO LONGER DEPENDENT ON OIL, GERMANY CAN ACHIEVE ENERGY SELF-SUFFICIENCY.

EVEN WITHOUT CLIMATE CHANGE ...
... A SUSTAINABLE TRANSPORT SECTOR WOULD MAKE MANY THINGS BETTER

BOTH IN CITIES...

... AND IN THE COUNTRY.

SUSTAINABLE TRANSPORT IS GOOD NOT JUST FOR CLIMATE PROTECTION

ONCE WE ARE NO LONGER DEPENDENT ON OIL, GERMANY CAN ACHIEVE ENERGY SELF-SUFFICIENCY.

TADA!
THEN IT’LL BE GOODBYE, BIG OIL!
ONCE WE ARE NO LONGER DEPENDENT ON OIL, GERMANY CAN ACHIEVE ENERGY SELF-SUFFICIENCY.
MY DREAM HAS FINALLY COME TRUE!
Discussion of electric vehicles and fuel-cell vehicles. This includes both battery-electric electric vehicles and hydrogen fuel-cell vehicles. Hydrogen is first split from water via electrolysis, and then converted into synthetic fuel via Fischer-Tropsch synthesis.

Greenhouse gases are all gases that raise the temperature of the earth's atmosphere. They include carbon dioxide (CO2), methane (CH4), and chlorofluorocarbons (CFCs). A unit of measurement for CO2 equivalents is the ton of CO2 equivalent. 

A unit of measurement for power-to-liquid is the MJ/P km, which refers to the amount of energy required to transport one person one kilometer in megajoules.

NIMBY
NIMBY (short for “not in my back yard”) describes the opposition of residents to a planned development – such as an airport, a low-incoming housing project, or, as in our case, a wind turbine – that they would otherwise support were it not being built so close to their homes.

Passenger transport
While the term “passenger” is normally used in English to refer to an individual transported in a vehicle that he or she does not operate, the OECD defines “passenger transport” as any form of transport of people by road, rail, water, or air.

Power-to-gas
Also abbreviated P2G, this refers to a process for producing gas from electricity, which can be stored and used to power vehicles.

Power-to-liquid
Refers to a process for producing liquid fuel from electricity. Hydrogen is first split from water via electrolysis, and then converted into synthetic fuel via Fischer-Tropsch synthesis.

Multimodal mix
When different means of transport (car, bus, bicycle) are combined in a single journey, the term “multimodal mix” is frequently used to refer to “mobile transport” (German: Elektromobilität; French: mobilité électrique). The term has been slow to catch on in English-speaking countries, most likely because “mobility” is already widely used in English to refer to “mobile computing” and “social mobility.”

Intermodal transport
When different means of transport (car, bus, bicycle) are combined in a single journey, the term “intermodal transport” is frequently used to refer to “multimodal mix.”

Reason #1 for Sustainable Transport
Reason #1 for Sustainable Transport: to Protect the Planet
International Energy Agency (2018): CO2 emissions from fuel combustion
NASA (2019): Global Climate Change: 2018 fourth warmest year in continued warming trend, ed. 6.2.2019
www.climate.nasa.gov

Greenhouse gases are all gases that raise the temperature of the earth's atmosphere. They include carbon dioxide (CO2), methane (CH4), and chlorofluorocarbons (CFCs).

Verkehrswende
A German neologism inspired by the term “Energiewende” (literally, “energy transition”), it is a compound term “Energiewende” (literally, “energy transition”), it is a compound term “Verkehrswende” (transport, traffic) and “Wende” (transition, turnaround). It refers to the transformation of the transport sector toward greater sustainability (pronunciation: Fair-cares-ven-duh).

Reason #2 for Sustainable Transport
Reason #2 for Sustainable Transport: to Improve Quality of Life
International Energy Agency (2018): CO2 emissions from fuel combustion
NASA (2019): Global Climate Change: 2018 fourth warmest year in continued warming trend, ed. 6.2.2019
www.climate.nasa.gov

The percentage of travelers using a particular mode to reach their workplace is called the mode share or modal share. It is calculated as a percentage of single journeys.

Reason #3 for Sustainable Transport
Reason #3 for Sustainable Transport: to Reduce Energy Consumption
International Energy Agency (2018): CO2 emissions from fuel combustion
NASA (2019): Global Climate Change: 2018 fourth warmest year in continued warming trend, ed. 6.2.2019
www.climate.nasa.gov

Reason #4 for Sustainable Transport
Reason #4 for Sustainable Transport: to Protect and Restore the Environment
International Energy Agency (2018): CO2 emissions from fuel combustion
NASA (2019): Global Climate Change: 2018 fourth warmest year in continued warming trend, ed. 6.2.2019
www.climate.nasa.gov
Agora Verkehrswende is a Berlin-based think tank that conducts in-depth research on mitigating climate change in the transport sector. The arguments in favor of a Verkehrswende – a sweeping transformation of the transport sector toward sustainability – are numerous and compelling. Yet so far action has failed to materialize, persuading us to ask: What can we do to increase public awareness for this important issue?

You’re holding the answer in your hands. This infographic novel shares our insights in a new format designed to reach a wider audience and engender broader public support for sustainable transport. The storyline follows a family of three generations, from the young and idealistic to the old and cantankerous, as they grapple with issues related to the climate and the future of mobility. They discover that sustainable transport is not just good for the climate, but also an opportunity to positively reshape how we live and work together.