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MOVING FORWARD: A PATH TO
NET ZERO
EMISSIONS

BY 2070

CHANGING HOW TOMORROW'S TRANSPORT IS
FUELED COULD HELP US HIT THAT GOAL. EXPLORE
THE POSSIBILITIES, IN 3-D AND AUGMENTED
REALITY.

Getting a new TV delivered to your doorstep can seem like magic. With a few taps on your smartphone, a global delivery process is set into motion: Trucks, trains, jets and even ships all have a role in whisking your order from factory to warehouse to your front door — and in making and

moving parts and raw materials to be assembled in the first place. Yet this impressive feat comes with a catch: Practically every vehicle involved burns fossil fuel, releasing CO2 and other gases that feed climate change.

***SEE A 3D VIEW OF WHAT SOME OF TOMORROW'S
TECHNOLOGIES WILL LOOK LIKE***

You are viewing a version of this article with immersive features designed for the web and older devices. The full AR experience is available only on newer iPhones and iPads using the NYTimes app.

Today, more than a third of the CO2 released in the United States comes from transportation sources, according to the Energy Information Administration. Absent alternatives, transportation's share of global emissions is

slated to continue growing in coming years.

It doesn't have to be that way. Shell's Scenarios team is exploring ways to reshape energy, buildings, industry and transport over the next half century. They've created what they call the "Sky Scenario": a thought experiment that envisions a future where electricity is ascendant, renewables reign, access to energy is universal and global climate change wanes.

**TRANSPORTATION
AS A SHARE OF
U.S. ENERGY-
RELATED CO₂
EMISSIONS, 2017**

The Sky Scenario is a

tool to envision what the future of energy might look like over the 21st century, when the way we fuel cars, planes, trucks, ships and trains — as well as the global economy — could be profoundly different from the way it is today.

That sort of future may sound far-fetched, but the ways we use energy have gone through similarly massive transformations in the past. The world moved from wood and coal in the 19th century to petroleum, natural gas and electricity in the 20th century. Each step has delivered meaningful gains in power, efficiency and quality of life. On the back of the landmark Paris Agreement, the

21st century is ripe for other major shifts in energy sources and use.

“Fifty years from now, the world will likely be very electrified,” says Ned Harvey, managing director at the Rocky Mountain Institute, a nonprofit energy think tank. “You can create electricity with renewable sources, and if the grids are well managed, you can move it around with no boundaries.”

“In the meantime, though, we need to develop ways to use carbon sequestration, hydrogen and liquified natural gas,” Harvey says. “To really make that change in the future, you need long-term scenarios like Sky

to help better
understand the
possibilities and
uncertainties ahead.”



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IN FOR THE LONG HAUL



Long-haul trucking is one of the most familiar transportation modes that could undergo deep change. Although the number of electric and hybrid passenger cars on the road is rising, trucking still relies on energy-dense diesel fuel to power big rigs carrying heavy loads across thousands of miles. And right now, more than 11 million long-haul trucks rumble down American highways each day, taking goods from ports on the coast to communities in the Heartland — in the process, releasing greenhouse gasses from burning diesel fuel.

Unlike electric batteries, hydrogen works more like conventional fuel: speedier to refill and able to power longer drives.

One near-term solution may be to create renewable biofuels that have a lower carbon impact. These fuels could come from plants, algae and even waste as feedstocks. Crucially they could be dropped into today's fuels — blended into conventional diesel or used as a substitute — with little to no modification of engines or infrastructure. In the next few decades, biofuels may help reduce total carbon produced by long-haul trucking. But eliminating emissions in the long term will require a suite of new energy sources.

In the future, commercial trucking may also incorporate energy from electric batteries, particularly for shorter delivery routes in dense urban areas. Though still costly, that technology is advancing and could soon reach a point where it is cost effective for vehicles to use on longer trips. Another plus: At scale, electric vehicles could be powered by near-zero-emission wind, solar or other renewables.

Likewise, hydrogen may also be a promising energy carrier to fuel tomorrow's trucks. Compressed as a liquid, hydrogen can be burned directly or used in fuel cells — devices that convert hydrogen into electricity to power motors or recharge vehicle batteries — while emitting only water vapor. And unlike electric batteries, hydrogen works more like conventional fuel: speedier to re-fill and able to power longer drives.

SKY
SCENARI

LOW CARBON, HIGH SEAS

SCENARIO

NOW
TO
2070

Sector
by
sector,
each
decade
could
bring
lower
emissions
via
unprecedented
change

To keep climate change from advancing, similar transformations would need to be applied to much larger vehicles: cargo ships. As of 2018, some 50,000 massive freighters move cargo worldwide, each using an average of 110 tons of fuel oil per day. Taken as a whole, maritime shipping accounts for 2-3% of global emissions. A European Parliament study found that absent cleaners method of fueling waterborne transport, the sector's share of global carbon emissions could grow to 17% by midcentury.

50,000

FREIGHT AND CARGO
VESSELS WORLDWIDE,
ESTIMATED

Energy system CO₂
emissions, Gt per
year

2080-
2090



Hydrogen
is 10%
of final
energy

Under Shell's Sky Scenario, curbing that rise will require both immediate change and long-term considerations. Over the next few decades, developing ships that run more efficiently and/or run on liquefied natural gas (LNG), biofuels or other renewable sources, could offer immediate benefits.

That's already underway, to some extent. Shell has partnered with Carnival Cruise lines, one of the world's

largest cruise companies, to build infrastructure for two new LNG ships that will launch in the early 2020s.

“The question that has been asked in the past is, ‘Why should LNG be a marine fuel?’” says Tim Downs, Shell’s general manager of shipping and maritime for the Americas. “But that question is rapidly becoming, ‘Why should it not be?’ The key will be building infrastructure to supply LNG in the same manner that we supply fuel oil today.”

“I think it will take a generation of ships,” Downs adds. “The average lifespan of a ship today is about 22 to 25 years. When that time is elapsed, we can have the global infrastructure in place to supply LNG far more widely.”

Further out, hydrogen also shows great promise as an energy medium to power tomorrow’s ships with far lower emissions.

FLYING ON BIOFUEL

While electric drivetrains and LNG may eventually dominate road transport, aircraft are a different story. Unlike fuel for road- and ocean-going vehicles, jet fuel

must perform unfailingly under even tougher conditions. It has to resist icing at high altitudes and must deliver massive amounts of energy for its weight.


“Short haul flights could be done with electric motors,” says Adam Klauber, the director of sustainable aviation at the Rocky Mountain Institute. “But for long haul, you really need a drop-in fuel that can be used with existing engines.”

That alternative could come in the form of biofuels. From a molecular standpoint, these substances look a lot like existing aviation-grade kerosene — otherwise known as jet fuel — and share many of the same qualities. So existing engines can use some form of it.



2%

**AVIATION AS SHARE OF
GLOBAL CO₂ EMISSIONS**



At San Francisco International Airport, Shell and United Airlines have signed a memorandum of understanding to make biofuels available commercially. The airline has already experimented with biofuels on flights on the West Coast, so ramping up infrastructure could be a first step toward carbon-neutral aviation, says Christine Bassitt, the account manager for Shell Aviation.

“Jet fuel is the only hydrocarbon expected to grow over next few years in production,” Bassitt says. “Today, biofuels are only a drop in the bucket. But we’re not looking to just do a one-off. We want to change aviation in a sustainable way.”

“Part of the reason for publishing Sky is to get people to recognize that climate change is a problem that has a solution — that there are steps you can take to make a difference.”

**DAVID HONE, CHIEF CLIMATE CHANGE ADVISOR,
SHELL**

Over the longer term, the road to greener flight will involve more than just reducing engine emissions directly, Bassitt says. By 2070, even aircraft may still rely on fossil fuels, to some degree. So countering those emissions by creating carbon-neutral fuels will be crucial.

Plant and algae biofuels can actually pull carbon from the atmosphere during production, since plants ‘eat’ CO₂ to survive. That carbon will still be released when the fuel is burned, but it’s a step in the right direction. In terms of net emissions, advanced biofuels can emit less carbon than petroleum, so they could help cut atmospheric greenhouse gasses, overall.

“It’s really about the full life cycle,” Klauber says, referring to biofuels. “You’re harvesting carbon from the atmosphere to make the fuel, so it’s captured in production. When you burn it, you wind up with lower carbon emissions in the end.”

ONE FUTURE, MANY PATHS

To be sure, consumers, companies and governments will face tough choices in the years to come. And the paths to a future of net-zero emissions vary by country, geography and sector. But if the world’s nations are going to meet the aims of the Paris Agreement, they’ll have to completely transform the way energy is used — and produced — across the global economy.

It won’t happen overnight. The road there will involve short-, mid- and long-term changes that impact us all. It’ll involve forming supportive government policies and getting consumers to embrace lower-carbon options. It’ll also require changing existing infrastructure, which could take decades.

To help navigate this multistage challenge, Sky Scenario calls for the advancement of emerging technologies that

can be used in the near future on a large scale, especially in fields like long-haul transport and heavy industry. Those are some of the hardest and most costly areas to decarbonize. But if they can be weaned from fossil fuels wherever possible, it may be enough to slow or even reverse climate change by 2070.

David Hone, Shell's chief climate change advisor, emphasizes that Shell's scenarios aren't hard-set policy proposals or even forecasts of the future. They're simply possible paths that humans could take to a future with more or (in the case of Sky) far less climate change. At their core, these thought exercises challenge society to make tough decisions and find viable solutions in the years to come.

"Part of the reason for publishing Sky is to get people to recognize that climate change is a problem that has a solution, that there are steps you can take to make a difference," says Hone. "The task in front of us is to focus on actually doing that."

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Explore Shell's vision for a cleaner future

LEARN MORE



Sky builds on previous Shell scenarios publications and is our most optimistic scenario in terms of climate outcomes. Shell has been developing energy-focused scenarios for almost 50 years, helping generations of Shell leaders, academics, governments and business leaders to consider possible pathways when making decisions. Typically, Shell Scenarios are plausible and challenging visions of the future. They consider real and potential trends in politics, demographics and technology. They stretch our thinking and help society make crucial choices and navigate critical uncertainties.

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