
UP.PARTNERS
VENTURES | LABS | SUMMIT
THE MOVING WORLD REPORT
2023 Macro and Micro Trends in Mobility
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MOBILITY IS THE UNDERLYING FABRIC OF SOCIETY

Representing a multi-trillion dollar annual market, mobility cuts across all facets of commerce and industry.

From electric and autonomous vehicles, to EVTOLs, hypersonic travel, space exploration, and many more groundbreaking ideas, unlocking the next wave of opportunities will require disruptive innovation in multiple dimensions of technology, infrastructure, supply chain and human resources. A great number of challenges lie ahead – we like to think of them as opportunities.

The UP.Partners Moving World Report is an extensive analysis of the macro and micro trends in mobility. Through detailed market research and expert insights, we identify the main themes shaping mobility in the coming decades. Battery technology, raw materials, energy infrastructure, pilot shortages, and sustainable fuels are a few of the inhibitors and accelerators we cover in the Moving World Report – it provides our perspectives on the most relevant themes that will influence how we transform the way we move people and goods on air, land, sea, and space.

Whether you're a seasoned mobility industry veteran or just getting started, this report is a carefully curated repository of information for anyone looking to stay ahead of the curve in the dynamic world of mobility.

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INTRODUCTION

The mobility industry is undergoing a dramatic transformation with rapid advances in technology, expansion into new markets, and increasing demand for cleaner transportation.

The latter is particularly important. As global CO2 emissions from the transportation sector continue to rise, environmental concerns become more pressing. There are increasingly stringent regulations on emissions and mounting pressures from consumers to become more sustainable. As a result, it's clear that innovation in the mobility sector to reduce its environmental footprint is no longer an option but a necessity.

This era of unprecedented change is rewriting the rules of success, creating both opportunities and challenges for those operating within the ecosystem. In turn, it's essential that industry professionals stay abreast of the latest developments with fact-based evidence in order to remain competitive and capitalize on emerging trends.

In this report, we will explore the various dimensions of the most important innovation dynamics impacting all major means of transportation, whether on the ground, in the air, at sea, or in space. We will take a detailed look at the latest trends and underlying drivers of change.

Finally, we will explore the exciting opportunities that come with such rapid progress.

We hope that the insights in this report will help startup founders, investors, regulators, and decision-makers at transportation companies to successfully navigate these changes and better prepare for the future of the moving world.

This is a future worth getting excited about. History has shown, as you increase a community's access to mobility, quality of life increases in tandem. From the horse to the bicycle, the automobile, the boat, the plane, and the spaceship, innovative mobility solutions allow us to connect, explore, learn, transact, and be of service to one another.

Every facet of mobility is being disrupted. Drones are starting to deliver packages. Over 400 companies around the world are developing some sort of flying car. The move toward increasingly automated and electric cars and trucks is accelerating by the day. In the next few years, more electric bicycles are expected to be sold than cars on an annual basis. Ocean liners and cargo ships will soon be powered by sustainable fuels. Humans will soon be back on the moon, and in the not-so-distant future, will land on Mars.

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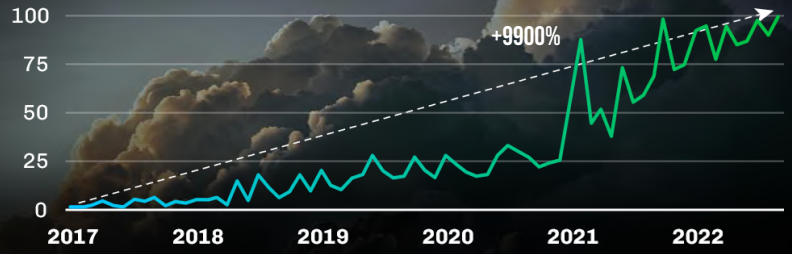
1 THE MOVING WORLD IN RAPID CHANGE

THE FUTURE OF MOBILITY IS BEING SHAPED ON MULTIPLE FRONTS

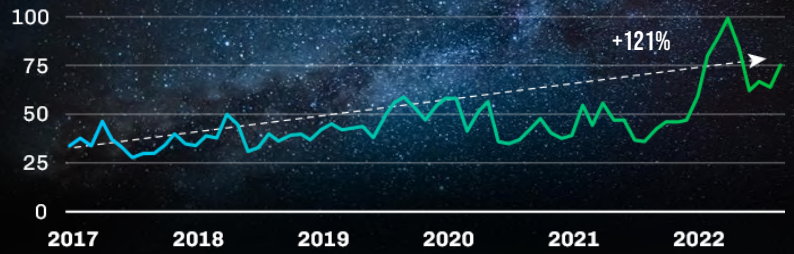
IN THE AIR

Google search interest worldwide for term eVTOL (indexed)



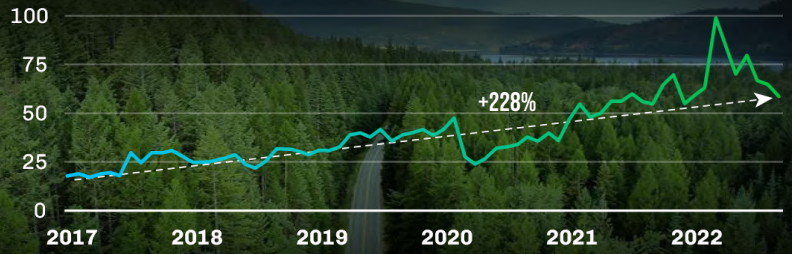
IN SPACE

Google search interest worldwide for term Space Economy (indexed)



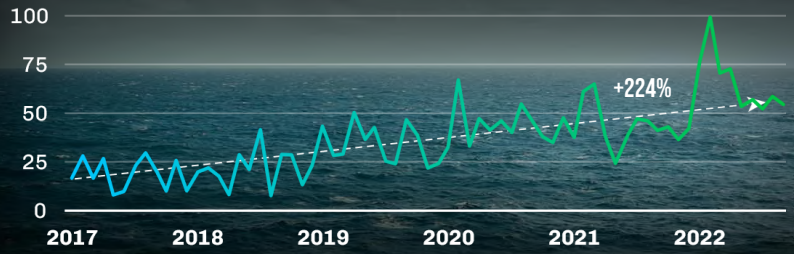
ON THE GROUND

Google search interest worldwide for term Electric Cars (indexed)



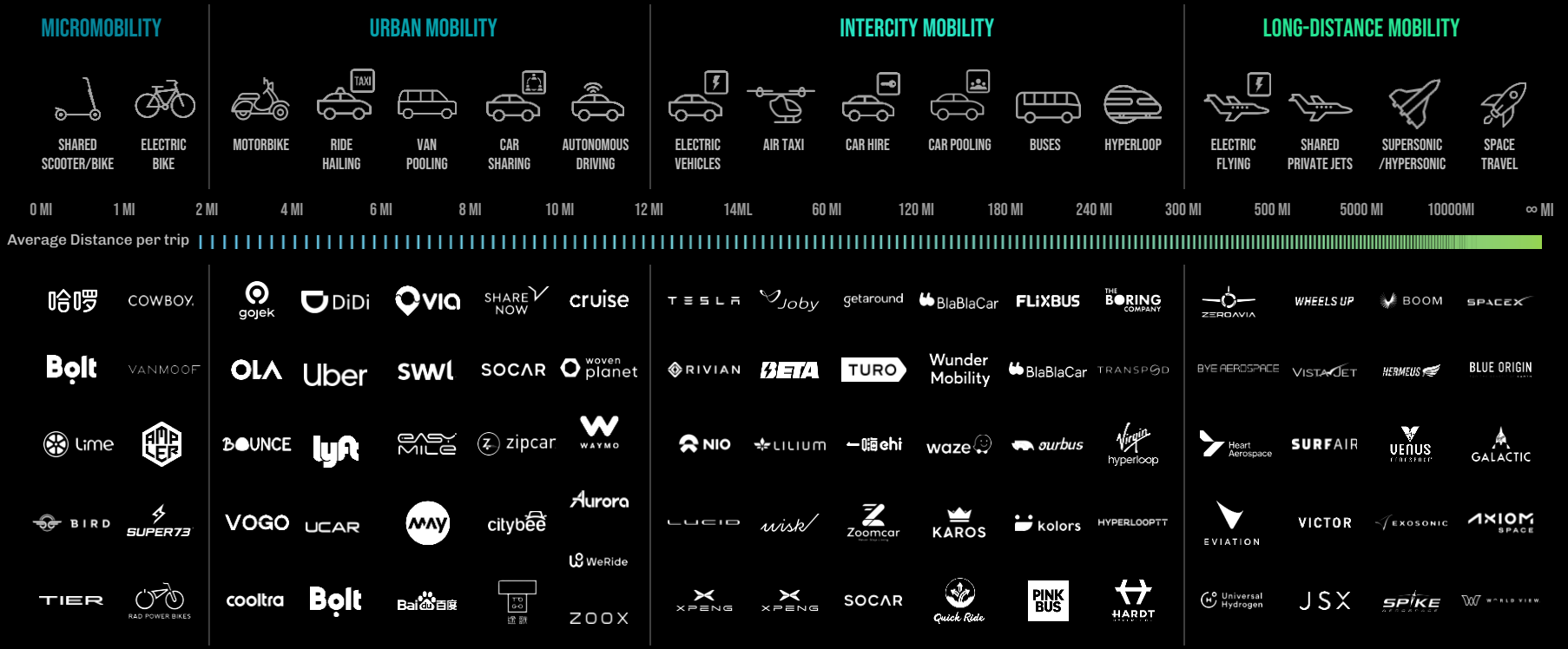
ON THE SEA

Google search interest worldwide for term Hydrogen Ship (indexed)



Source: Google Trends

AS A RESULT, A VIBRANT ECOSYSTEM OF NEW PASSENGER TRANSPORTATION HAS EMERGED



Source: UP.Partners analysis based on original mapping from Lufthansa Innovation Hub's TNMT.com

THE SAME IS TRUE FOR CARGO TRANSPORTATION

VISIBILITY AND COLLABORATION PLATFORMS

Freight Forwarding
flexport. · sennder · forto

Supply Chain Management
DELHIVERY · project44 · SHIPPEO

Asset Tracking
samsara · TRACKONOMY · easypost

Financial Services
Tradeshift · taulia · PRIMATRADE

SEA

Vessel Tracking	Weather Forecasting
spire	planet.
Autonomous Shipping	**Fuel Optimization**
SEADRONIX	NAUTILUS LABS
Smart Containers	**On-Ship Operations**
SKYCELL	SCANREACH

PORT

Enterprise Management	Security and Inspection
noodle.ai	AIROBOTICS
Predictive Maintenance	**Fuel Storage**
C3.ai	hydrogenious
Customs Clearance	**Vessel Scheduling**
KLEARNOW	PORTCALL.COM

HINTERLAND

Trucking Platforms	Fleet Management
CONVOY · BLACKBUCK	PLATFORM SCIENCE · motive
Hyperloop & Trains	**Electric & AV Trucks**
THE BORING COMPANY · TRANSPOD	Plus · NIKOLA

WAREHOUSE

Automation & Robotics	Micro Fulfillment
Geek+ · LOCUS	Fabric · waresix
Distribution Solution	**Storage & Inventory**
ShipBob · FineEx 发网	DEAR by Cin7 · shiphero

LAST MILE

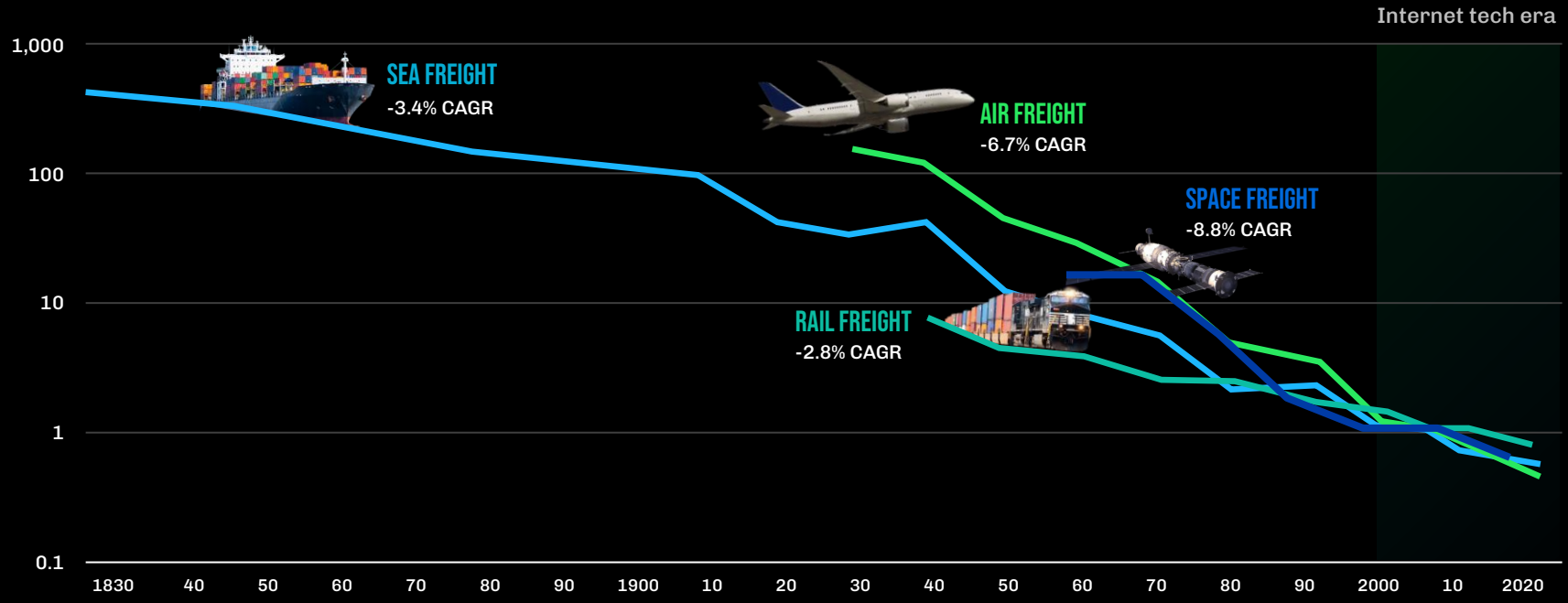
Delivery Services	Marketplace & Matching
ninjavan	LALAMOVE
Drop-off Stations	**AV Shuttles**
instabox	nuro
Delivery Drones	**Smart Boxes**
zipline	smartbox

Source: UP.Partners analysis

GIVEN SUCH INNOVATION DYNAMICS, WE CAN EXPECT TRANSPORT COSTS TO DECLINE FURTHER

DEVELOPMENT OF TRANSPORT COSTS AT REAL RATES

Cost in 2005 indexed to 1



Source: UP.Partners analysis based on data from McKinsey and the Center for Strategic and International Studies

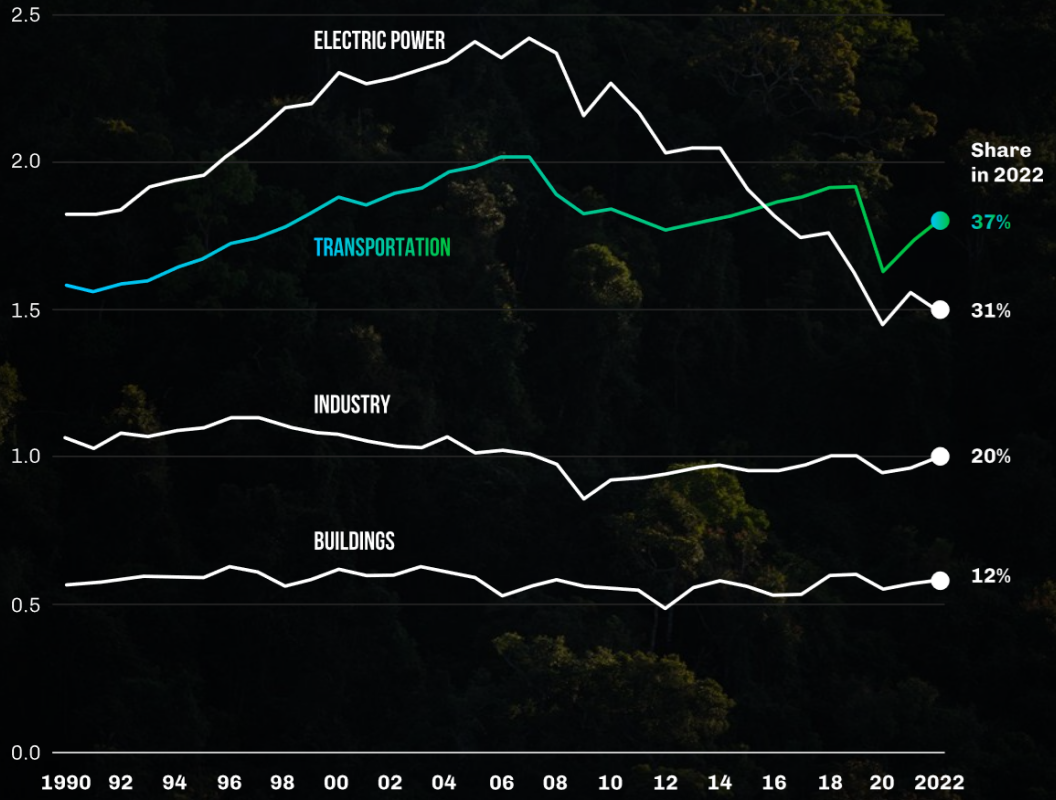
1.1 HOWEVER, THE BIGGEST INDUSTRY CHALLENGE HAS YET TO BE SOLVED

MOBILITY HAS BECOME THE MAJOR CO2 CONTRIBUTOR IN MANY COUNTRIES LIKE THE U.S.

Despite the leaps and bounds made by the mobility sector in terms of innovative new transportation modes, it has yet to effectively reduce CO2 emissions. In fact, according to major energy agencies like the EIA and the IEA, the transport sector still has the highest reliance on fossil fuels of any sector and accounts for an estimated 37% of CO2 emissions in the United States. While transportation was one of the sectors most affected by the COVID-19 pandemic, which caused a temporary decline in CO2 output, emissions continued to rise as demand increased.

ENERGY-RELATED CO2 EMISSIONS BY SECTOR IN THE U.S.

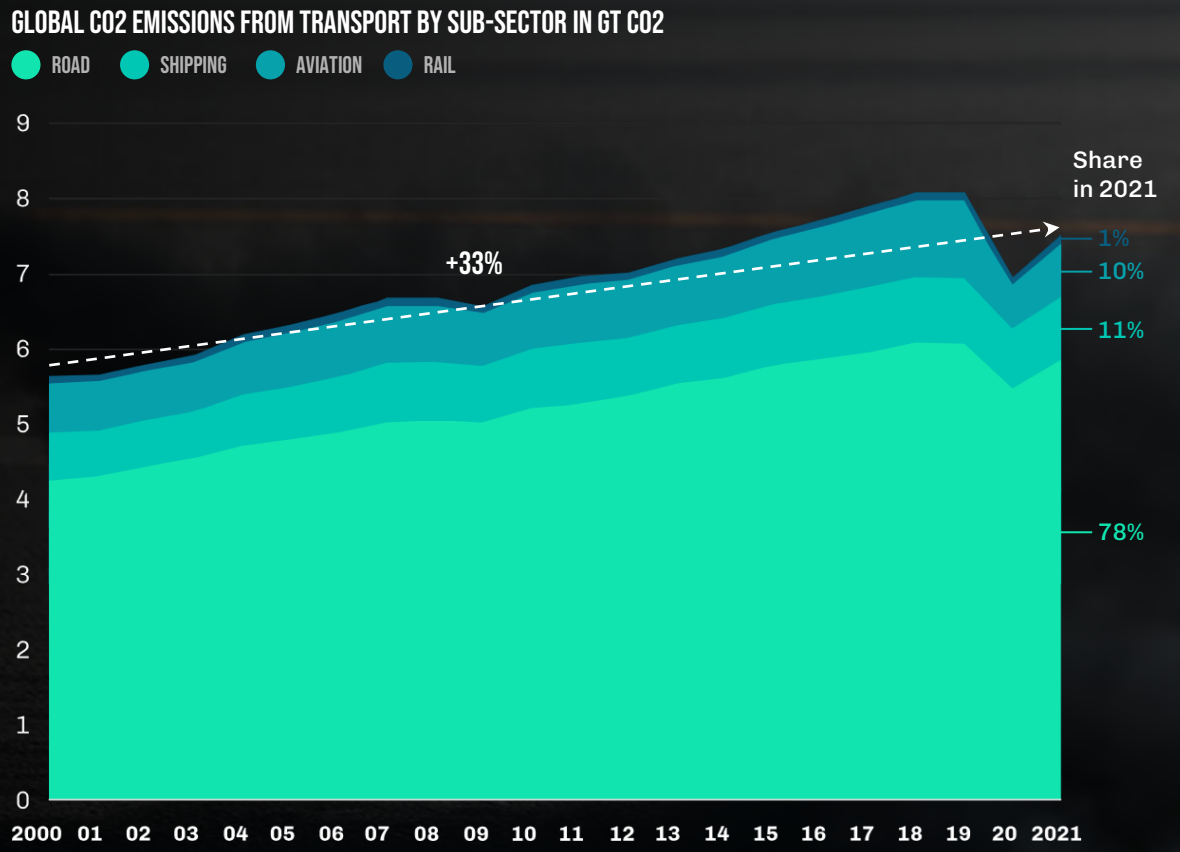
In billion metric tons



Source: U.S. Energy Information Administration (EIA)

GLOBALLY, EMISSIONS FROM TRANSPORTATION HAVE GROWN BY ONE-THIRD SINCE 2000

To truly understand the scope and gravity of the sustainability challenge for the mobility sector, it's essential to look beyond the U.S. border at global CO2 emissions generated by transportation. This includes all developing nations that are much further behind in decarbonizing their respective transportation sectors. Globally, over the last 20 years, emissions from transportation have grown by one-third. This massive jump was driven primarily by growth in access to (fossil-fuel-based) mobility for billions of people, as well as global trade expanding exponentially.

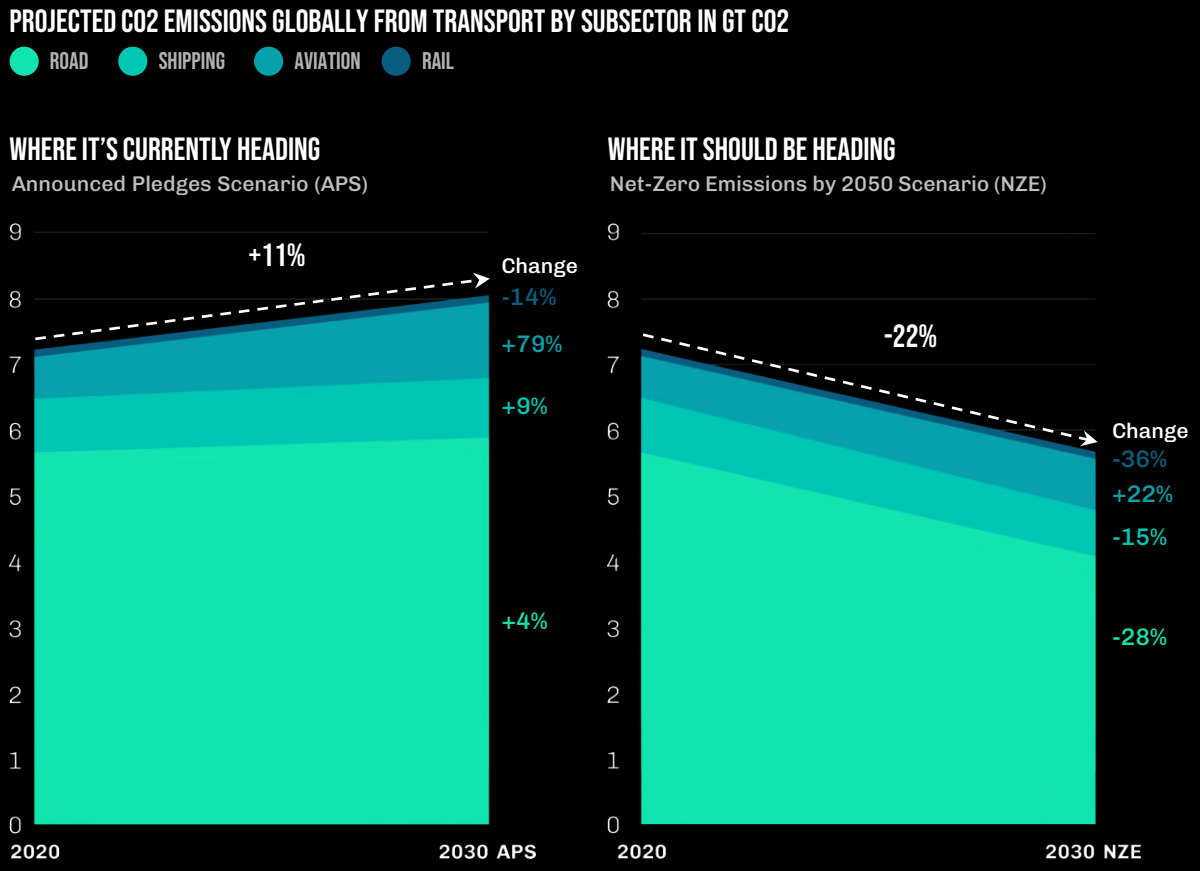


Source: International Energy Agency (IEA)

MOBILITY'S NET-ZERO FUTURE IS A FANTASY, UNLESS RADICAL INNOVATION IS UNLOCKED

Without aggressive innovation practices, alongside decisive action from governments around climate change initiatives, global transport-related greenhouse gas emissions are likely to grow by another 11% by the end of the decade. This takes into account all the announced climate commitments made by governments around the world thus far. Such a scenario is in stark contrast to the necessary reduction of more than 20% the world needs in order to have a realistic shot at reaching net-zero by 2050.

As these figures demonstrate, tackling transportation-related climate change is one of the most urgent priorities. If we are to have any hope of limiting global warming by 2° Celsius or less over pre-industrial levels by 2050—the target established by the Paris Agreement back in 2016–radical innovation is required from industry leaders and governments.



Source: UP.Partners analysis based on data from the International Energy Agency (IEA)

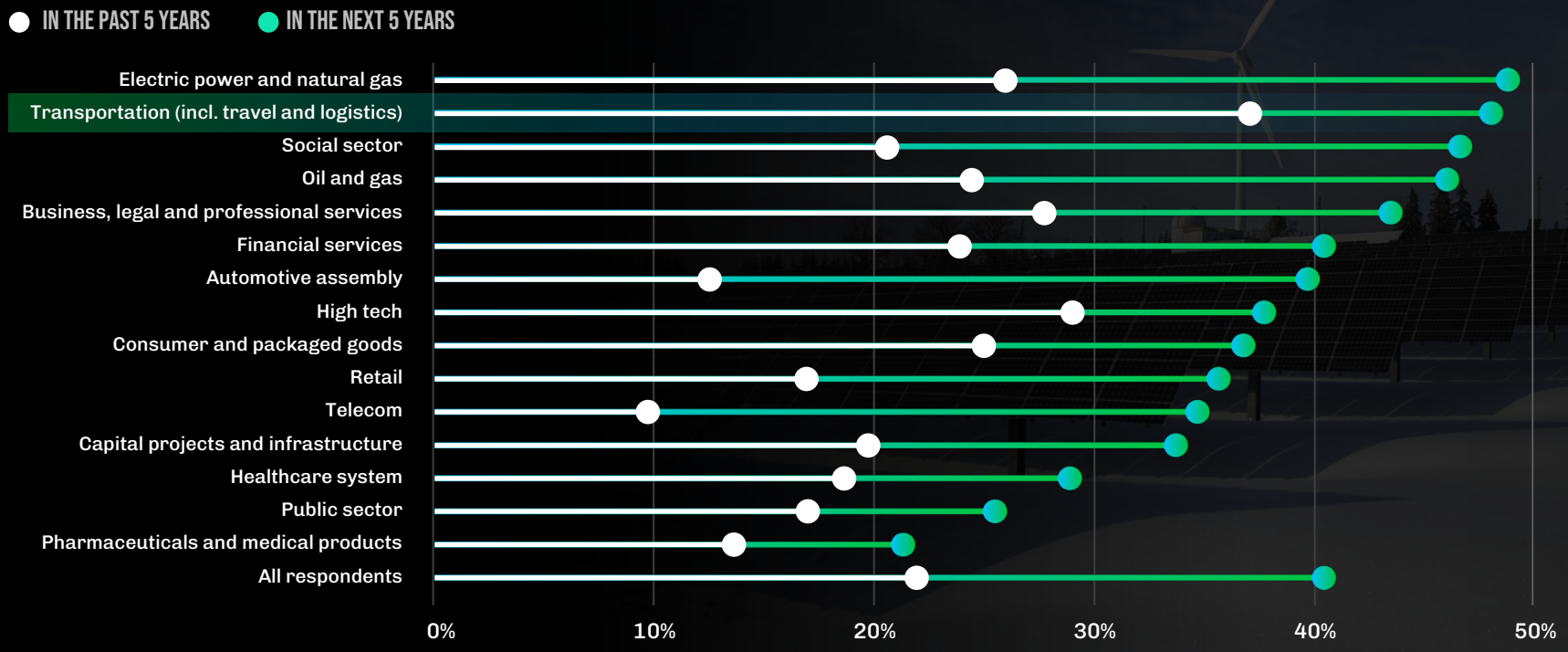
FORTUNATELY, INVESTORS HAVE BECOME EXCITED ABOUT SUSTAINABILITY

What sector/theme would you consider as the most promising for Venture Capital investments in Europe in the near future?

Source: State of European Tech 2021

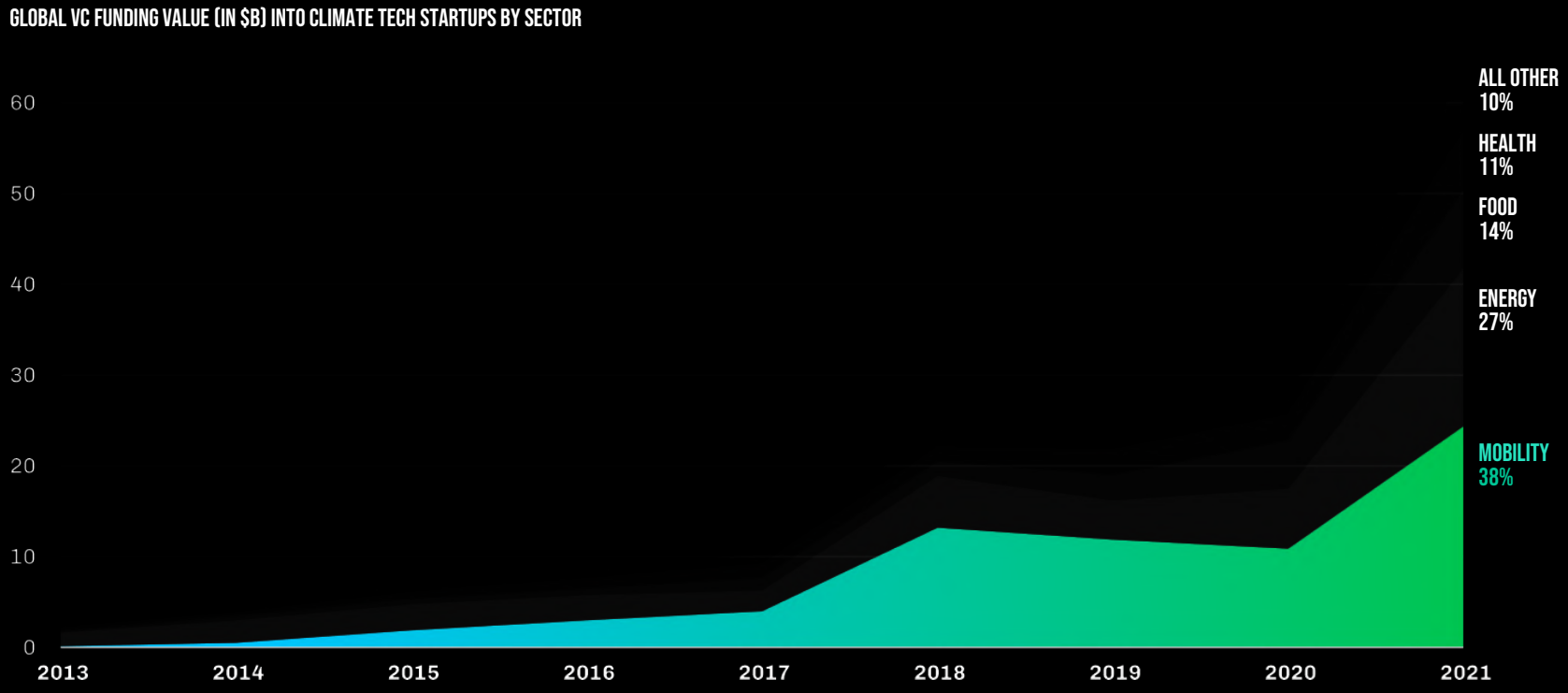
SUSTAINABILITY IS EXPECTED TO UNLOCK MASSIVE COMMERCIAL IMPACT FOR MOBILITY

Share of respondents expecting at least modest value created from sustainability programs by industry



Source: McKinsey

NO WONDER SUSTAINABLE MOBILITY HAS BECOME THE MOST IMPORTANT CLIMATE SEGMENT



Source: UP.Partners analysis based on data from Dealroom

1.2 NEW STARTUP OPPORTUNITIES IN A TURBULENT MACRO ENVIRONMENT

MOBILITY FUNDING HAS OUTPACED MOST TECH SECTORS

Over the past decade, there has been an explosion of innovation in mobility. This progress has been propelled by more than $375 billion USD in Venture Capital funding for mobility startups since 2013—see next page.

The sum of money is remarkable, but so is the growth of funding. Mobility has been one of the fastest growing tech segments across the Venture Capital landscape over the past decade—a strong indicator of the accelerating innovation dynamics driven forward by startups shaping the future of the moving world.

The sector had its initial inflection point back in 2014 when shared mobility, mostly in the form of ride-hailing, started gaining greater traction, especially in the U.S. From 2016 on, mobility funding grew more holistically across a wider range of categories including micromobility, autonomous and electric vehicles, Advanced Air Mobility and last-mile cargo delivery. These forces created a vibrant ecosystem of thousand of startups shaping the future of the moving world.

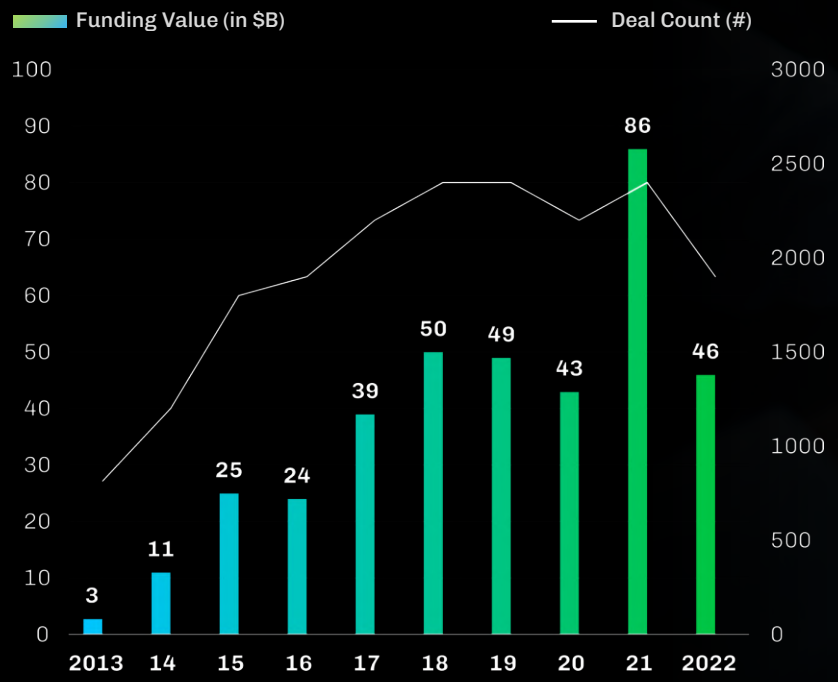
GROWTH IN TOTAL VENTURE CAPITAL FUNDING VALUE

Funding value in 2013 indexed to 1x

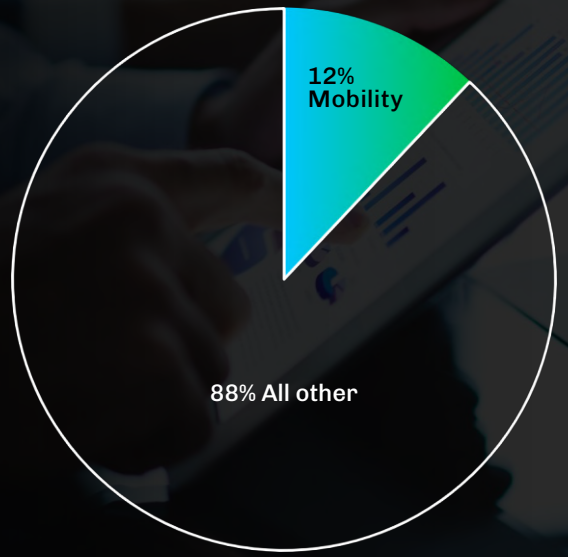
Source: UP.Partners analysis based on data from Dealroom

LARGE SUMS OF SMART MONEY HAVE FLOWED INTO MOBILITY TECH

VENTURE CAPITAL ACTIVITY IN MOBILITY STARTUPS



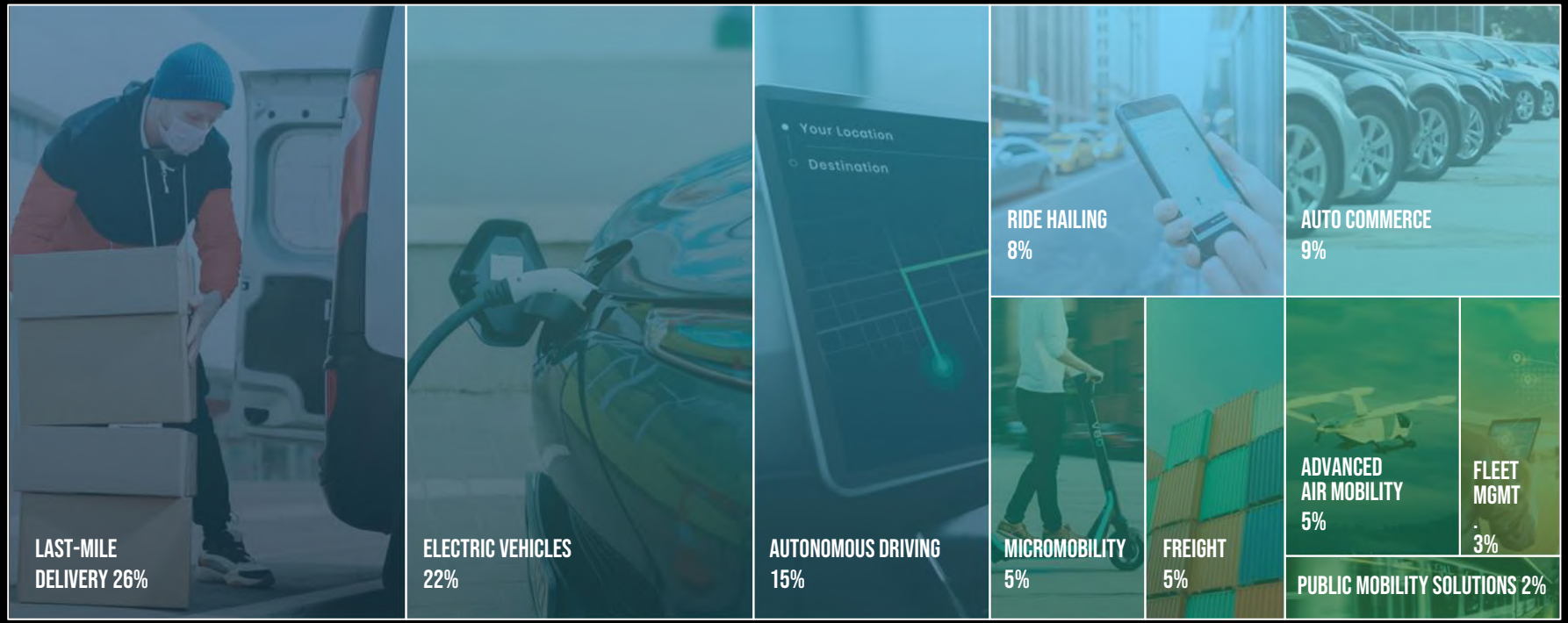
SHARE OF VENTURE CAPITAL FUNDING VALUE BY INDUSTRY OVER THE LAST 10 YEARS



Source: UP.Partners analysis based on data from Dealroom

INVESTORS ARE EYEING A WIDE RANGE OF MOBILITY THEMES

Share of Venture Capital funding value in Mobility startups by major sub-categories since 2020



Source: UP.Partners analysis based on data from PitchBook Data Inc.

BUT THE 2022 MARKET CORRECTION CAUSED TECH FIRMS TO SUFFER, INCL. THOSE IN MOBILITY

The past year has been characterized by a paradigm shift in the macroeconomic environment. The decade leading up to 2022 was marked by low interest rates and cheap money supply, which helped fuel an unprecedented surge in growth stocks, such as technology companies. However, rising inflation and the reaction of central banks in raising interest rates have resulted in a stock market crash, marking the end of the decade-long tech rally. As a result of these forces, mobility technology firms were affected by this market correction too.

In fact, the Mobility Tech vertical experienced a particularly strong adjustment in overall sector value due to its high exposure to SPAC companies. For instance, more than half of the ten most prominent air-taxi startups announced SPAC mergers in 2020 and 2021. This speculative bubble ultimately burst and drew down company valuations despite no change in underlying business fundamentals. Whether or not the downward pressure on tech stocks will ease in the coming year remains to be seen. Investors will likely remain cautious for a while.

2022 YEAR-TO-DATE STOCK PRICE PERFORMANCE*

Indexed to 100 on Jan, 3rd 2022

Source: UP.Partners analysis based on data from Lufthansa Innovation Hub's TNMT.com, PitchBook Data Inc.
*Data as of Dec 1, 2022

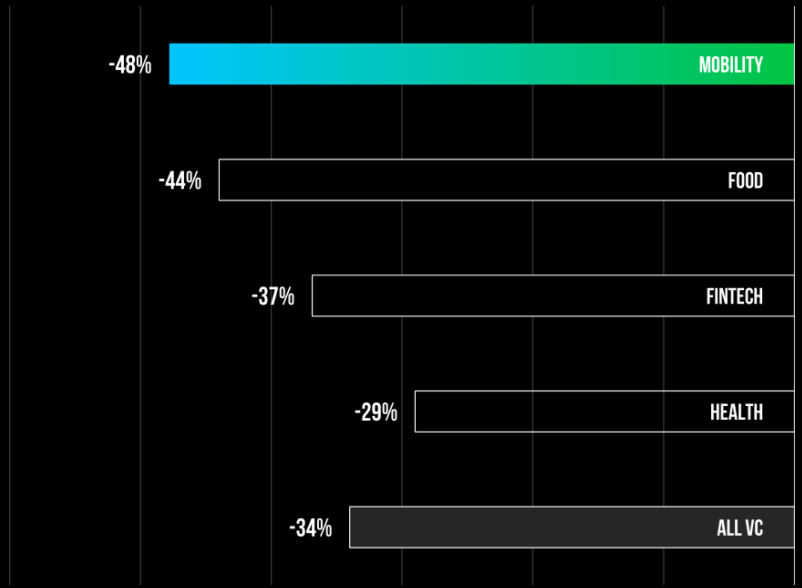
ALSO, PRIVATE MARKETS HAVE COOLED DOWN ACROSS INDUSTRY VERTICALS

MOBILITY

Quarterly VC funding value (in $B) in Mobility startups

ALL MAJOR VERTICALS

Change in total VC funding value in 2022 vs. 2021



Source: UP.Partners analysis based on data from Dealroom

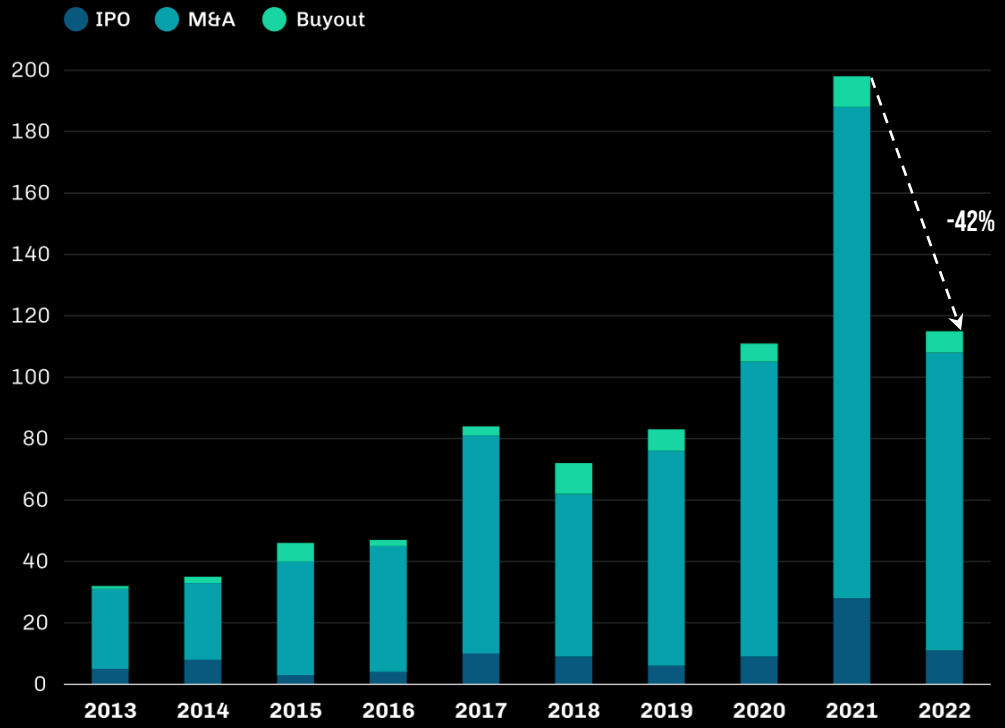
AS A RESULT, THE NUMBER OF EXIT OPPORTUNITIES HAS RETURNED TO NORMAL

The private financing market tends to lag public stocks, giving startup founders and VC investors time to adjust their expectations for potential exit prices. But the shift is now in full effect. Tech startups are arguably dealing with the hardest fundraising climate in more than a decade. Following a record year for venture financings and IPOs in 2021, tech financing cooled down significantly, particularly for late-stage companies. The slowdown of the IPO market, for instance, has resulted in a virtual freeze in pre-IPO rounds.

Interestingly, overall exit opportunities for mobility startups have stayed relatively strong. In fact, the decline in 2022 looks more like a natural correction to healthy grounds in line with pre-2021 levels. Looking ahead, the share of acquisitions could go up as publicly traded companies, PE firms or even other well-funded startups hunt for attractive late-stage acquisition targets at reasonable prices.

VENTURE CAPITAL EXIT ACTIVITY OF MOBILITY STARTUPS

In number of events

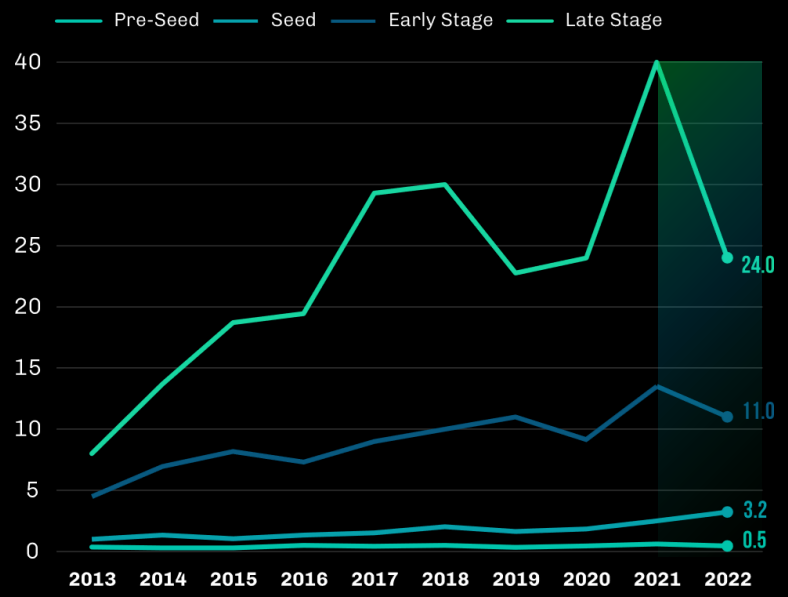


Source: UP.Partners analysis based on data from PitchBook Data Inc.

BUT OTHER THAN LATE-STAGE DEALS, MOBILITY STARTUPS REMAIN HIGHLY ATTRACTIVE

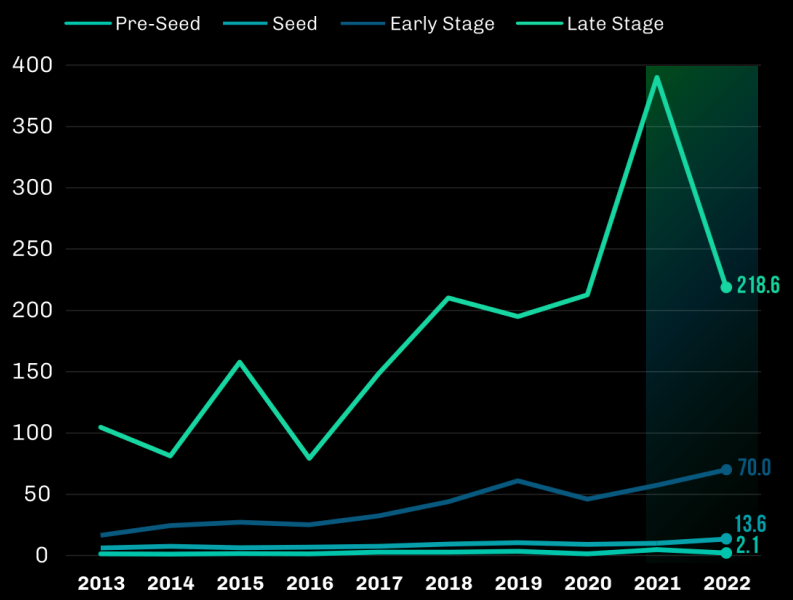
DEAL SIZE

Median VC deal size (in $M) of Mobility startups



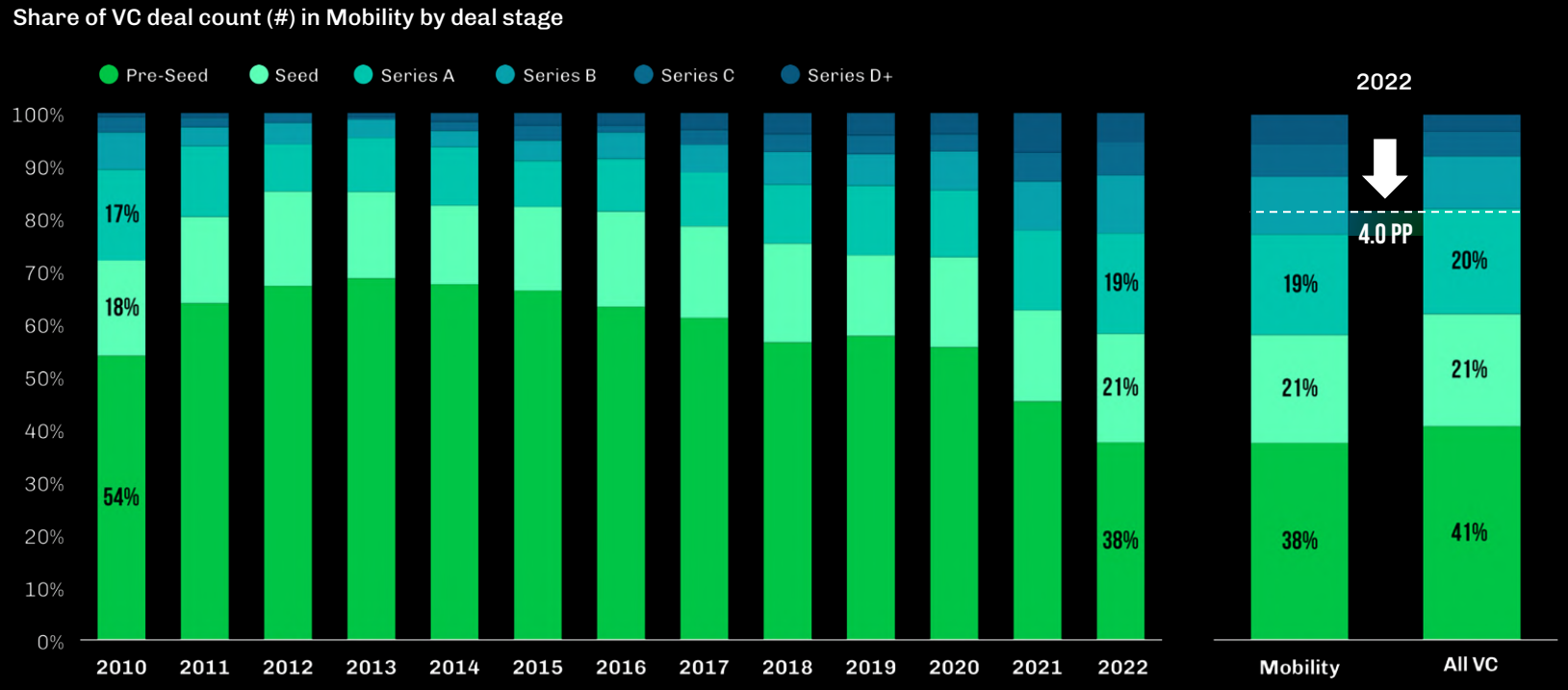
DEAL VALUATION

Median post deal valuation (in $M) of Mobility startups



Source: UP.Partners analysis based on data from PitchBook Data Inc.

EARLY-STAGE VC HAS BEEN THE BACKBONE OF MOBILITY—THIS NEEDS TO REMAIN THE CASE

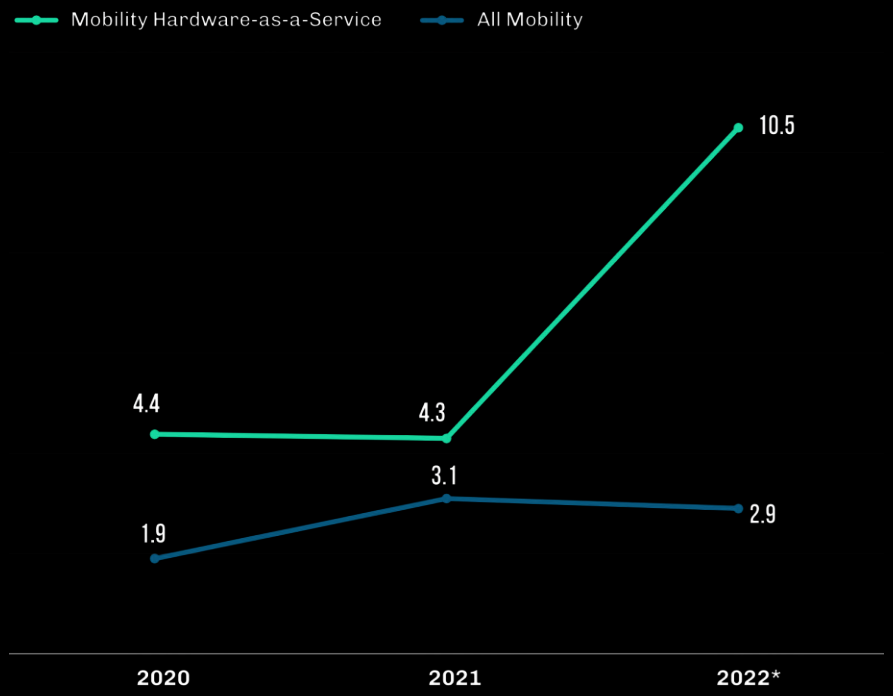


Source: UP.Partners analysis based on data from Dealroom

THERE IS ONE SPECIFIC EARLY-STAGE MOBILITY THEME THAT HAS GAINED MASSIVE TRACTION

Despite the more hostile macro environment, early-stage startup companies in mobility have remained resilient as the previous pages have illustrated. In terms of the type of early-stage mobility firms that look the most promising, startup companies with a so-called "hardware-as-a-service" (HaaS) model appear to be the hidden winners of the past year. HaaS mobility firms—those providing hardware, software, maintenance, and other services in one package for a monthly (recurring) fee—have seen their average first-time VC deal tickets jump to $10.5 million USD in 2022. This is almost four times higher than conventional mobility companies. Where is this price premium coming from? Hardware is a fundamental part of climate investing, therefore, experiencing a comeback in investor interest. HaaS models, in particular, help companies transform the significant upfront capital expenditure into a recurring payment, which is more easily accommodated as an operating expense. For the HaaS company itself, this provides more predictable revenue and more sticky customer relationships—two important elements investors appreciate in the face of a looming recession.

MEDIAN DEAL SIZE (IN $M) FOR U.S. STARTUPS IN FIRST VC ROUND

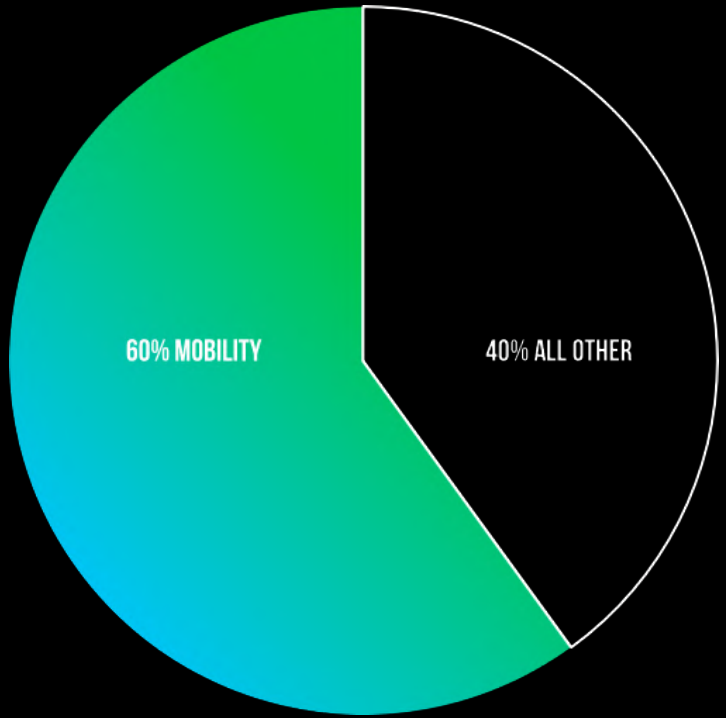


Source: UP.Partners analysis based on data from Silicon Valley Bank and PitchBook Data Inc.
*Data as of October 1st, 2022

THE ACCELERATING TREND OF HARDWARE-AS-A-SERVICE IS DOMINATED BY MOBILITY FIRMS

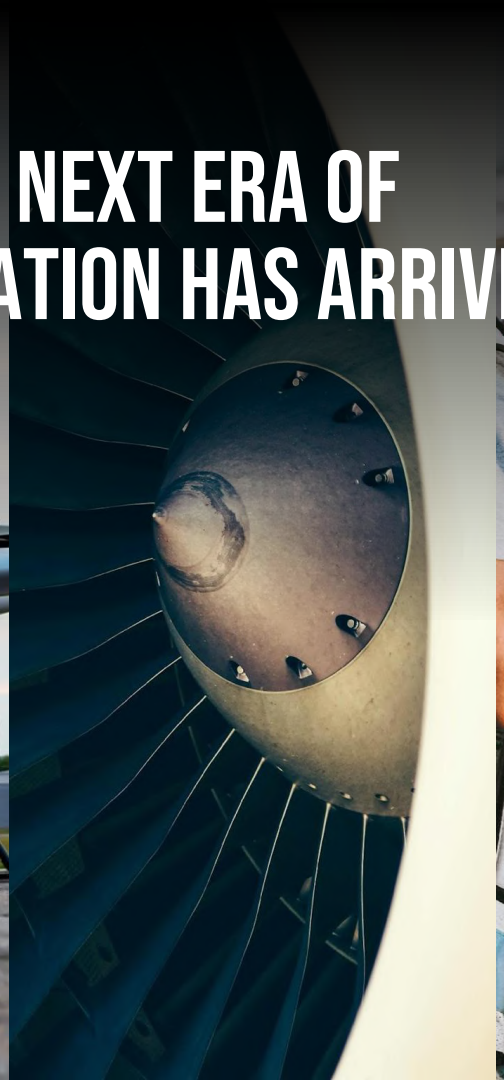
The HaaS movement in 2022 has been significantly bolstered by a number of innovative startups from the mobility sphere. This is evidenced by findings from Silicon Valley Bank's premier industry database, which revealed that 60% of funding dollars for the space were funneled towards mobility startups last year—ranging everywhere from construction robots mapping out job sites, security bots roaming office buildings and autonomous drones gathering data from the open ocean. These companies are leveraging their physical assets to generate expensive datasets with an eye on providing value-added services through greater depth and breadth of insights, thereby increasing customer lifetime value whilst driving profits higher too. In summary, the transportation sector is blazing the trail and establishing a new business model to prove that mobility will be playing an important role as we move into the future of commerce. Undoubtedly, this disruption marks just one step in what promises to be an ongoing transformation for moving businesses around the world.

SHARE OF U.S. VC FUNDING VALUE IN HAAS COMPANIES BY INDUSTRY IN 2022*



Source: UP.Partners analysis based on data from Silicon Valley Bank's "The State of HaaS"
*Data as of October 1st, 2022

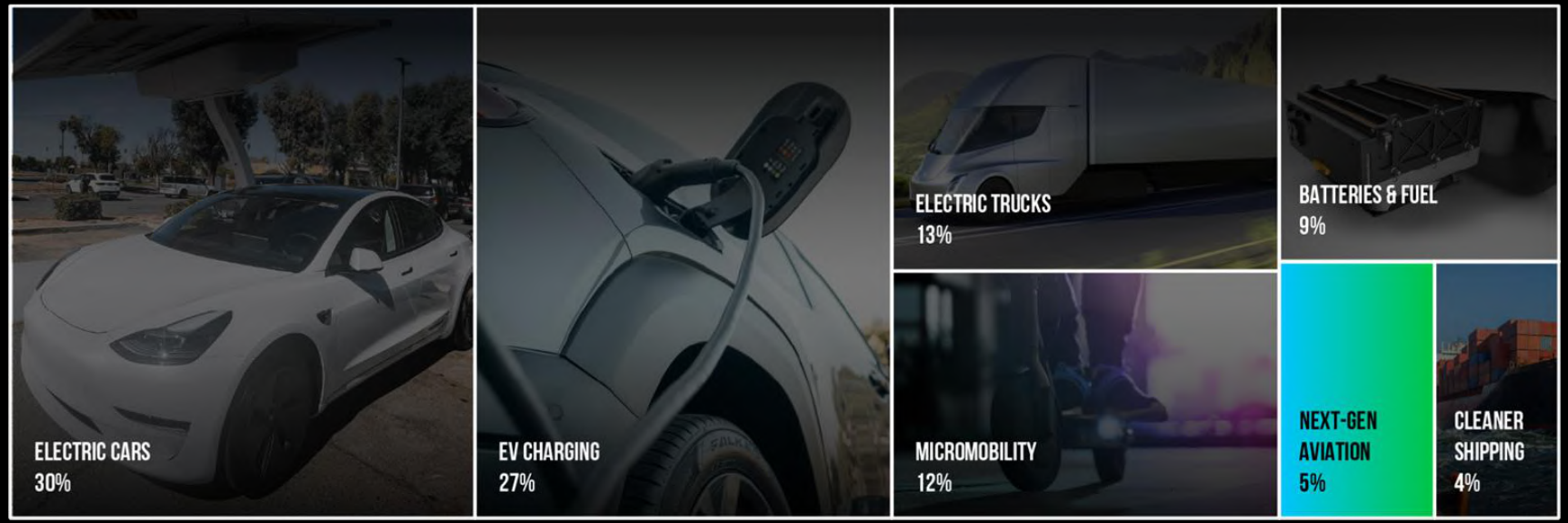
1.3 THE NEXT ERA OF AVIATION HAS ARRIVED



COMPARED WITH GROUND TRANSPORT, AVIATION REMAINS A NICHE FOR CLIMATE INVESTORS

Share of VC funding value in Sustainable Mobility startups by major sub-categories in 2022

On the Ground: 82%



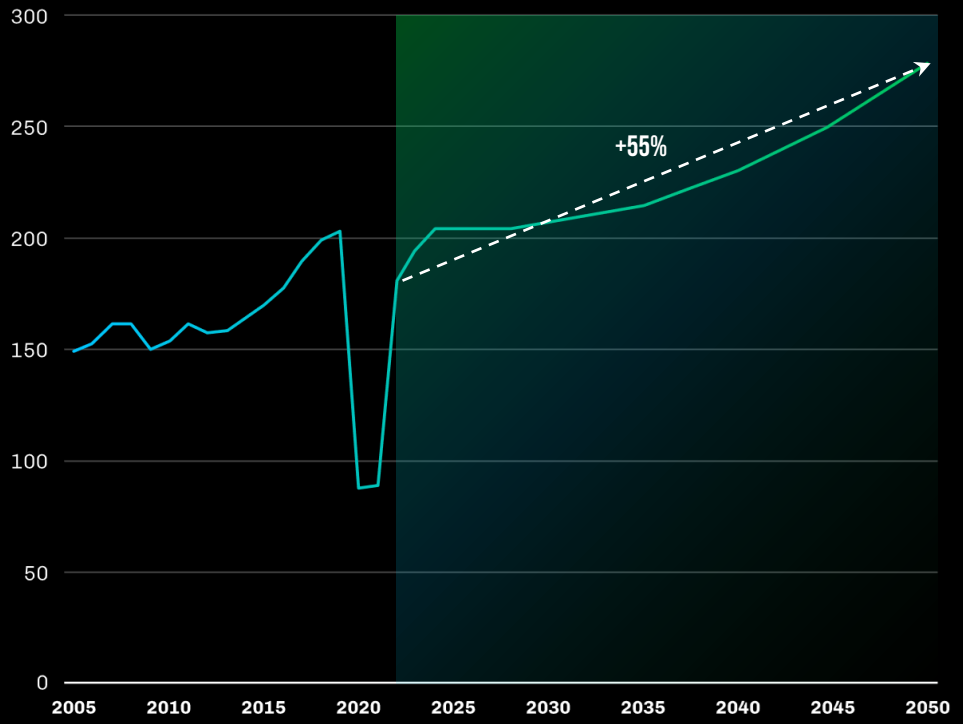
Source: UP.Partners analysis based on data from Dealroom

AVIATION, IN PARTICULAR, IS FACING AN UNCERTAIN PATH TOWARDS DECARBONIZATION

The pursuit of greener transportation is particularly challenging for the aviation industry. The conventional jet engine will only be able to offer small incremental fuel efficiency gains in the future, which will not move the needle. Therefore, in the face of climate change, we have little choice but to pursue dramatic reinvention in the form of alternative propulsion technologies and truly sustainable biofuels. Without them, current forecasts indicate that the aviation industry's CO2 footprint will grow by another 55% through 2050. This is a catastrophic outlook that would further raise pressure from regulators, customers, and investors, turning flying into an even more controversial topic in climate debates than it already is today.

CO2 EMISSIONS FROM AVIATION IN EUROPE IN MILLION METRIC TONS

Forecast based on medium passenger growth scenario with current available technologies only



Source: Eurocontrol data as reported by Bloomberg

EVEN AIRLINE INVESTORS ARE GETTING NERVOUS

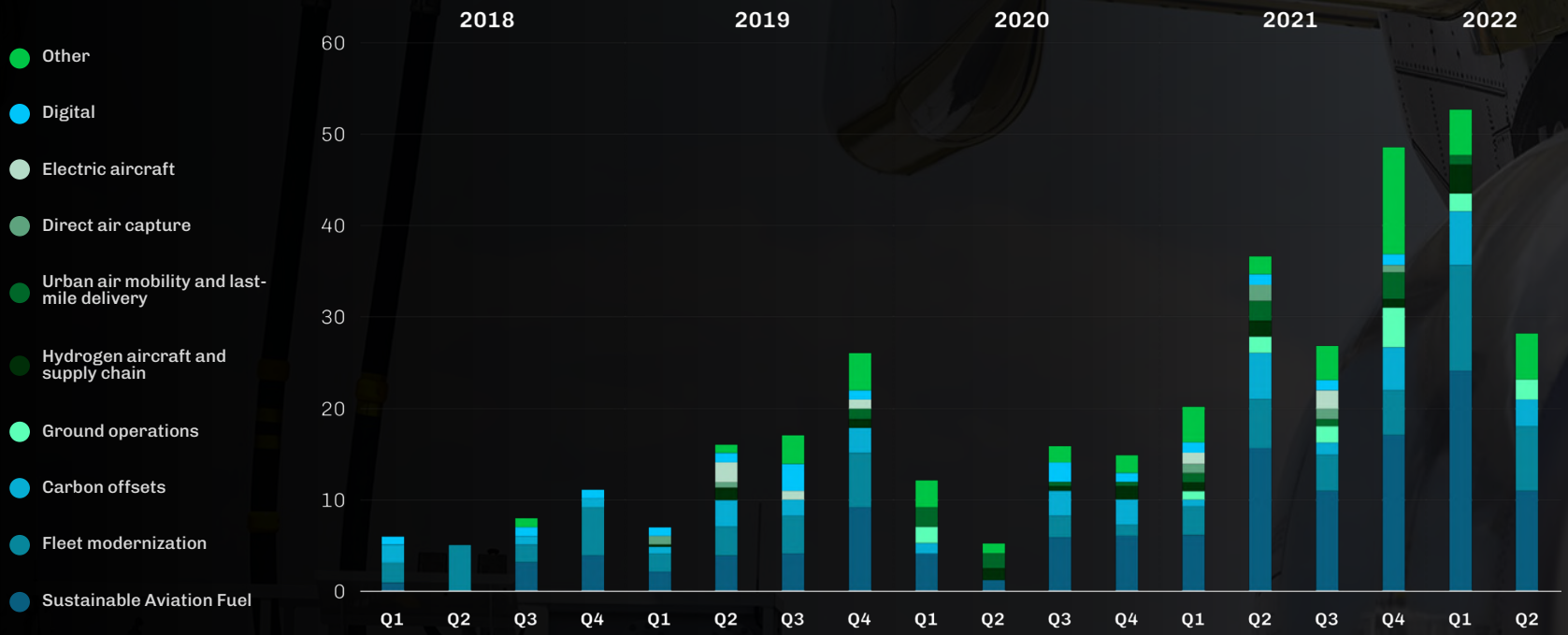
FREQUENCY OF CLIMATE ISSUES DISCUSSED IN AIRLINE EARNINGS CALLS

In number of sentences per earnings call

Source: HSBC

WHILE AIRLINES ARE MOSTLY REACTING BY SWITCHING TO CLEANER JET FUELS...

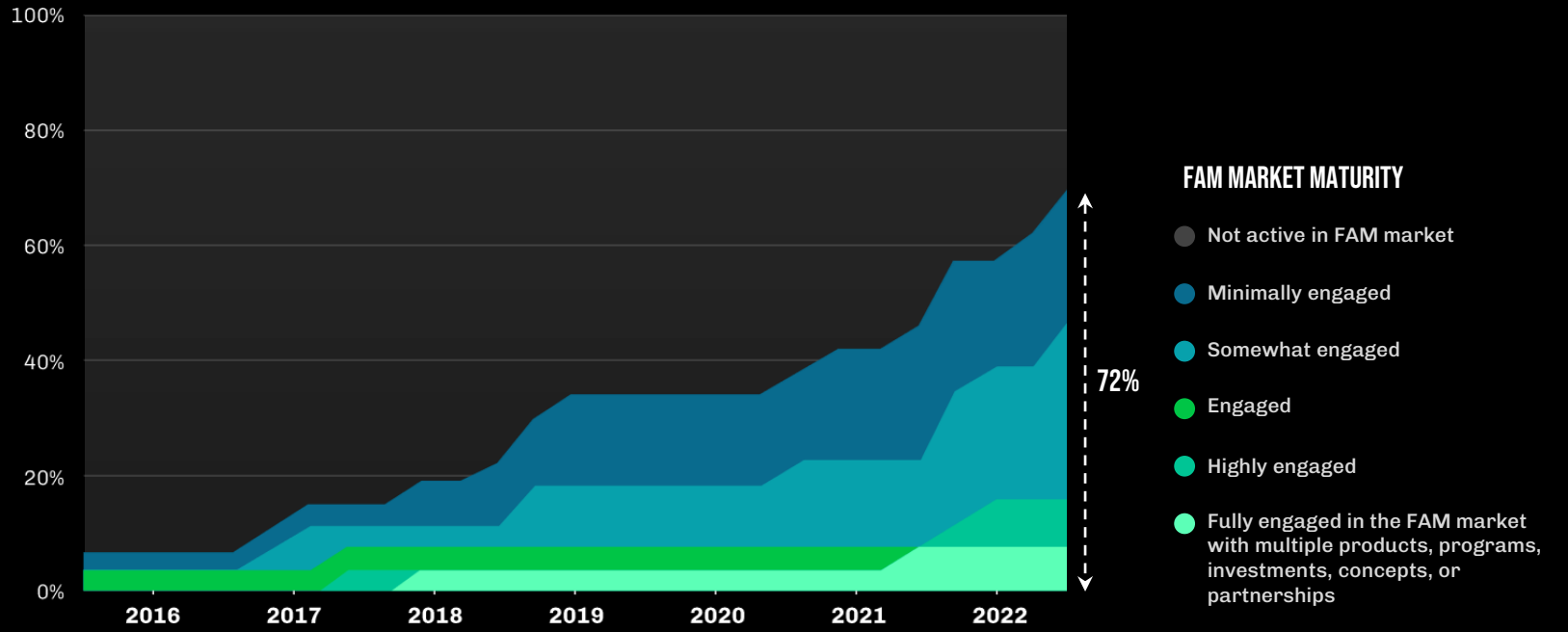
Number of initiatives by major airlines



Source: BloombergNEF

...THE MAJORITY OF AIRCRAFT OEMS HAVE REALIZED THE NEED TO RADICALLY TRANSFORM

Share of top 25 aerospace OEMs active in the Future Air Mobility (FAM) segment*

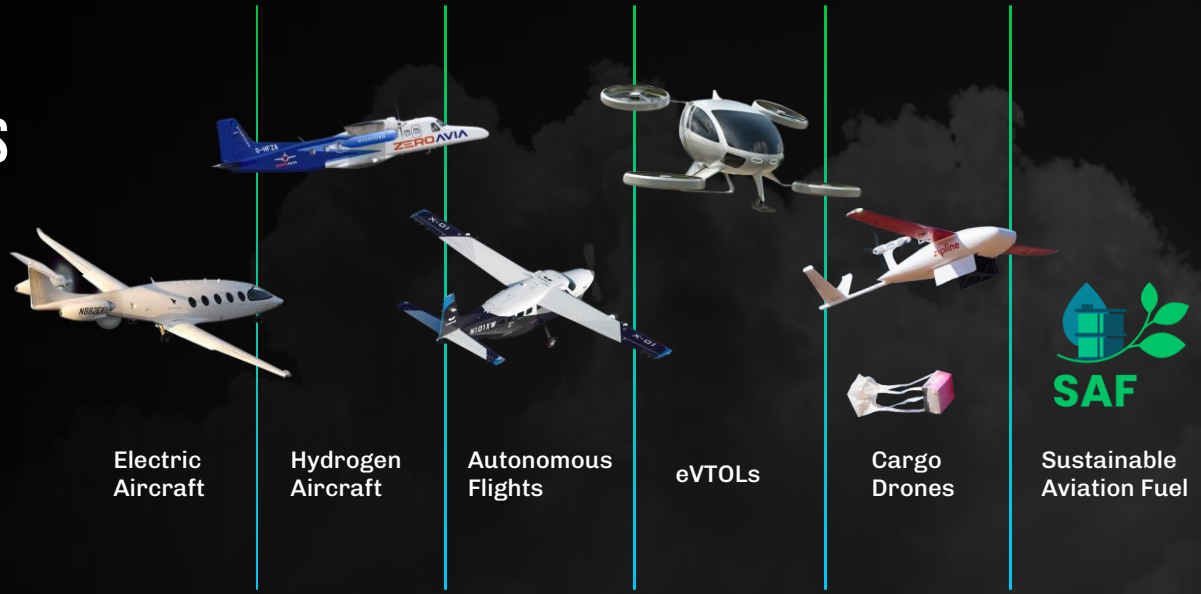


Source: McKinsey
*FAM includes VTOL, battery electric and hybrid-electric aircraft, hydrogen propulsion as well as autonomous systems

AVIATION IS EXPERIENCING MULTIPLE TECH DISRUPTIONS AT VARIOUS MATURITY STAGES

While the wider aviation industry is eagerly attempting to innovate its way out of fossil-fuel dependence, it's not clear yet which technologies will provide the best path forward, or when airlines will be ready to embrace them. Hydrogen-powered commercial aircraft, for example, likely won't be ready for decades, given that engineering hurdles and regulatory scrutiny loom as potential roadblocks. But the progress made across other major new technologies shaping the next era of aviation is very promising. Let's look at the current state of each technology one by one.

SIX MAJOR TECHNOLOGICAL TRENDS IN AVIATION

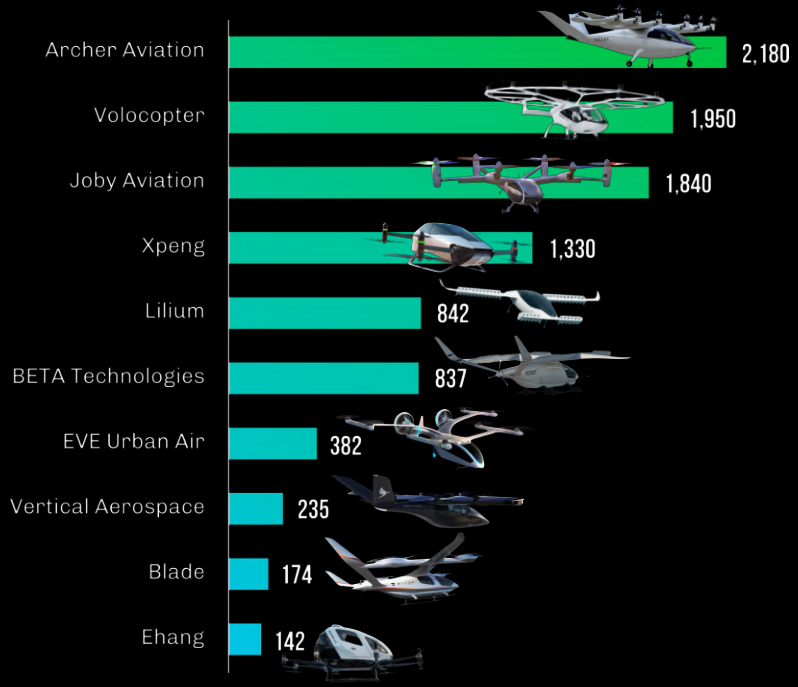


Source: UP.Partners analysis

EVTOLS, FOR EXAMPLE, HAVE ATTRACTED LOTS OF COMMERCIAL INTEREST

THE TEN MOST-FUNDED EVTOL COMPANIES

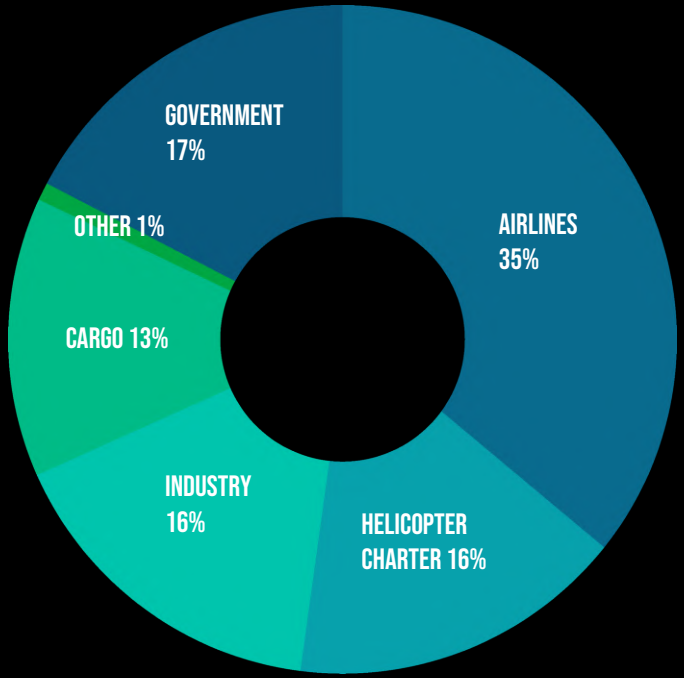
Total funding raised in million USD



Source: UP.Partners analysis based on data from PitchBook Data Inc. and press

SHARE OF ADVANCED AIR MOBILITY AIRCRAFT ORDERS BY TYPE OF CUSTOMER

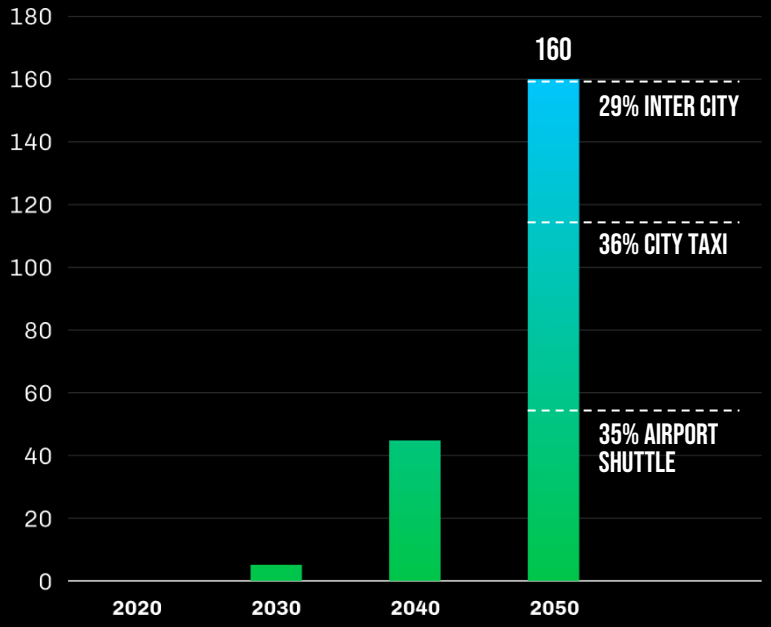
As of mid-2022



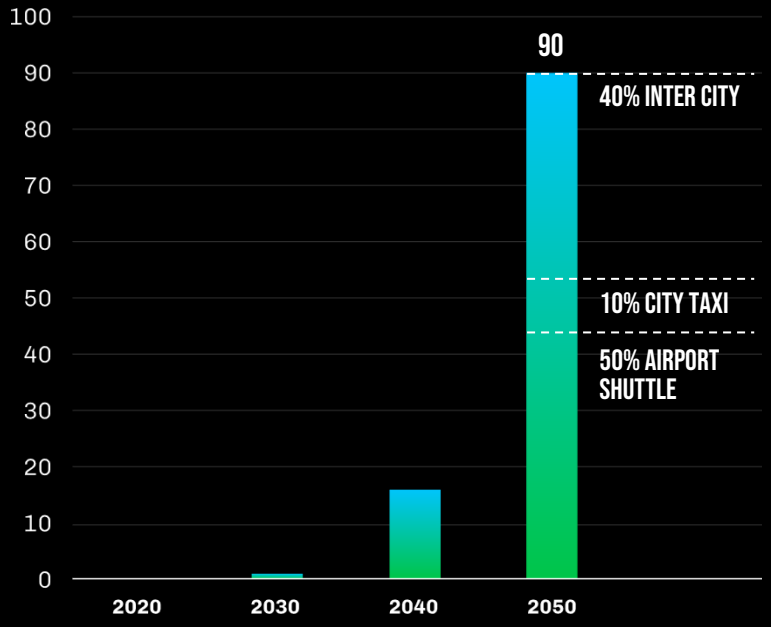
Source: Roland Berger

WHILE FUTURE AIR-TAXI APPLICATIONS ARE HIGHLY SPECULATIVE, THEY SEEM PROMISING

FORECAST OF THE NUMBER OF EXPECTED PASSENGER EVTOLS IN OPERATION
In thousand



FORECAST OF EXPECTED REVENUES FROM PASSENGER EVTOL OPERATIONS
In billion USD



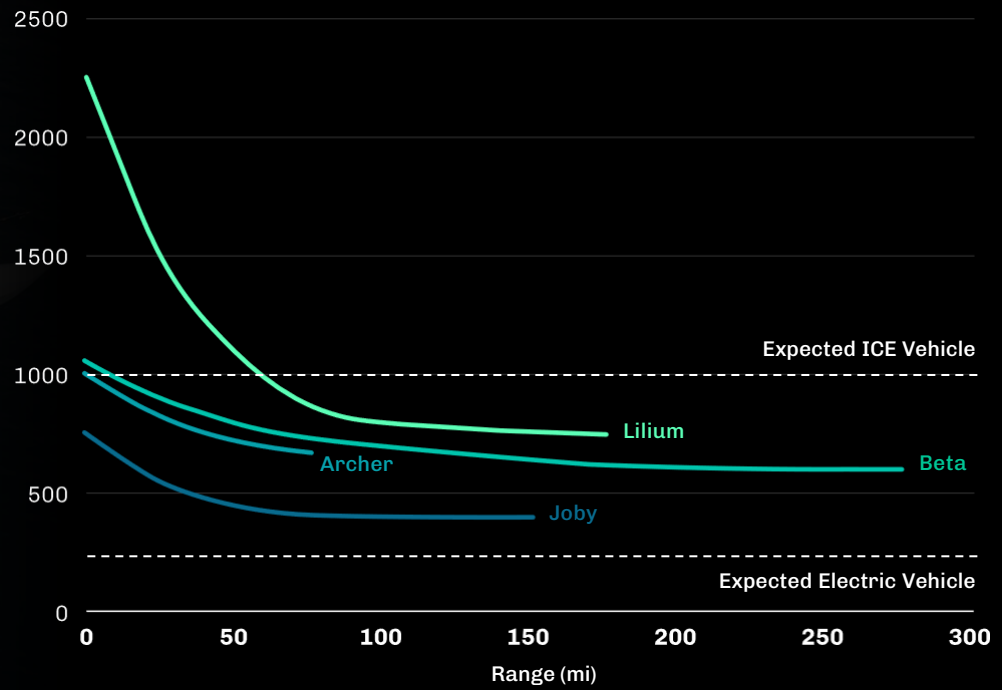
Source: Roland Berger

EVTOLS ARE EVEN EXPECTED TO BEAT CONVENTIONAL CARS IN TERMS OF ENERGY EFFICIENCY

The potential of electric vertical take-off and landing vehicles to reduce transportation emissions has recently been bolstered by a Carnegie Mellon University study, which compared a handful of the most prominent eVTOL design concepts favorably with traditional cars. The research found that as the length of cruising range increases—meaning they can fly longer distances—eVTOLs become increasingly more energy efficient than their automobile counterparts. This is an encouraging development, given that it has been long questioned whether or not such aircraft could have any positive environmental impacts due to limited flying ranges and passenger carrying capacity. It now seems plausible that these futuristic machines may provide a much-needed reduction in carbon emission levels after all.

ENERGY CONSUMPTION OF SELECTED EVTOL AIRCRAFT (AT MEDIAN OCCUPANCY) VS. TERRESTRIAL VEHICLES

In Wh per passenger-mile



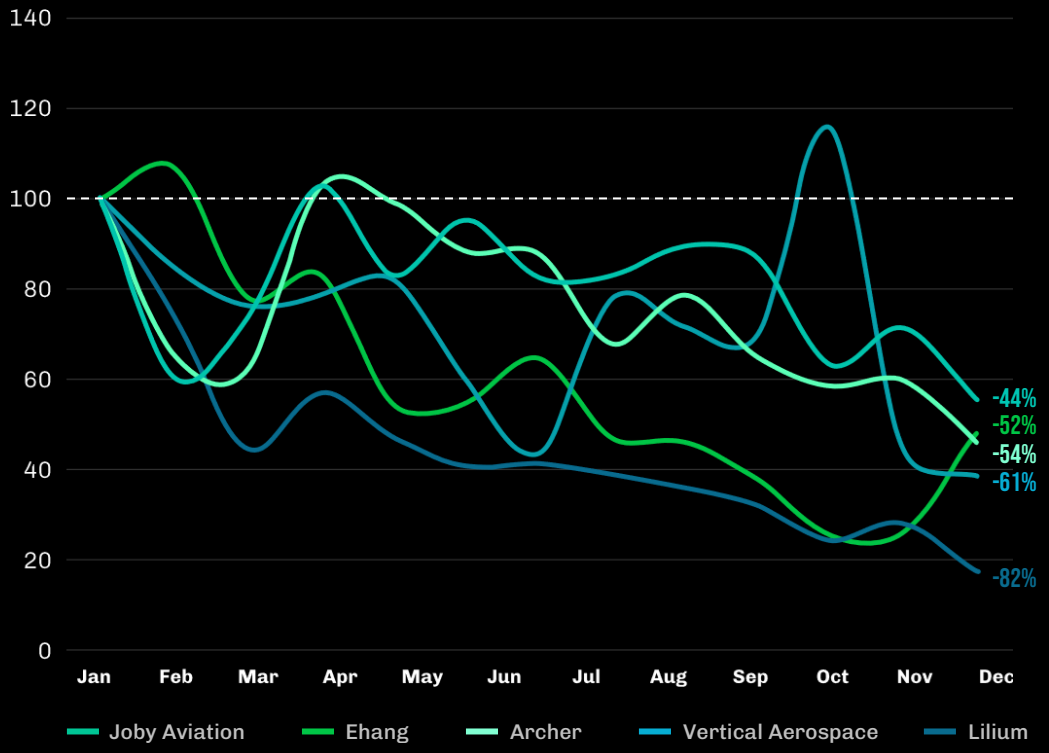
Source: UP.Partners illustration based on Shashank Sripad, Venkat Viswanathan, Carnegie Mellon University

UNTIL THEN, EVTOL FIRMS WILL HAVE TO WEATHER A TOUGHER INVESTOR CLIMATE

Despite positive momentum in terms of prototype development and a rising number of test flights, it's not all rosy for aspiring air-taxi contenders. Besides the engineering complexity that comes with creating commercially viable air-taxi services, today's leading eVTOL companies are faced with waning investor confidence. Massive capital injections play a vital role in advancing research and development to reach certification and market launch. Thus, favorable sentiment from capital markets is key for these firms' survival and success. 2022, however, brought with it a souring macro environment that has caused the valuations of public companies (especially those that went public through special purpose acquisition companies in 2021) to drop significantly. It remains uncertain if they can survive this recessionary period, which could extend beyond expectation.

STOCK PRICE PERFORMANCE OF MAJOR EVTOL COMPANIES IN 2022

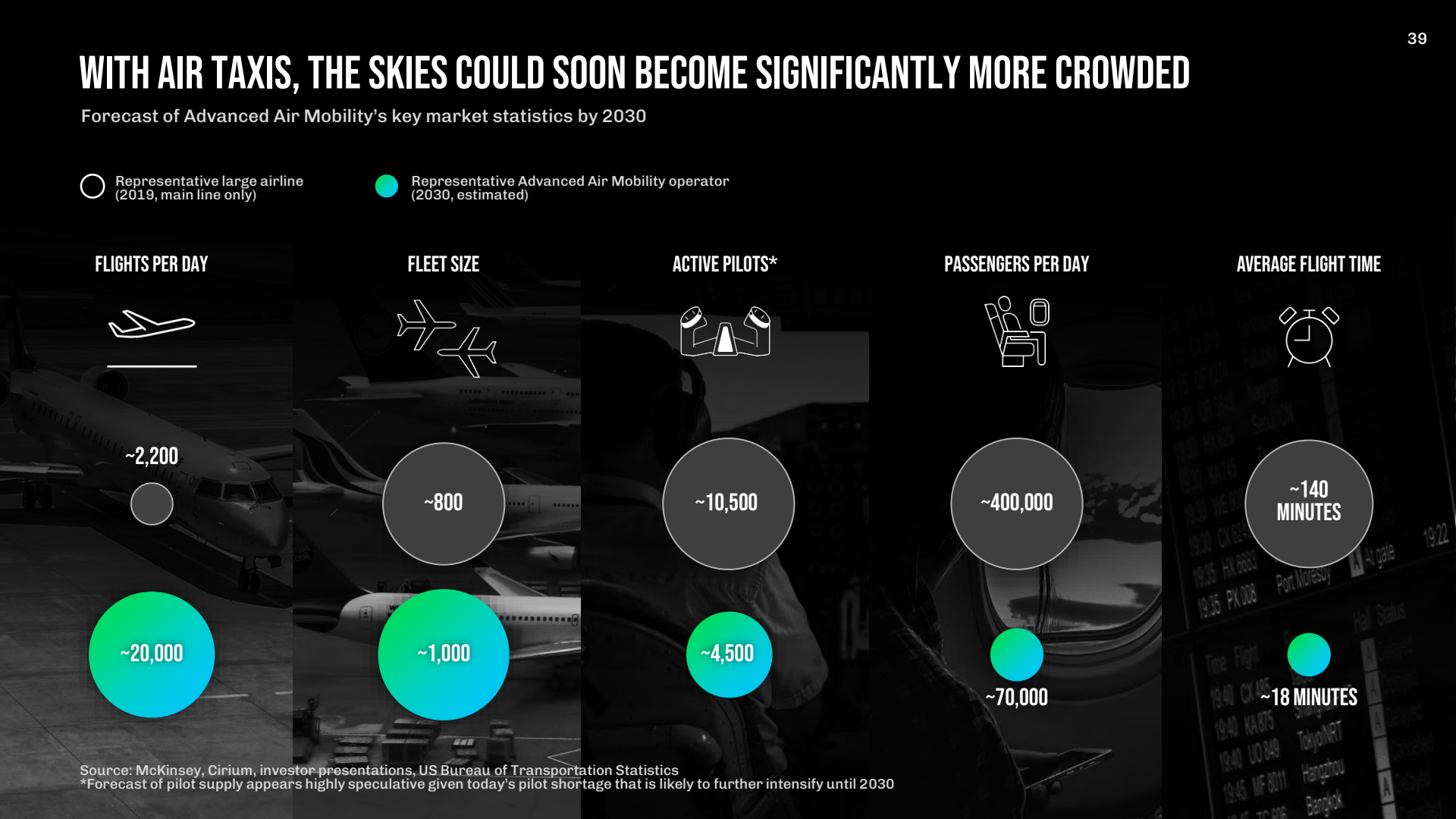
Indexed to 100 on Jan 7, 2022, monthly data



Source: UP.Partners analysis based on data from Google Finance

WITH AIR TAXIS, THE SKIES COULD SOON BECOME SIGNIFICANTLY MORE CROWDED

Forecast of Advanced Air Mobility's key market statistics by 2030



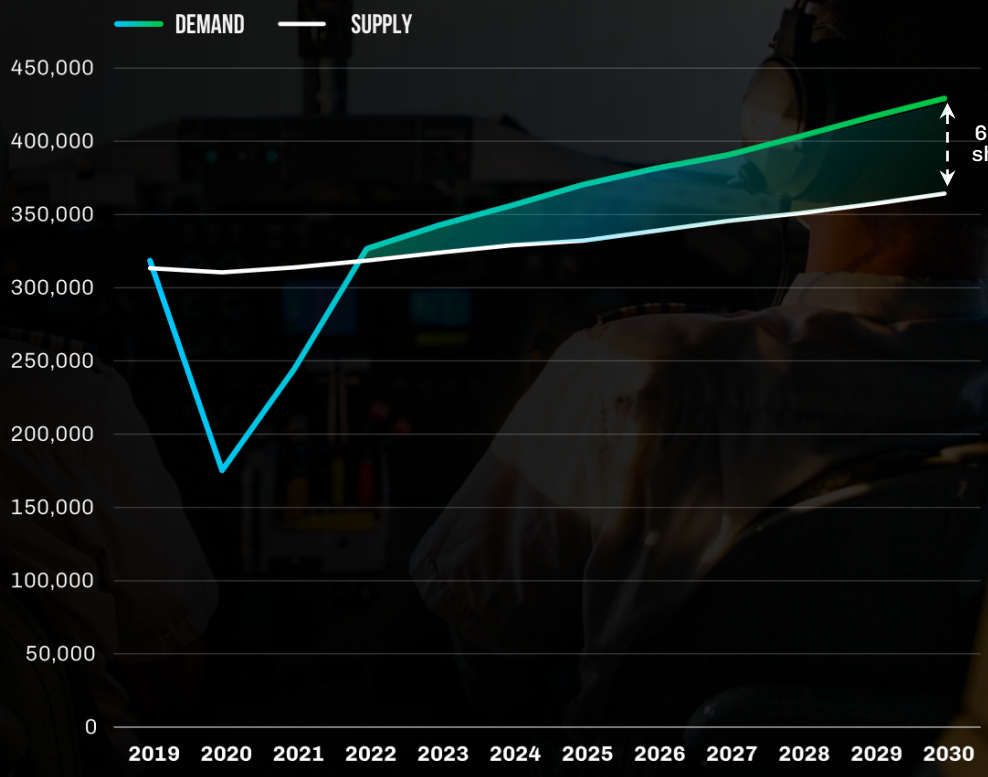
Source: McKinsey, Cirium, investor presentations, US Bureau of Transportation Statistics
*Forecast of pilot supply appears highly speculative given today's pilot shortage that is likely to further intensify until 2030

THE PILOT SHORTAGE WILL FURTHER PUSH AUTONOMOUS TECHNOLOGY ADVANCEMENTS

Autonomous flight technology has been gaining momentum due to its immense potential for improving safety and efficiency; the latter ultimately leading to cost reductions. The shortage of pilots across the commercial airline industry is another key factor driving resources toward the development of more advanced autonomous technology. Research from Oliver Wyman estimates that the airline industry already lacks 18,000 pilots in 2023, a delta that will expand to 65,000 by 2030. This shortfall can be attributed to myriad complexities, such as an aging population with an increasing number of baby boomers reaching the mandatory retirement age for commercial airline pilots as well as a shrinking pool of potential candidates. Furthermore, there has been a raft of pilots deciding to take early retirement during the COVID-19 pandemic, which accelerated the impact of the shortfall.

GLOBAL PILOT DEMAND VERSUS SUPPLY

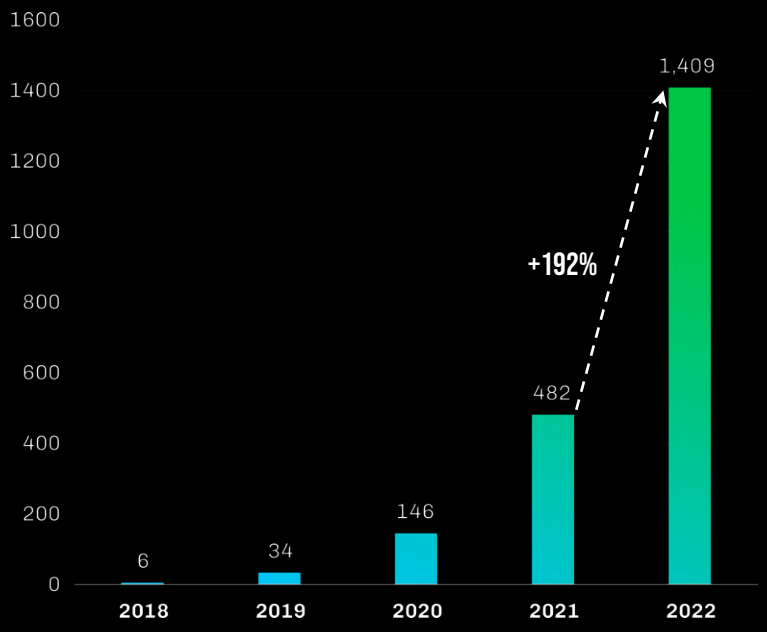
In number of pilots



Source: Oliver Wyman

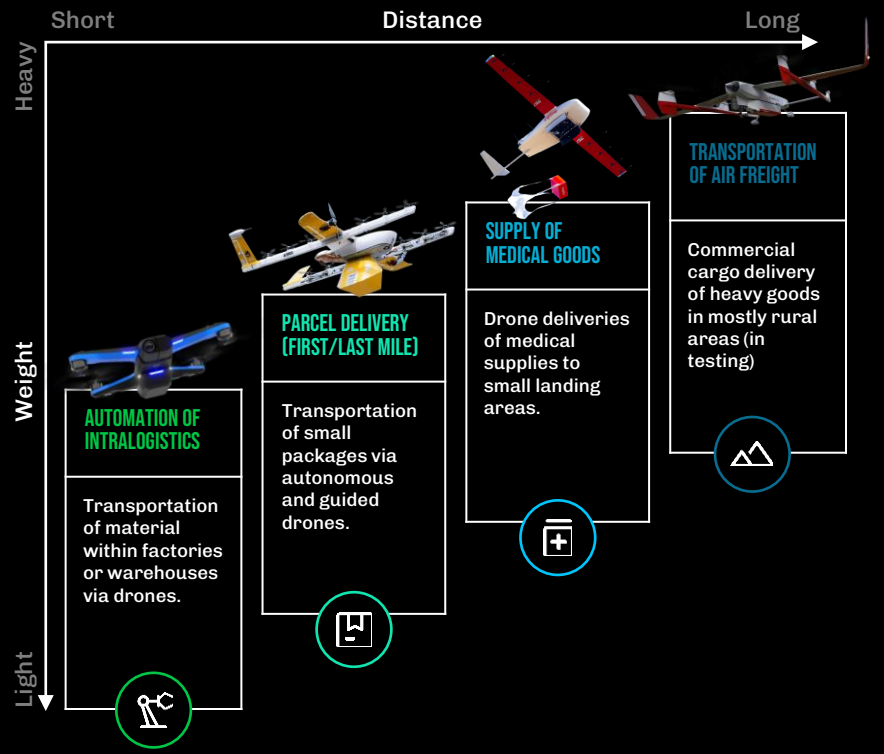
IN THE MEANTIME, THE BUSINESS OF UNMANNED CARGO DRONES IS ALREADY REAL AND BOOMING

NUMBER OF COMMERCIAL DRONE DELIVERIES (IN THOUSAND)



Source: McKinsey

MAJOR USE CASES FOR CARGO DRONES

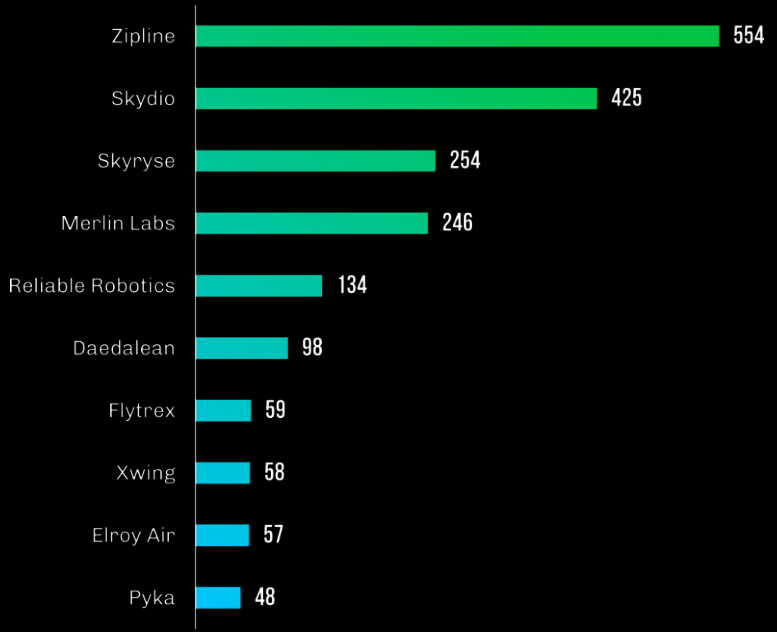


Source: Roland Berger

CARGO DRONES (AND PASSENGER AIRCRAFT) WILL EVENTUALLY FLY FULLY AUTONOMOUSLY

THE TEN MOST-FUNDED AUTONOMOUS FLIGHT STARTUPS*

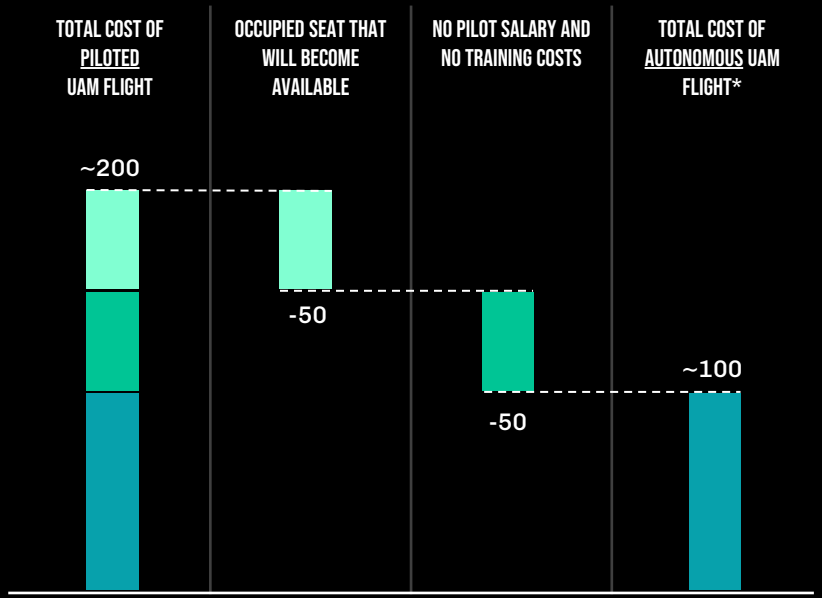
Total funding raised in million USD



Source: UP.Partners analysis based on data from PitchBook Data Inc.
*Excluding startups with military focus

ESTIMATED COSTS FOR AUTONOMOUS URBAN AIR MOBILITY (UAM)

Cost per passenger-seat-kilometer, in constant 2019 US dollars



Source: UP.Partners simplified chart based on McKinsey analysis
*Total cost likely to be even lower due to higher utilization rate of unmanned aircraft

ELECTRIC AVIATION IS STILL MANY YEARS AWAY BUT THE MARKET IS FORMING TODAY

Selected activities/events in the electric aviation space in 2022 (not all-encompassing)

JAN — AirAsia orders Vertical Aerospace's electric aircraft from Avolon.

FEB — Heart Aerospace runs successful first subscale test flight for electric aircraft.

MAR — Eviation signs deal with Cape Air for 75 all-electric Alice commuter aircraft.

APR — Airbus to test hydrogen jet engine in step towards zero emission aviation.

MAY — ZeroAvia and MONTE strike deal for 100 hydrogen-electric powertrains.

JUN — Hawaiian Airlines invests in Regent and its electric seaglider "Monarch" to be used for inter-island flights.

JUL — Eviation inks deal for 50 electric planes to operate in Florida and the Caribbean.

AUG — Rolls-Royce and Hyundai collaborate on all-electric propulsion and hydrogen tech.

SEP — Air France KLM to support Ampaire's development of 19-seat electric aircraft.

OCT — Air Canada purchases 30 electric-hybrid aircraft under development by Heart Aerospace.

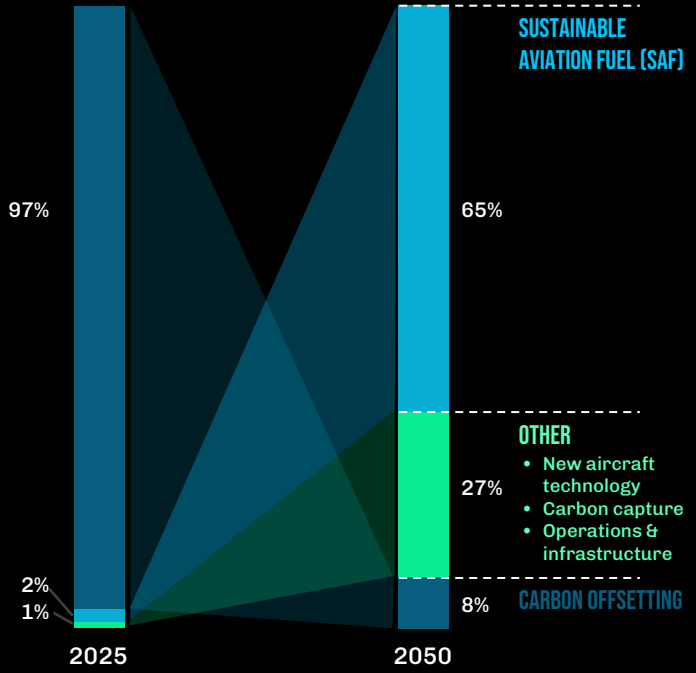
NOV — United Airlines is the first airline ever to directly invest in a battery manufacturer named Natron Energy.

DEC — American Airlines invested in Universal Hydrogen to help build a green hydrogen distribution network.

Source: UP.Partners research based on press articles

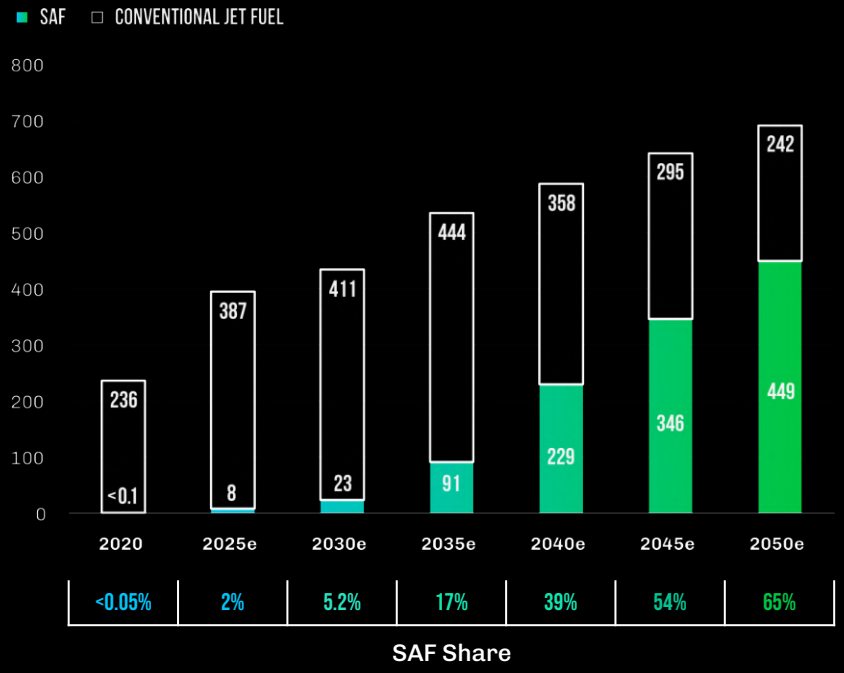
UNTIL THEN, THE INDUSTRY DEPENDS ON SAF AS A BRIDGE TECHNOLOGY

IATA PROJECTIONS ON THE EMISSIONS REDUCTION CONTRIBUTIONS BY TECHNOLOGY TYPE FOR A NET-ZERO FUTURE FOR AVIATION



Source: IATA, FlyNetZero

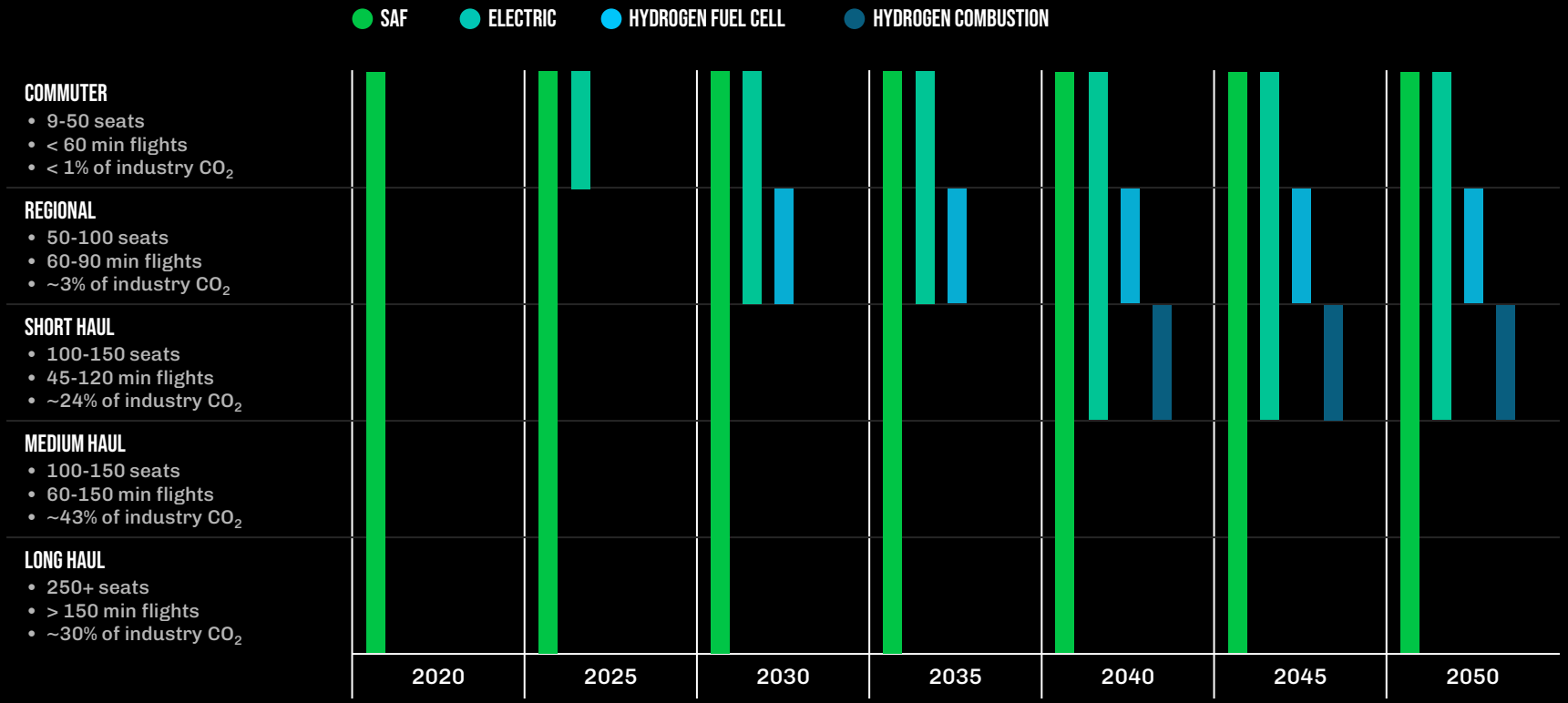
PROJECTED FUEL CONSUMPTION OF COMMERCIAL AIRLINES INCL. SHARE OF SAF REQUIRED TO REACH NET-ZERO (IN BILLION LITERS)



Source: Sustainable Aero Lab, IATA, Statista

THE LONGER FLIGHTS GET, THE MORE AVIATION WILL RELY ON SAF

Estimated reliance on electric vs. hydrogen vs. SAF for major aviation use cases



Source: Waypoint

BUT SAF WILL NEVER ENABLE A ZERO-CARBON FUTURE FOR AVIATION

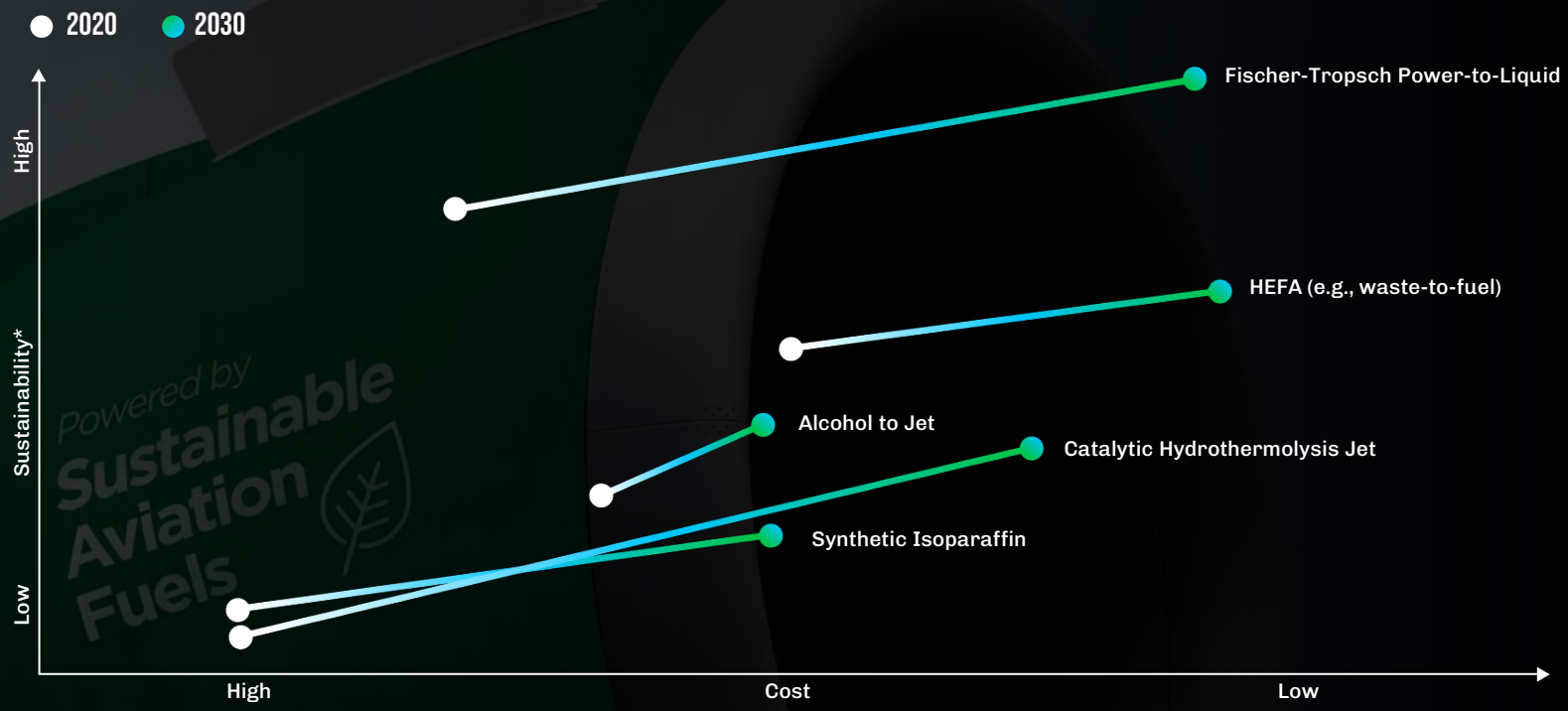
Potential to reduce emissions from aviation →

	NET ZERO	ZERO CARBON	ZERO EMISSIONS (TRUE ZERO)	
DESCRIPTION	Solutions that emit the same amount of GHG emissions that they remove, e.g. via carbon sinks but without a reduction in gross emissions.	Solutions that do not emit CO_2, but may emit other GHGs (potentially also causing contrails).	Solutions that release no greenhouse gases at all during operation.	
SOLUTION	Sustainable Aviation Fuel (SAF)	Hydrogen Combustion	Hydrogen Fuel Cell	Battery Electric
IMPACT	SAF does not reduce tailpipe emissions from burning fuel in-flight. Burning SAF returns carbon to the atmosphere that had previously been absorbed by plants or that would have been released as industrial waste gases or household garbage.	Hydrogen Combustion replaces kerosene with hydrogen in modified jet engines. Therefore, no CO2 is emitted from burning fossil jet fuel. It still emits water vapor and NOx.	Hydrogen Fuel Cells convert hydrogen and air to electricity, which powers a motor to drive propellers.	Powering all-electric aircraft with batteries only, using electricity generated from renewable sources.
REQUIRING NOVEL ELECTRICAL SYSTEMS	✗	✗	✓	✓
REQUIRING NOVEL AIRCRAFT CONFIGURATIONS	✗	✓	✓	✓
COMPLEXITY	●●○○○	●●●●○	●●●●●	●●●●●

Source: UP.Partners analysis based on Roland Berger

ALSO, THE CLIMATE IMPACT OF SAF VARIES DEPENDING ON FEEDSTOCKS AND PRODUCTION TYPE

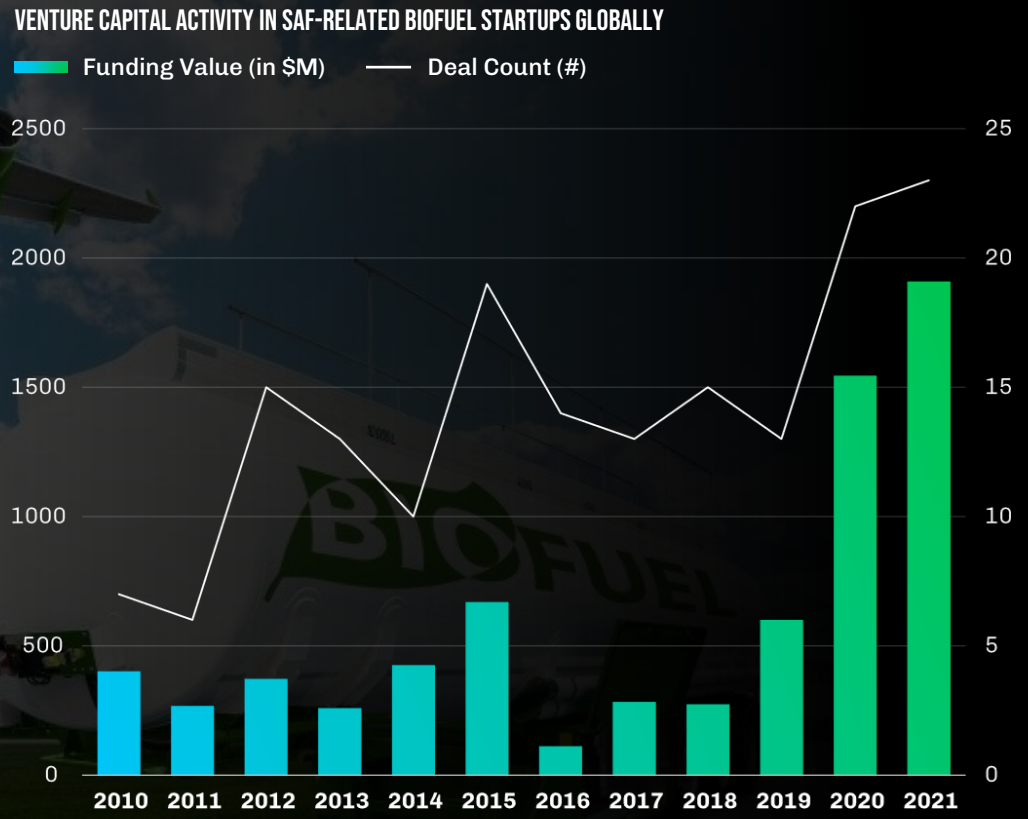
Evaluating different SAF options



Source: Roland Berger
*The sustainability score considers CO2 reduction potential, non-CO2 emissions, max. blend percentage, feedstock availability, as well as land- and water usage

FORTUNATELY, INVESTMENTS IN NEXT-GEN BIOFUEL AVIATION STARTUPS ARE ON THE UPTAKE

Medium- and long-haul aviation is going to be impossible to electrify over the next few decades due to fundamental limitations in battery chemistry and physics. Therefore, Sustainable Aviation Fuel is the only alternative to limit the climate impact of intercontinental air travel. Fortunately, SAF solutions have gained traction among startup founders over the last six years, making it an increasingly competitive sector. This has led venture capitalists to intensify funding SAF-focused ventures. There are several reasons why investing in SAF solutions looks attractive. Firstly, there is a strong push to substitute conventional jet fuel with SAF due to government regulations and consumer preferences. Governments around the world are increasingly implementing policies that require airlines to reduce their emissions by using cleaner fuels. Additionally, more and more consumers are becoming environmentally conscious and prefer companies that adhere to high sustainability standards when selecting flights.



Source: Sustainable Aero Lab

NEW SAF APPROACHES ARE DRIVEN FORWARD BY A GROWING ECOSYSTEM OF STAKEHOLDERS

EARLY-STAGE STARTUPS

LanzaJet · Alder Fuels · WASTEFUEL · SAF+ CONSORTIUM · zenid · phycobloom · CAPHENIA · norsk e-fuel · Northwest Advanced Bio Fuels · zero petroleum

LATE-STAGE STARTUPS

SkyNRG · SG Preston · CLEARFUELS · Edeniq · EMERGING FUELS TECHNOLOGY · GEFS · SunCHEM · BYOGY · NOVAPANGAEA TECHNOLOGIES · RED ROCK BIOFUELS

BIOTECH

VELOCYS · amyris · AEMETIS · レグルス · gevo · Green Plains · Fulcrum BioEnergy · enviva · Renewable Energy Group · Swedish BioFuels

FUEL SERVICES

World Fuel Services · Axens · Worley · TOYO ENGINEERING · UGI CORPORATION · JETEX · AVFUEL CORPORATION · green fuels · CEPSA · AFS

ENERGY

NESTE · bp · world energy · TotalEnergies · Shell · Chevron · ExxonMobil · SASOL ecoFT · Honeywell · eni

Source: Sustainable Aero Lab

SUMMARY OF SECTION 1

The mobility industry is experiencing an unprecedented rate of change across all major modes of transportation.

Section 1 of this report quantified the amount of capital that has flowed into technology companies shaping the future of mobility. Over the past ten years, more than $375 billion USD has been invested into Mobility Tech startups around the world. This represents about 12% of total Venture Capital across all sectors raised in the same timeframe. We identified the most attractive new mobility themes for investors and showcased more than one hundred of the leading startup companies spearheading the movement towards next-gen passenger and cargo transportation.

Despite these massive strides in innovation towards new modes of transportation, we also evidenced how the biggest challenge for the mobility industry has not yet been solved. Transportation has become the biggest contributor of CO2 in many advanced economies around the world like the U.S.

Even worse, projected global CO2 emissions from transportation over the next ten years are expected to further increase by double-digit growth rates, which seriously threatens mobility's net-zero future.

As a result, we outlined how radical innovation is a necessity to enable a more sustainable future of transportation.

Fortunately, we also showed that the investor community has realized the need (and commercial opportunity) for bolder technology approaches to mitigate transportation's climate impact.

In fact, sustainability has become the most important theme for investors to guide their capital allocation. As well, mobility itself has become the most important climate segment of all. 38% of global VC funding dollars invested into Climate Tech in 2021 were allocated to "sustainable mobility" startups.

Interestingly, aviation has only been a niche area for climate investors thus far. This is worrisome as the pursuit of greener transportation is particularly challenging for the aviation industry, which is arguably the hardest transport mode to be decarbonized.

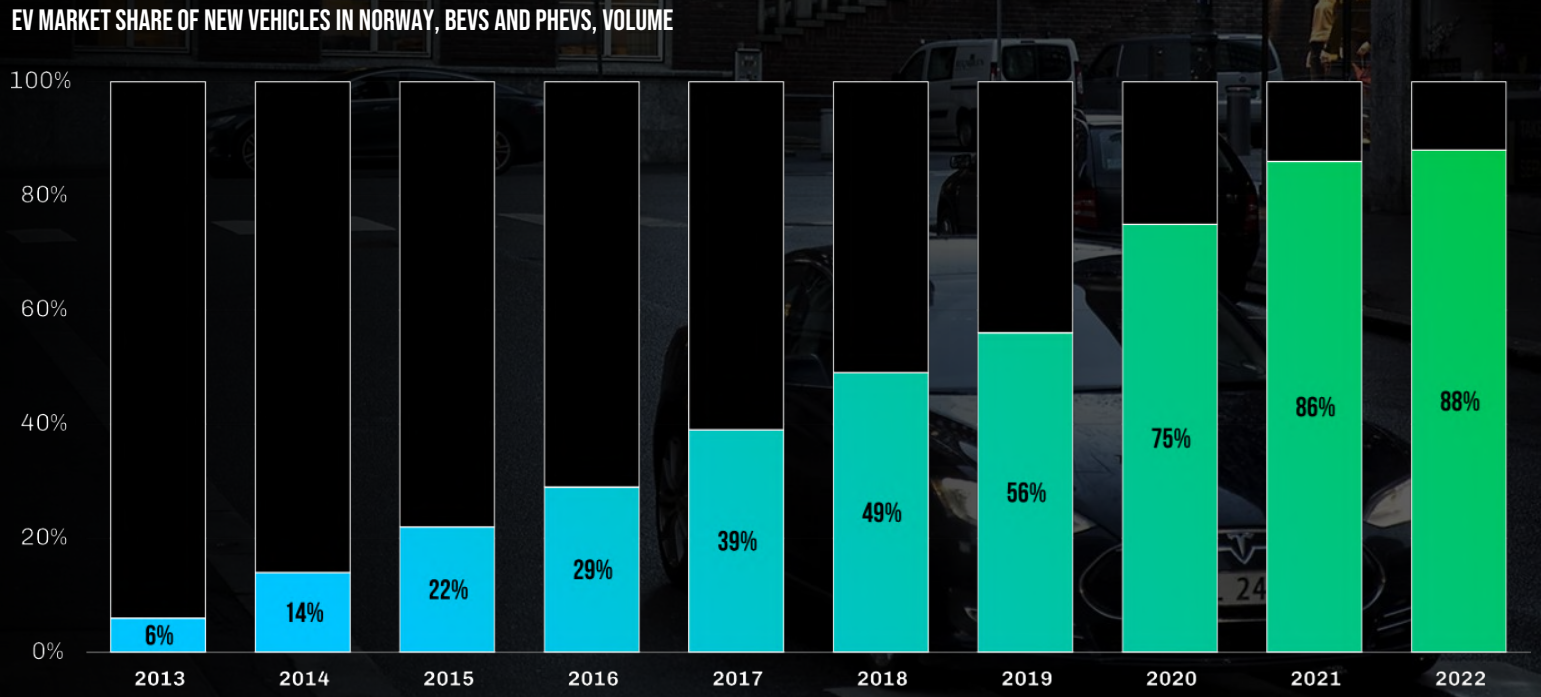
Still today, it's not clear yet which technologies will provide the best path forward for aviation. But the progress being made across the major new technologies shaping the next era of aviation, such as air taxis aka eVTOLs, electric and hydrogen aircraft, autonomous flight systems, Sustainable Aviation Fuel (SAF), and cargo drones, is promising.

Air taxis, in particular, have attracted tons of commercial interest thus far, although real-world applications remain highly speculative. Unmanned cargo drones, on the other hand, are already real and booming with more than 1.4 million successful drone deliveries made in 2022. Electric aviation, however, is still many years away. Until then, aviation's cleaner future will depend on SAF, which is barely in use today—representing less than 1% of global jet fuel consumption in 2022.

Fortunately, a growing ecosystem of biofuel startups may change this in the future.

2 THE NEXT DECADE OF ROAD TRANSPORT

NORWAY IS A MODEL FOR ELECTRIC VEHICLE ADOPTION

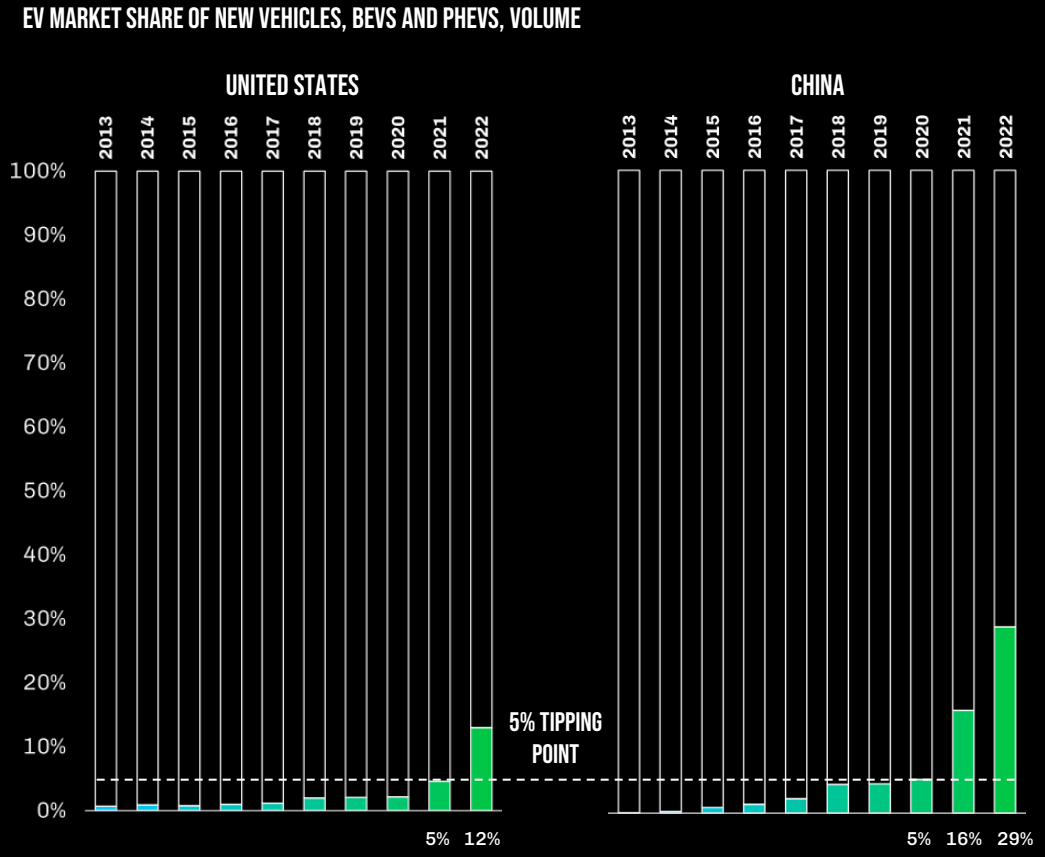


Source: Global EV Data Explorer by IEA (2022), Norwegian Road Federation (OFV)

THE WORLD'S TWO BIGGEST AUTO MARKETS HAVE LONG STRUGGLED TO FOLLOW SUIT

At the end of 1879, Thomas Edison flipped a switch to light up a revolutionary invention: the incandescent bulb. Electricity slowly spread across American homes for an entire quarter century before it reached 5% of households. After that point, there was no turning back. By 1950, electricity had been installed in every corner of the nation. This phenomenon has become known as the S-Curve. When breakthrough technologies reach this initial 5% threshold number, the adoption rate begins to grow exponentially until eventually waning off at completion.

We are now witnessing something similar take place with electric vehicles. Both China and the U.S. have taken more than ten years to reach their respective 5% tipping points. Since then, electric vehicle adoption has basically doubled each year. The Norway EV trajectory now seems replicable for the two biggest auto markets in the world.

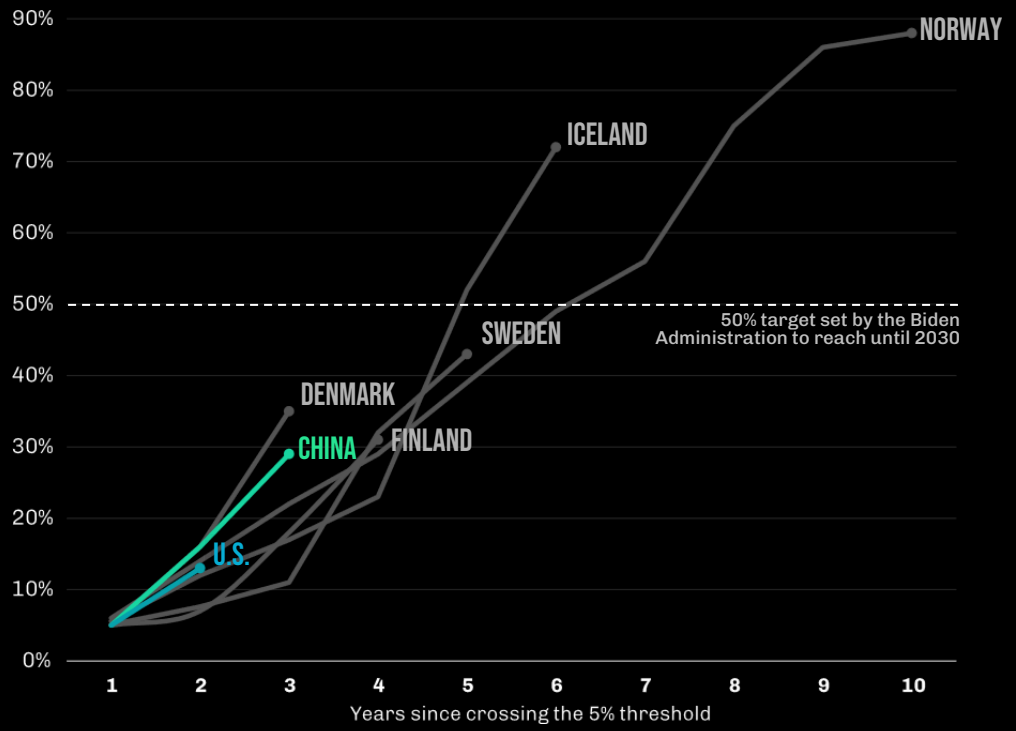


Source: UP.Partners analysis based on data from IEA's Global EV Data Explorer and press articles

BOTH MARKETS NOW TRACE THE NORWAY TRAJECTORY, AND THEY ARE NOT ALONE

Interestingly, the U.S. is only one of the most recent additions to a growing number of nations in which electric cars make up at least 5% of new vehicle sales, a threshold that opens the gate to mass adoption. If this trend continues, half of America's new car sales will be electric by the end of 2030, an ambitious goal set by the Biden Administration that long seemed out of reach. Now, the U.S. should be able to hit the target several years earlier than anticipated—an assessment that is also supported by industry analysts, such as those at Bloomberg.

It's important to note that every country mapped on this chart has a program of massive state subsidies, road privileges, and pollution rules in place that have laid the foundation for more rapid EV adoption. On a similar note, the S-shaped adoption curve is not a law of physics. Rather, it's a pattern-based framework that may suggest when a new technology gains widespread acceptance. However, there are still many things that can go wrong on the way up.



Source: UP.Partners analysis based on data from IEA's Global EV Data Explorer and inspired by BloombergNEF

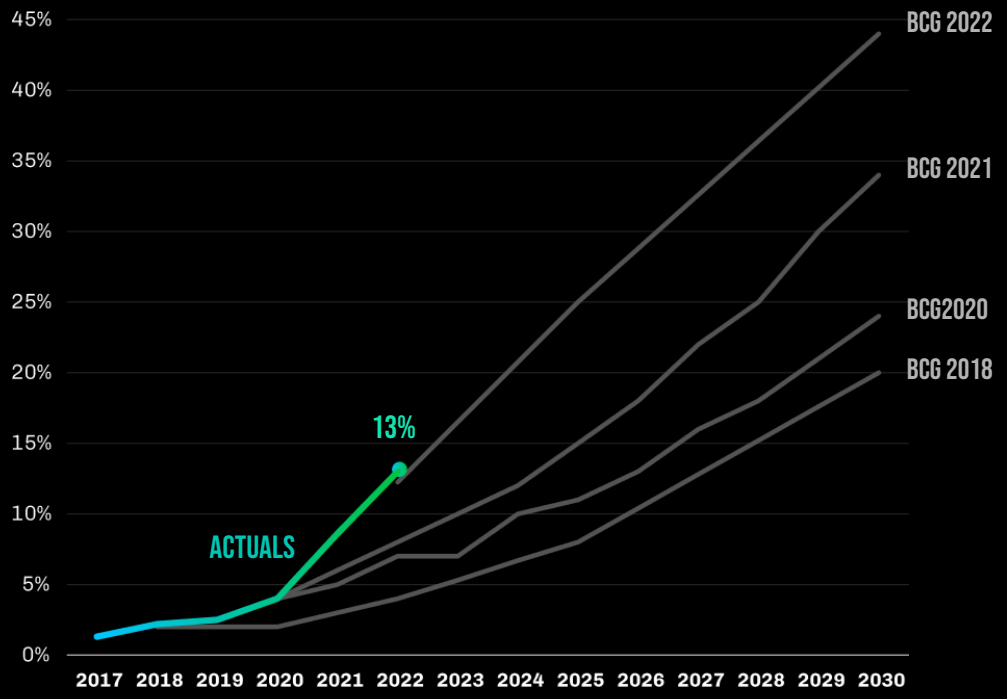
GLOBAL EV ADOPTION HAS BEATEN EXPERT PROJECTIONS, BUT WILL THIS CONTINUE?

It's reasonable to expect an S-curve EV growth trajectory around the world, since most limitations are universal: not enough chargers, expensive upfront costs, and a lack of consumer awareness. The 5% threshold is where these obstacles usually give way. The countries soon to cross that threshold include Canada, Australia, and Spain. In fact, the 5% tipping-point effect is similarly visible when looking at the adoption of electric vehicles on a global level. Since passing the milestone in 2021, the share of newly sold electric vehicles around the world jumped to 13% last year. 2022 really marked a turning point in customer sentiment.

Interestingly, this uptake has surprised many industry experts, including those at the Boston Consulting Group. Their annual predictions of global EV penetration rates have repeatedly fallen short of actual sales figures—a great reminder that predictions are like weather forecasts, advisory at best.

GLOBAL EV MARKET SHARE OF NEW VEHICLES, BEVS AND PHEVS, VOLUME

BCG projections vs. actual EV adoption

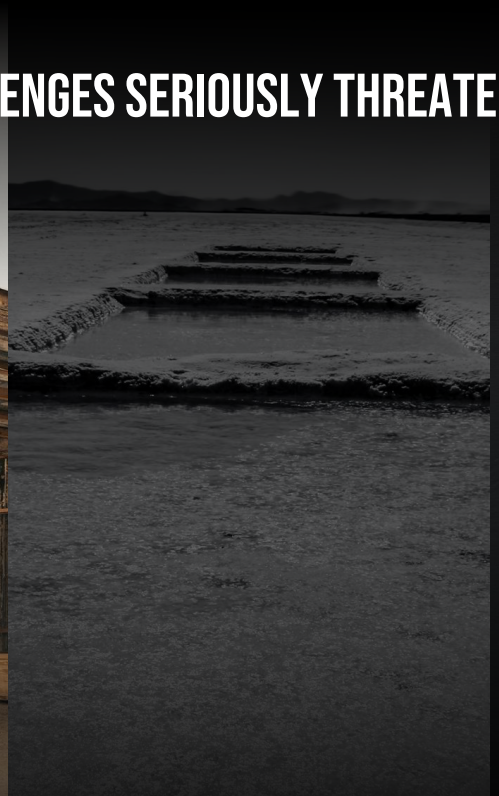


Source: UP.Partners analysis based on reports by BCG over the years

2.1 OVERCOMING MAJOR EV ROADBLOCKS

A NUMBER OF CHALLENGES SERIOUSLY THREATEN FURTHER EV GROWTH

LACK OF CHARGING INFRASTRUCTURE



A WORSENING RAW-MATERIAL SHORTAGE

ONGOING SUPPLY CHAIN TURMOIL

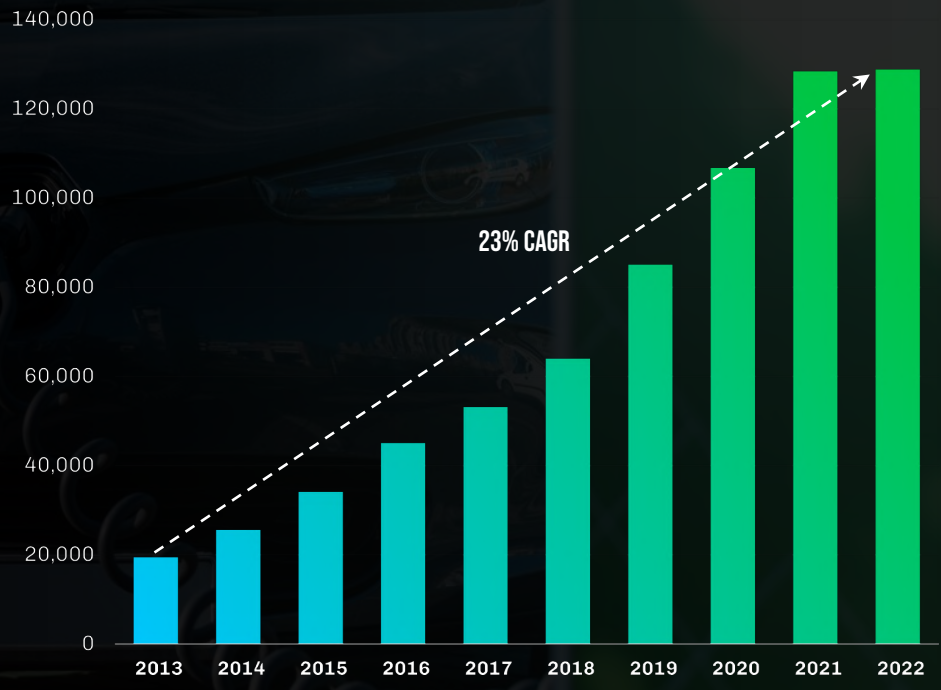
OVERLOADED GRID INFRASTRUCTURE

EV CHARGING EXPANSION IN THE U.S. LOOKS IMPRESSIVE, BUT IS THIS ENOUGH?

Charging infrastructure is critical to the success of the EV industry, especially in the US. It is necessary to have public networks of charging outlets, chargers available at home and work, and access to fast-charging options for longer trips. Without these options, EV adoption will be limited moving forward.

While growth in charging stations over the past decade looks promising—see chart on the right—America still needs more electric car chargers to overcome the range anxiety fears many drivers have. A 2022 analysis conducted by Energy Innovation alongside researchers at GridLab and the University of California, Berkeley found that the country needs to invest $6.5 billion USD in charging infrastructure annually for the next 30 years. This is significantly more than the one-off $5 billion USD initiative that was included in the $1 trillion USD bipartisan infrastructure bill announced in 2022 by the Biden Administration.

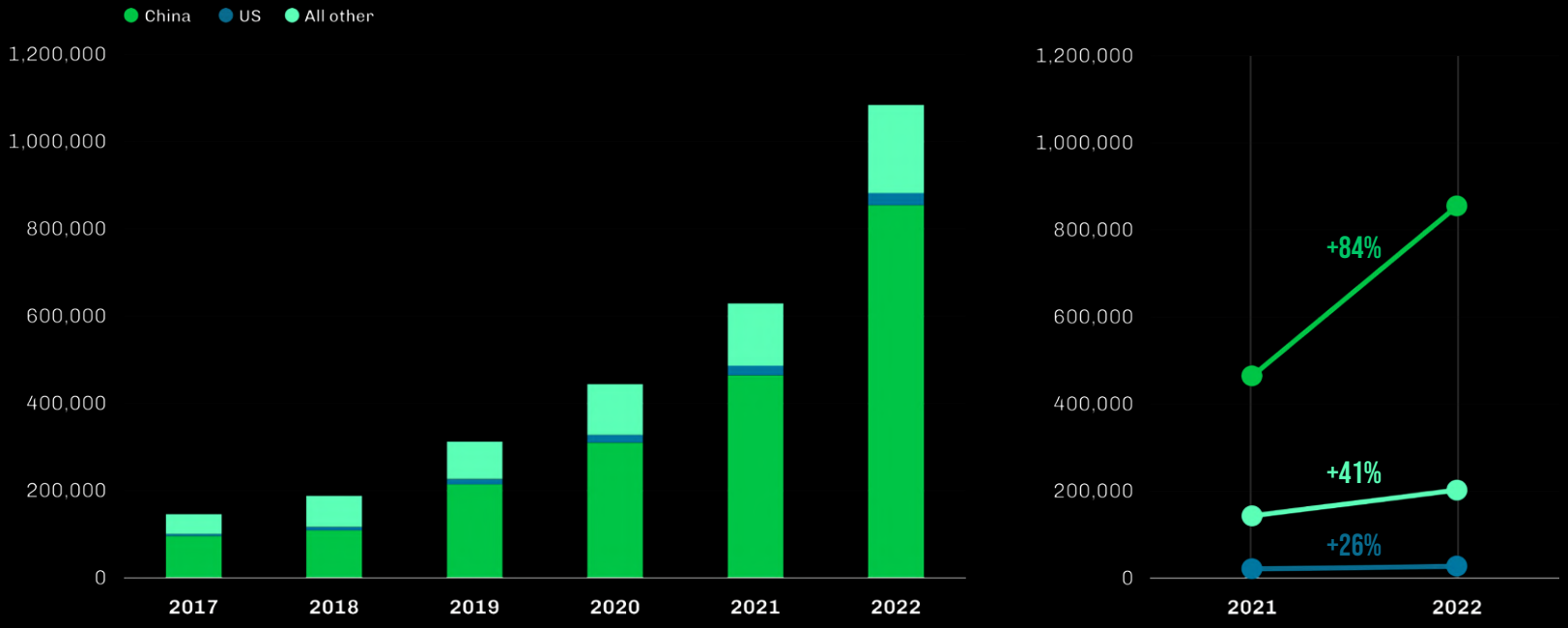
NUMBER OF EV CHARGING OUTLET INSTALLATIONS IN THE U.S.*



Source: National Renewable Energy Laboratory
*Does not include residential EV charging infrastructure

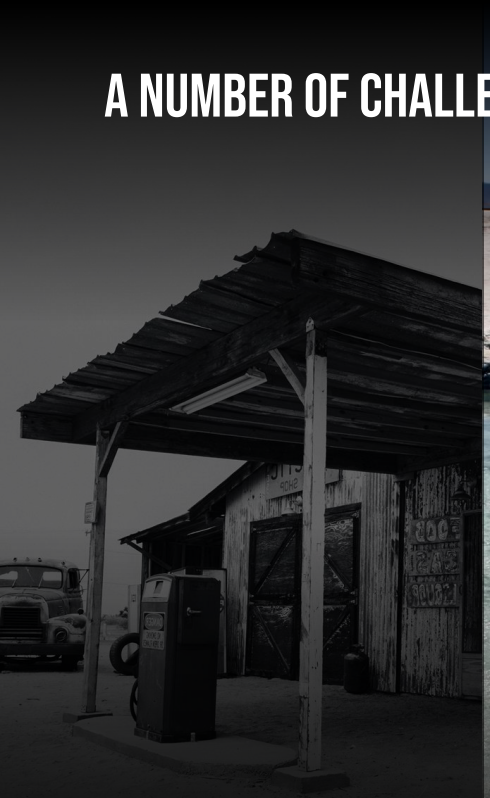
FAST-CURRENT CHARGER GROWTH IN THE U.S. IS WAY TOO LOW TO KEEP UP WITH PACE IN CHINA

NUMBER OF FAST-CHARGER DIRECT CURRENT (DC) INSTALLATIONS (50KW+)

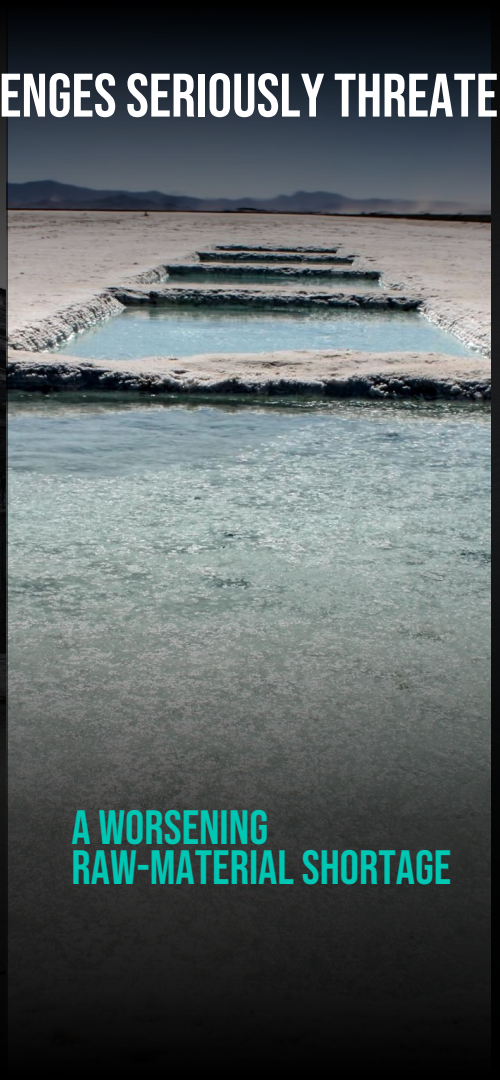


Source: UP.Partners analysis, BloombergNEF, China EV Charging Association, National Renewable Energy Laboratory

A NUMBER OF CHALLENGES SERIOUSLY THREATEN FURTHER EV GROWTH



LACK OF CHARGING INFRASTRUCTURE



A WORSENING RAW-MATERIAL SHORTAGE

ONGOING SUPPLY CHAIN TURMOIL

OVERLOADED GRID INFRASTRUCTURE

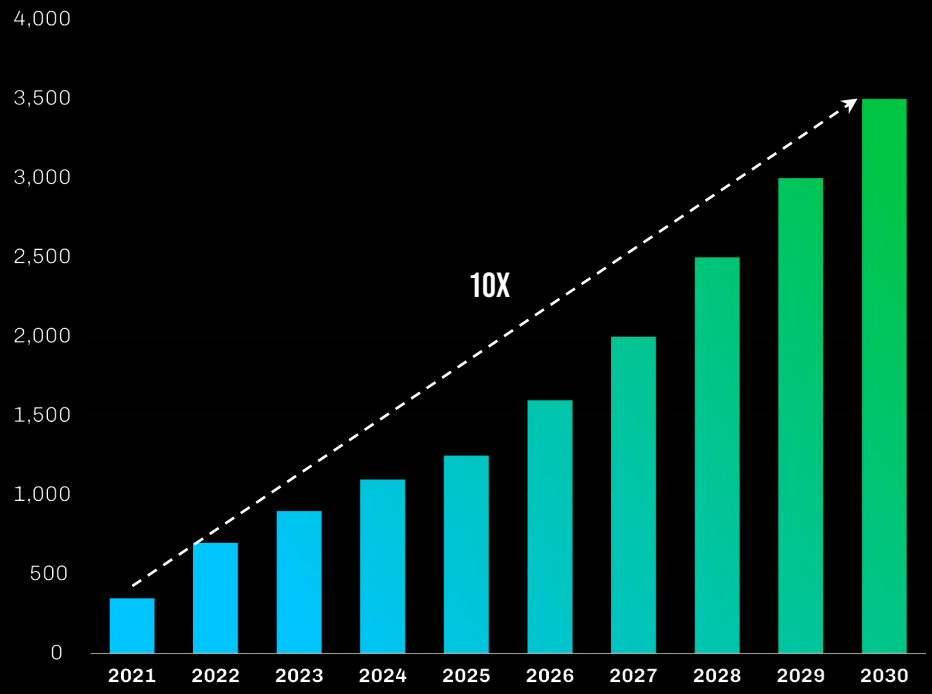
BATTERY DEMAND WILL RISE TEN-FOLD BY 2030. CAN RAW MATERIAL SUPPLY KEEP UP?

A lack of charging infrastructure is not the only major hurdle in encouraging more people to switch to electric vehicles. EV adoption can only progress as fast as the vehicles can make it off the factory floor. The proliferation of electric vehicles has created a seismic shift in the automotive industry, driving unprecedented demand for batteries to power these green machines.

The question is whether enough batteries can be produced to power every electric vehicle in the future. Goldman Sachs forecasts a ten-fold increase in battery demand between 2021 and 2030. But the availability of minerals necessary to create the batteries powering most EVs is facing a particular strain.

PROJECTED EV BATTERY DEMAND

In GWh (does not account for e-buses and two-wheelers)



Source: Goldman Sachs, BloombergNEF

LITHIUM, NICKEL AND COBALT ARE THE MAIN METALS DEFINING THE COST OF A BATTERY

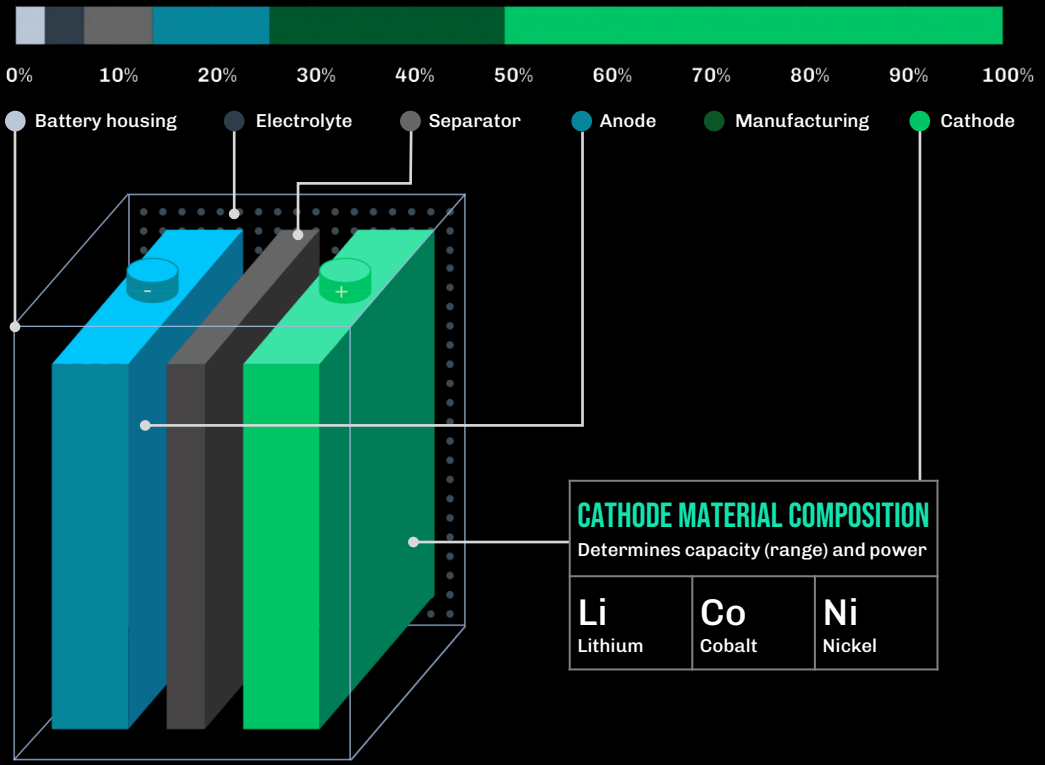
Lithium-ion batteries are the primary power source for electric vehicles. A lithium-ion battery consists of several components that work together to store and generate electricity. These components can be divided into three main categories: cells, modules, and packs.

Cells are the smallest unit of a battery. They are made up of an anode (the negative electrode) and a cathode (the positive electrode), which are held apart by a separator and soaked in an electrolyte solution. This is the part of the battery where chemical reactions take place in order to create electricity.

The cathode and anode have two main functions: they store energy from external sources, and release energy when the battery is being used. They are typically made from a combination of metals, mostly lithium, cobalt, and nickel.

Lithium is one of the key components in electric vehicle batteries. But global supplies are under severe strain. China is estimated to control 65% of the world's capacity for processing and refining lithium.

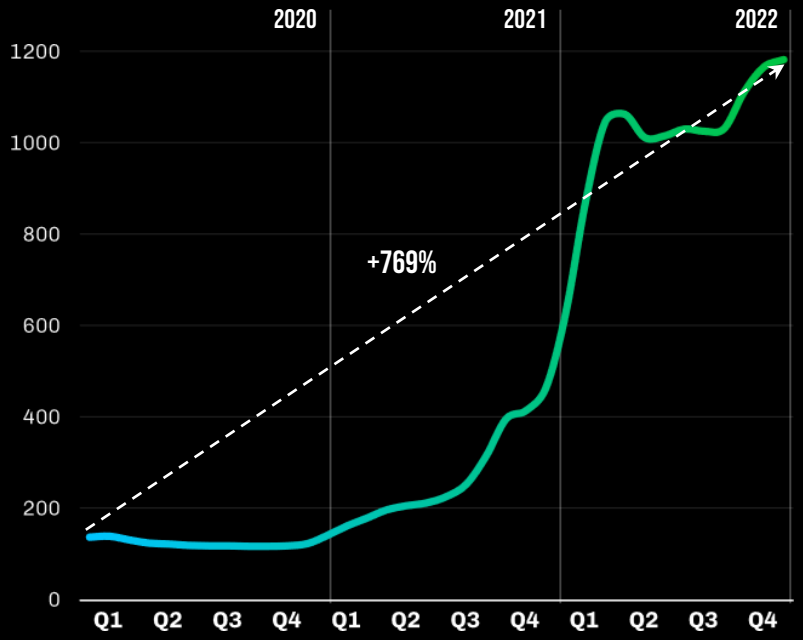
THE AVERAGE COST BREAKDOWN OF A LITHIUM-ION BATTERY CELL FOR EVS IN 2021



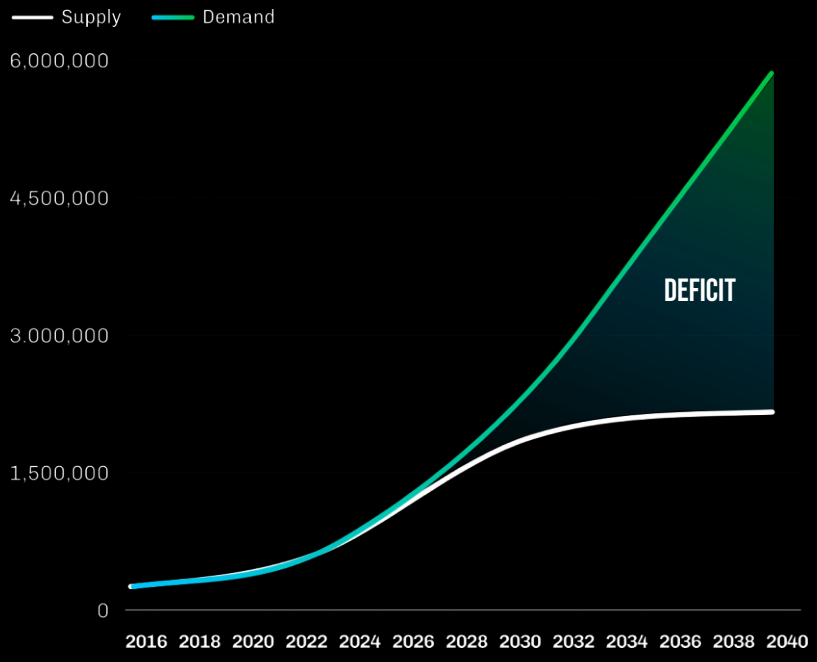
Source: UP.Partners analysis inspired by VisualCapitalist

THE LITHIUM PRICE IS ALREADY SPIKING TODAY DUE TO DEMAND OUTSTRIPPING SUPPLY

LITHIUM PRICE INDEX
Monthly tracked



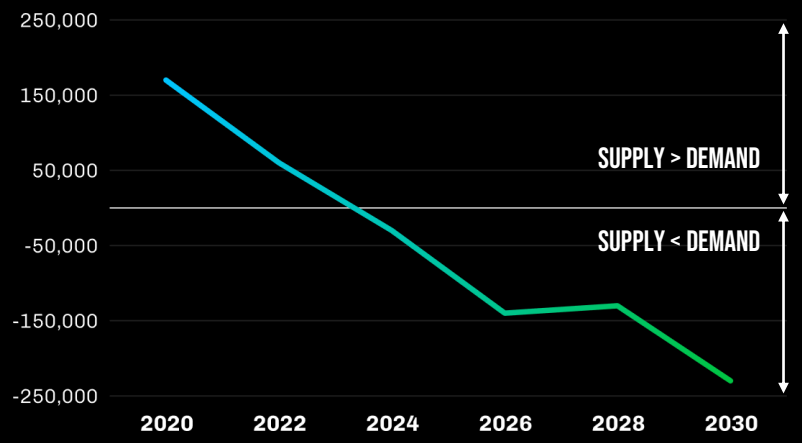
PROJECTED DEMAND AND SUPPLY OF LITHIUM
In tons of lithium carbonate equivalent (LCE)



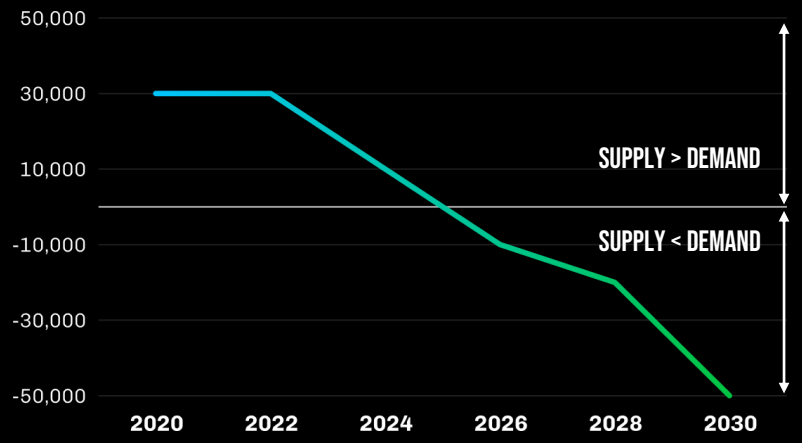
Source: UP.Partners analysis based on data from Benchmark Mineral Intelligence

FOR NICKEL AND COBALT, THE OUTLOOK IS ALSO WORRISOME GIVEN LONG PRODUCTION LEAD TIMES

ESTIMATED NICKEL SUPPLY MINUS ESTIMATED NICKEL DEMAND
In tons of Nickel metallic equivalent



ESTIMATED COBALT SUPPLY MINUS ESTIMATED COBALT DEMAND
In tons of Cobalt metallic equivalent



6-13 YEARS

Project lead time from discovery to first production including exploration, feasibility studies, and construction.

4-10 YEARS

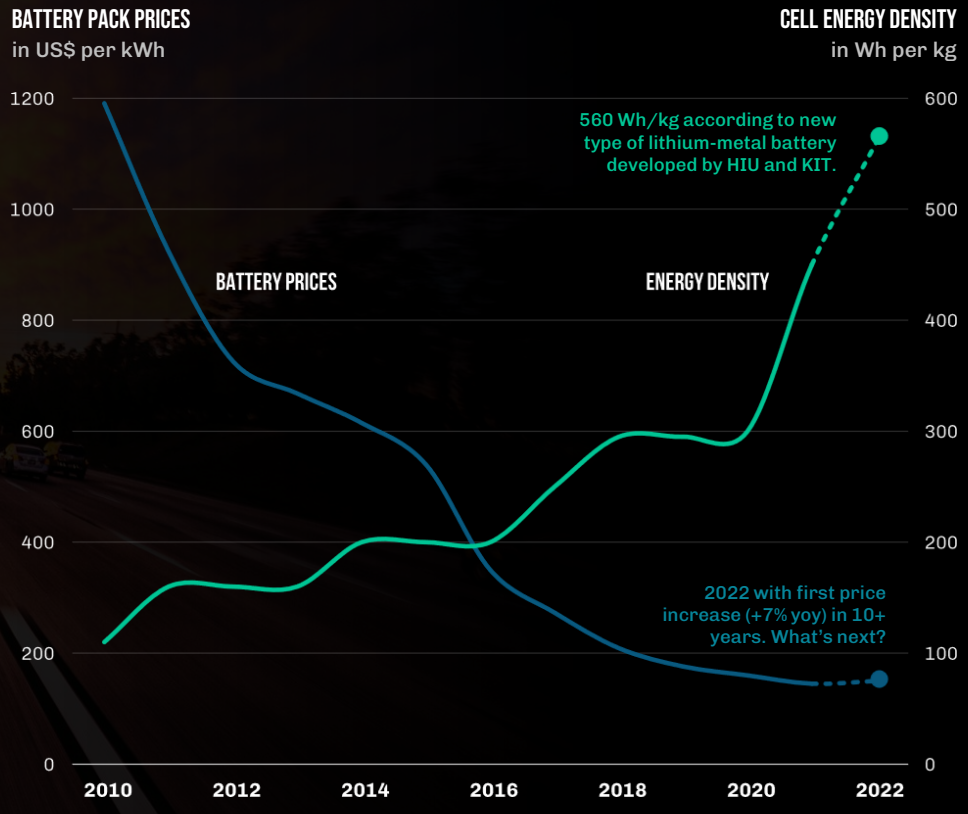
Project lead time from discovery to first production including exploration, feasibility studies, and construction.

Source: UP.Partners analysis based on data from Roland Berger and Resources Policy Volume 73

EVS AND THEIR BATTERIES HAVE LONG FOLLOWED A STEADY LEARNING CURVE

One phenomenon underpinning the 5% tipping point from which many new technologies, including EVs, gain mass-market appeal is known as the experience curve. The more lithium-ion batteries are deployed, the better we get at making them. When looking at historical price levels of battery packs for EVs, it turns out that falling battery prices have been one of the most consistent trends in the electric vehicle industry for the last decade. The costs of battery packs have decreased by close to 90% since 2010. In 2022, however, this trend was interrupted for the first time as battery prices increased, primarily driven by the lithium shortage. It remains to be seen how this supply constraint will evolve in 2023 and impact pricing. What could offset rising raw material costs are further gains in the energy density levels of batteries. In 2008, lithium-ion batteries had a volumetric energy density of 55 watt-hours per kg; by 2021, that had increased by a factor of 8 to 450 watt-hours.

Additionally, there are accelerating market signals that the EV industry might move away from NMC (lithium-nickel-mangan-cobalt-oxide) battery material to LFP (lithium iron phosphate) batteries with more domestic production expected in the U.S. This would likely mitigate supply constraints of essential raw materials.

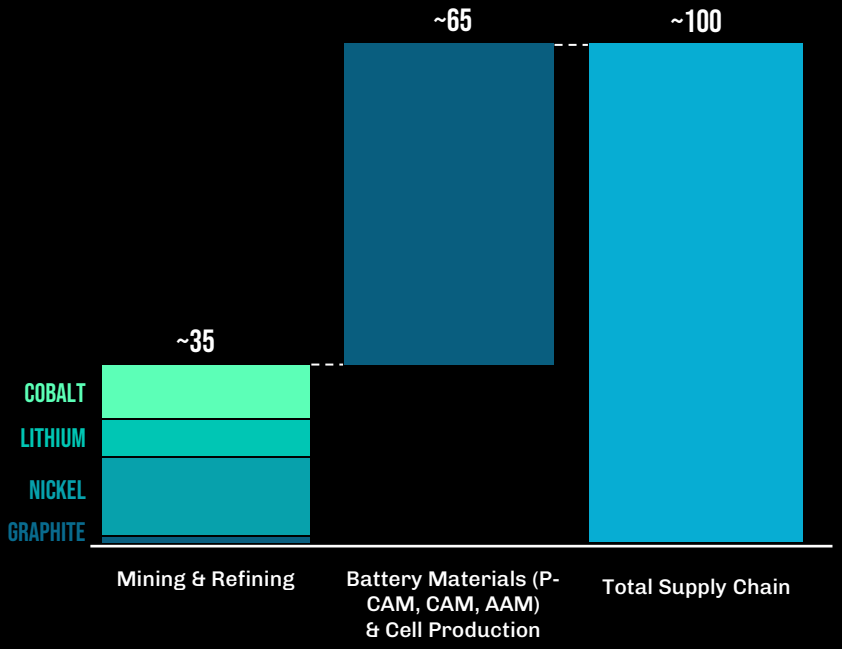


Source: UP.Partners analysis based on data from Reuters, Benchmark Mineral Intelligence, AlixPartners, BNEF, Energy.gov, Karlsruher Institut für Technologie (KIT)

HUGE INVESTMENTS ARE NEEDED TO EXPAND THE BATTERY SUPPLY CHAIN

CAPEX ESTIMATE INTO BATTERY SUPPLY CHAIN TO MEET EUROPEAN EV DEMAND

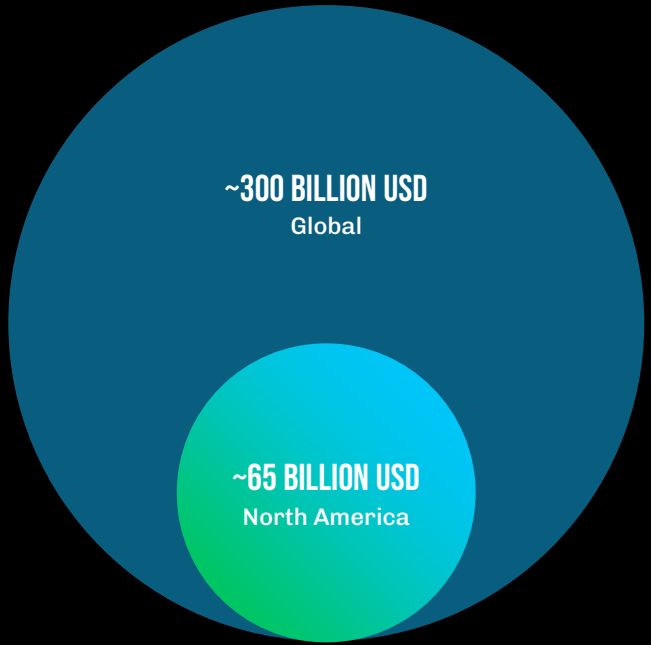
In billion USD until 2030, for 1,000 GWh equivalent



Source: UP.Partners simplified chart based on Roland Berger analysis

ESTIMATED DIRECT INVESTMENTS INTO NEW BATTERY GIGAFACTORIES TO MEET EV DEMAND

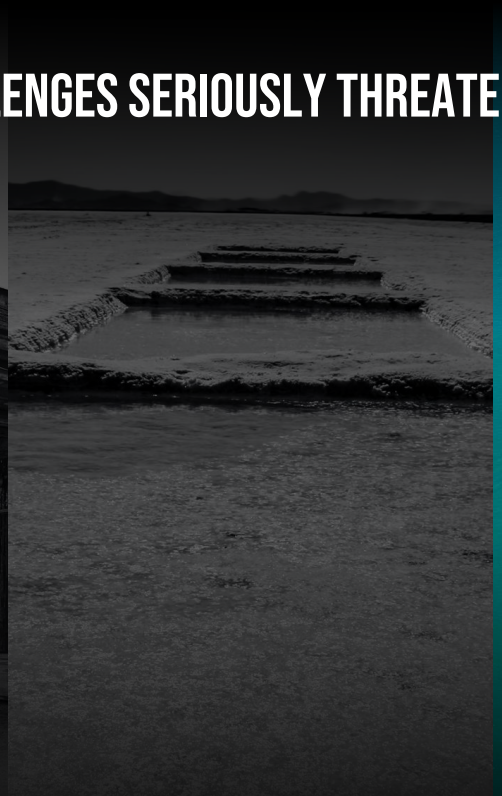
Until 2030



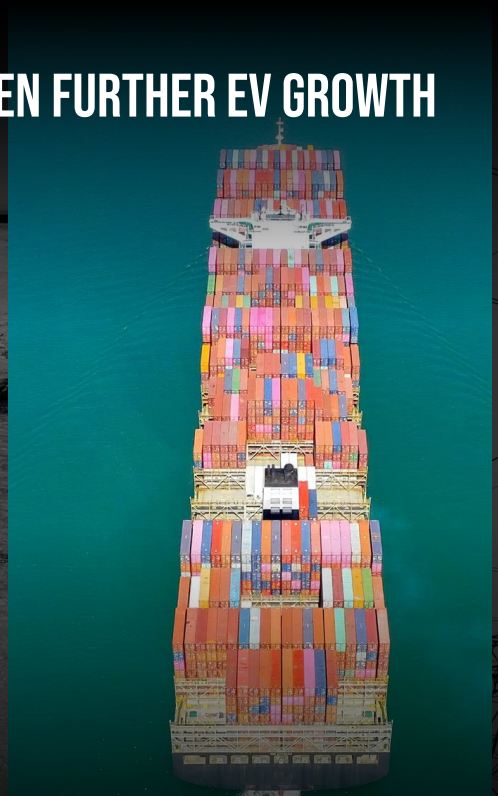
Source: McKinsey

A NUMBER OF CHALLENGES SERIOUSLY THREATEN FURTHER EV GROWTH

LACK OF CHARGING INFRASTRUCTURE



A WORSENING RAW-MATERIAL SHORTAGE



ONGOING SUPPLY CHAIN TURMOIL

OVERLOADED GRID INFRASTRUCTURE

GENERAL SUPPLY CHAIN TURMOIL ADDS ANOTHER LEVEL OF COMPLEXITY FOR EV FIRMS

The automotive sector and the wider economy have been subject to considerable strain due to supply chain complications. The mounting pressure resulting from changes in demand and output fluctuations caused by COVID-19 lockdowns, as well as additional factors, such as natural disasters, labor shortages, and political turmoil, have placed a huge burden on all aspects of global production and logistics networks. This has severely impacted not only battery production but also other major industries across the globe.

The Global PMI Comment Tracker by IHS, arguably the gold standard for measuring supply chain disruptions, shows the extent to which manufacturers have been facing delays on shipping as a lingering result of the pandemic and other complications. While the situation has clearly recovered since the peak in 2021 when supply chain disruptions were ten times more severe than the long-run average, global supply chains continue to be under pressure, especially since changes in the environment and in the global economy are increasing the frequency and magnitude of external shocks.

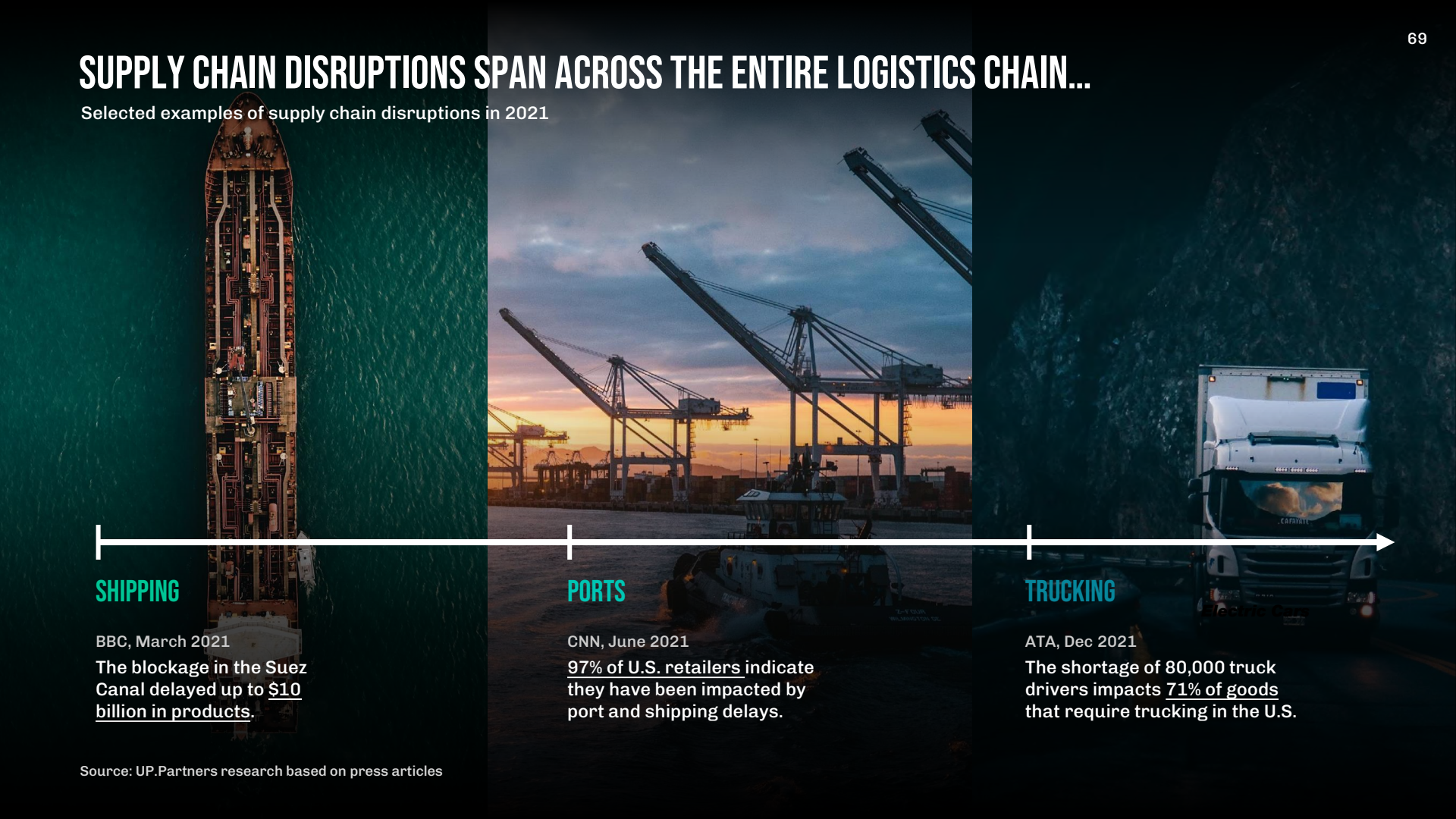
GLOBAL SHIPPING DELAYS ACCORDING TO THE IHS PMI COMMENT TRACKER

Indexed to 1 which represents the long-run average

Source: S&P Global (IHS)

SUPPLY CHAIN DISRUPTIONS SPAN ACROSS THE ENTIRE LOGISTICS CHAIN...

Selected examples of supply chain disruptions in 2021



SHIPPING

BBC, March 2021

The blockage in the Suez Canal delayed up to $10 billion in products.

PORTS

CNN, June 2021

97% of U.S. retailers indicate they have been impacted by port and shipping delays.

TRUCKING

ATA, Dec 2021

The shortage of 80,000 truck drivers impacts 71% of goods that require trucking in the U.S.

Source: UP.Partners research based on press articles

...AND THEY PRESENT AN UNSUSTAINABLE BURDEN FOR COMPANIES

Quantifying the impact of supply chain disruptions in 2021

-$228M

Estimated average annual cost to surveyed large-cap companies as a result of supply chain disruptions.

83%

The share of companies that have suffered reputational damage because of supply chain problems.

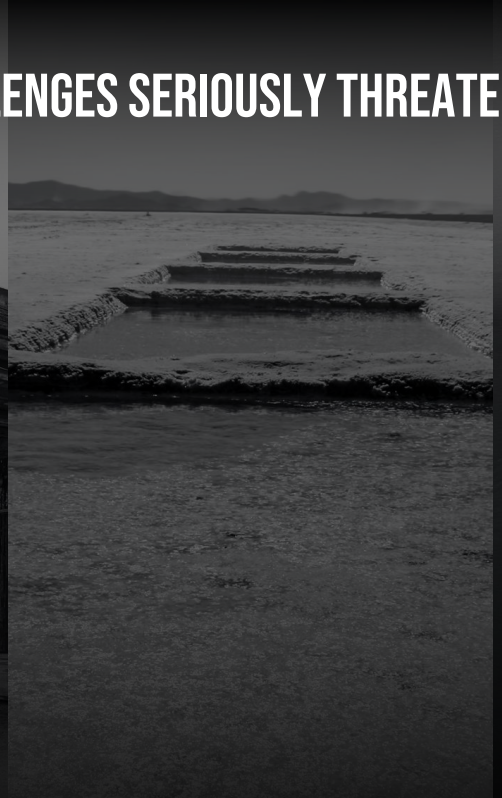
22

The average number of times per year when global supply chain risks were discussed at board level.

Source: Interos

A NUMBER OF CHALLENGES SERIOUSLY THREATEN FURTHER EV GROWTH

LACK OF CHARGING INFRASTRUCTURE



A WORSENING RAW-MATERIAL SHORTAGE

ONGOING SUPPLY CHAIN TURMOIL

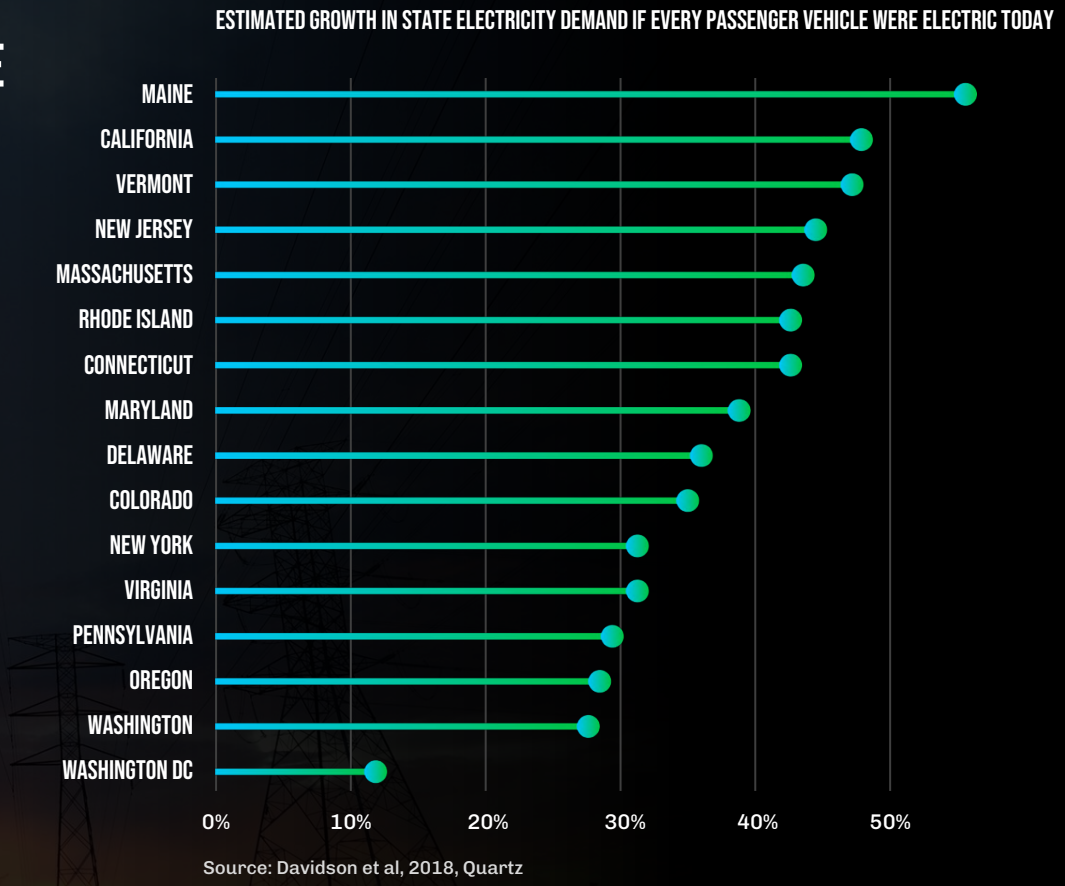
OVERLOADED GRID INFRASTRUCTURE

TODAY'S GRID INFRASTRUCTURE COULD BE UNPREPARED TO HANDLE MILLIONS OF ELECTRIC CARS

The fourth major challenge that could jeopardize the success story of electric vehicles is the fact that charging them could challenge electricity grid operations.

In 2022, EVs accounted for less than 2% of cars on the road in California. As drivers tend to hold on to new cars for about a decade, it will still likely take a couple of decades to fully replace every gas-powered vehicle driving around. Despite this, the prospect poses a challenge for the electric grid, which will need a lot more juice to keep up with demand. In fact, according to a 2018 analysis by energy economists at the University of Texas, a complete overnight EV conversion in California would require 47% more electricity than what is being consumed today—a demand that would likely outpace current grid capacity and operation capabilities.

However, California and other states will not experience a sudden shift to EVs. Instead, demand will grow gradually. In turn, this will create an incentive for utility and power companies to invest in new generation and transmission infrastructure.



Source: Davidson et al, 2018, Quartz

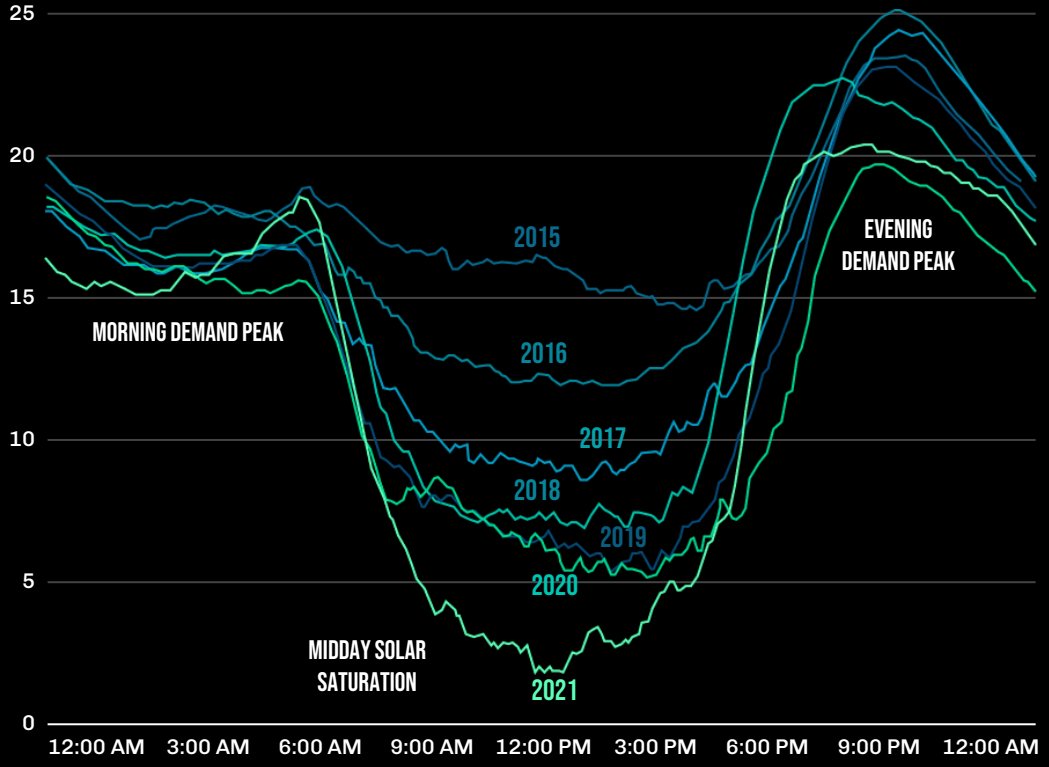
AT LEAST IN PLACES THAT RELY HEAVILY ON RENEWABLE ENERGY

In places like California that have aggressively transitioned to renewable energy over the past decade, electricity supply fluctuates heavily throughout the day. This has resulted in the widely known “duck curve,” which shows the difference in electricity demand and the amount of available solar and wind energy throughout the day. During the day, when the sun is shining, solar power floods the market, dropping off in the afternoon. Electricity demand starts peaking in the evening as people come home (and fire up their ACs).

A system like this presents immense challenges for utility operators to balance supply and demand. This is especially the case when a growing number of EVs are likely to intensify these patterns due to overnight charging. A common strategy to avoid overtaxing the power grid is to incentivize EV drivers to charge their vehicles during the day when demand is lowest. This requires better public and workplace charging infrastructure that supports daytime charging, as well as software and incentives to manage charging at the best times of the day. Also, the pairing of stationary batteries with renewables needs to be accelerated, same as smarter grid management efforts. The latter is currently driven forward by more and more startups.

NET LOAD CURVE IN CALIFORNIA (THE CALIFORNIA DUCK CURVE)

In GW, representing electricity demand (load) minus utility-scale wind and solar

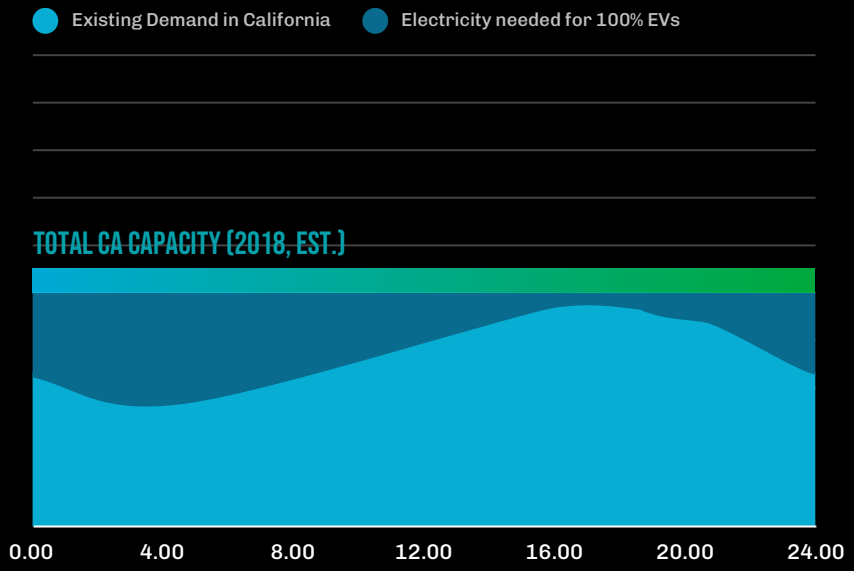


Source: Caiso

THE TIMING OF EV CHARGING WILL BE CRITICAL TO GUARANTEE GRID STABILITY

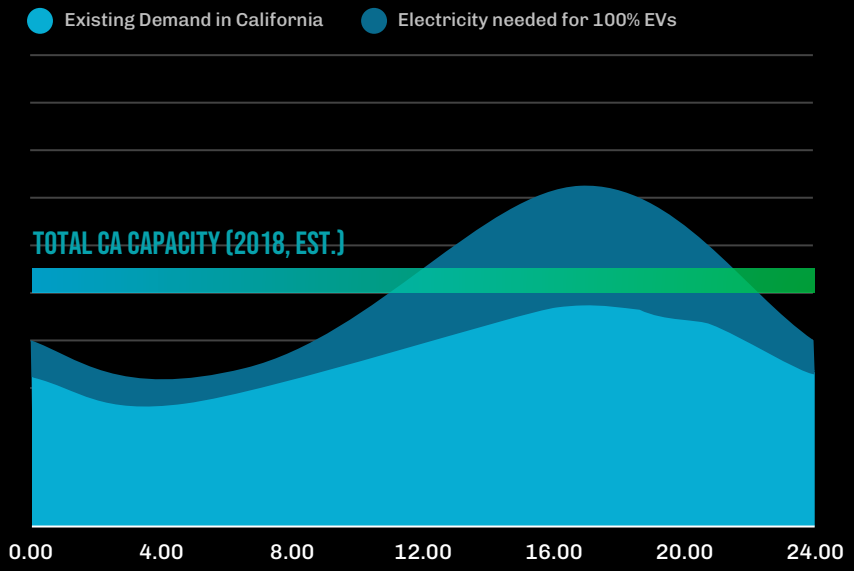
WELL-MANAGED CHARGING WITH OFF-PEAK PATTERNS WON'T OVERBURDEN GRIDS

Energy demand (in GW) with ideal vehicle charging at 100% EV penetration



HOWEVER, UNREGULATED CHARGING ESPECIALLY DURING HIGH-PEAK HOURS WILL LEAD TO BLACKOUTS

Energy demand (in GW) with high-peak vehicle charging at 100% EV penetration



Source: Energy Institute, University of Texas at Austin

WITHOUT SMART CHARGING, HEATWAVES LIKE THE ONE LAST SEPTEMBER CAN OVERSTRESS GRIDS

Timeline of major events during the heatwave in California in September 2022

THURSDAY, AUGUST 25

California approves a bold plan to ban the sale of new gasoline cars by 2035 as part of the Advanced Clean Cars II rule.

WEDNESDAY, AUGUST 31

California asks EV owners to avoid charging their cars between 4 p.m. and 9 p.m. due to high loads and rising temperatures across the state.

MONDAY, SEPTEMBER 5 MORNING

California experiences one of the most brutal September heatwaves in state history, expected to last nine days.

TUESDAY, SEPTEMBER 6 NOON

The state power grid operator warns residents to be “ready for rotating power outages,” after narrowly escaping that outcome on Monday.

TUESDAY, SEPTEMBER 6 AFTERNOON

Democratic Gov. Gavin Newsom urges residents to conserve, warning in a video message that "the risk for outages is real and it's immediate."

TUESDAY, SEPTEMBER 6 LATE AFTERNOON

The grid hits a peak demand of 52,061 megawatts, “a new all-time record,” with temporary power losses in some areas including Palo Alto.

TUESDAY, SEPTEMBER 6 EVENING

The cellphones of 27 million Californians light up with a new type of emergency alert: “Conserve energy now to protect public health and safety.”

TUESDAY, SEPTEMBER 6 NIGHT

Thanks to a significant amount of load reduction, major blackouts are avoided. However, temperatures during the night remain high, continuing to stress grids as solar levels off in the evening.

WEDNESDAY, SEPTEMBER 7 NOON

The state’s grid operators say the sudden conservation on Tuesday evening saved the day. Extremely high temperatures continue for several more days.

Source: UP.Partners research based on press articles

BUT IN ALL FAIRNESS, THERE ARE ALSO TRENDS THAT COULD HELP ACCELERATE EV GROWTH

STATE POLICIES PUSH EVS TO NEW HEIGHTS

AUTOMAKERS GO ALL IN ON ELECTRIC

EVS ARE A ONE-WAY STREET FOR CONSUMERS

EVS HAVE NEARLY REACHED COST PARITY

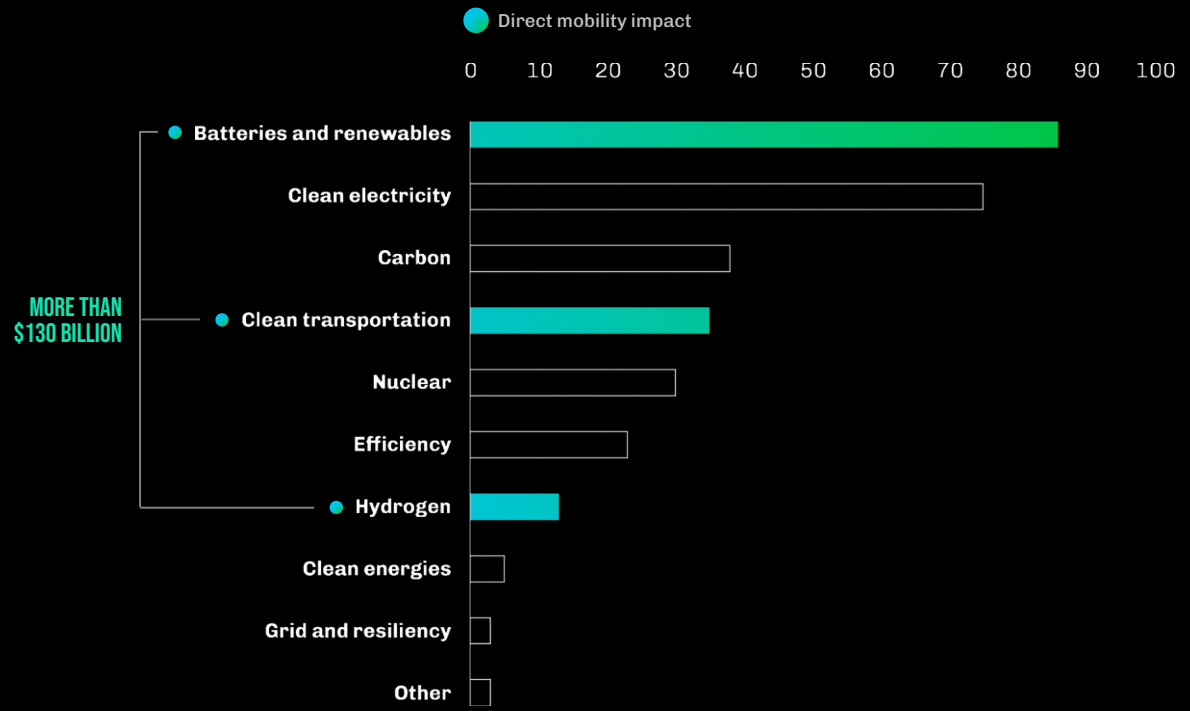
GOVERNMENTS ARE FUNDING THE EV TRANSITION MORE BOLDLY THAN EVER BEFORE

Governments around the world are making big investments into the decarbonization of their economies with an eye on more sustainable sources of energy. Electric cars, in particular, have received attention as an avenue toward achieving this goal. There has been funding provided for research and development in this area as well as to encourage the adoption of electric vehicles.

The Inflation Reduction Act, for example, signed into law in August 2022, includes nearly $370 billion USD to address climate change. The law includes hundreds of billions of dollars to tackle global warming by building more solar and wind power infrastructure, making buildings more energy efficient, and helping people buy electric vehicles. Analysts from Princeton University and Rhodium Group estimated that by the end of the decade, this initiative would help the U.S. reduce planet-warming emissions by about 40% compared to 2005 levels, which is a big step toward a truly low-carbon economy.

ENERGY FUNDING (TOTAL OF ~$370 BILLION) BY TOPIC AS PART OF THE INFLATION REDUCTION ACT

In billion USD



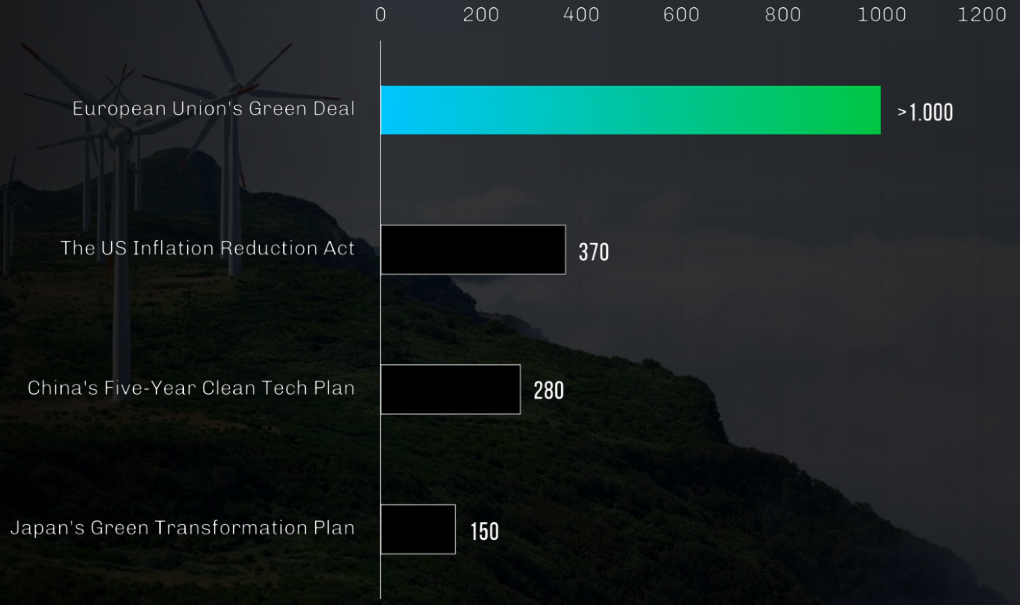
Source: UP.Partners analysis based on data from McKinsey & Company, Inflation Reduction Act of 2022, NPR

THE EU IS EXPECTED TO LAUNCH THE LARGEST CLIMATE-ORIENTED STATE-AID PROGRAM EVER

The funding size of the Inflation Reduction Act (IRA) has most recently been topped by the ambition of the European Commission to turn Europe into the first climate-neutral continent by 2050. In its February announcement called The Green Deal Industrial Plan, the European Commission fostered its willingness to speed up the contribution of Europe's clean-tech industries to a net-zero future via massive state-aid support of six main areas that are almost copy-pasted from the Inflation Reduction Act, namely batteries, solar panels, wind turbines, heat pumps, electrolyzers to produce hydrogen, carbon capture technology and critical raw materials. In the longer term, the European Commission will also explore establishing a so-called "European Sovereignty Fund" to finance projects on critical and emerging technologies collectively. How exactly the funding for all these areas will be allocated and support cleaner mobility remains to be seen at this report's publication date.

MAJOR CLEAN-TECH ORIENTED SUBSIDY PROGRAMS

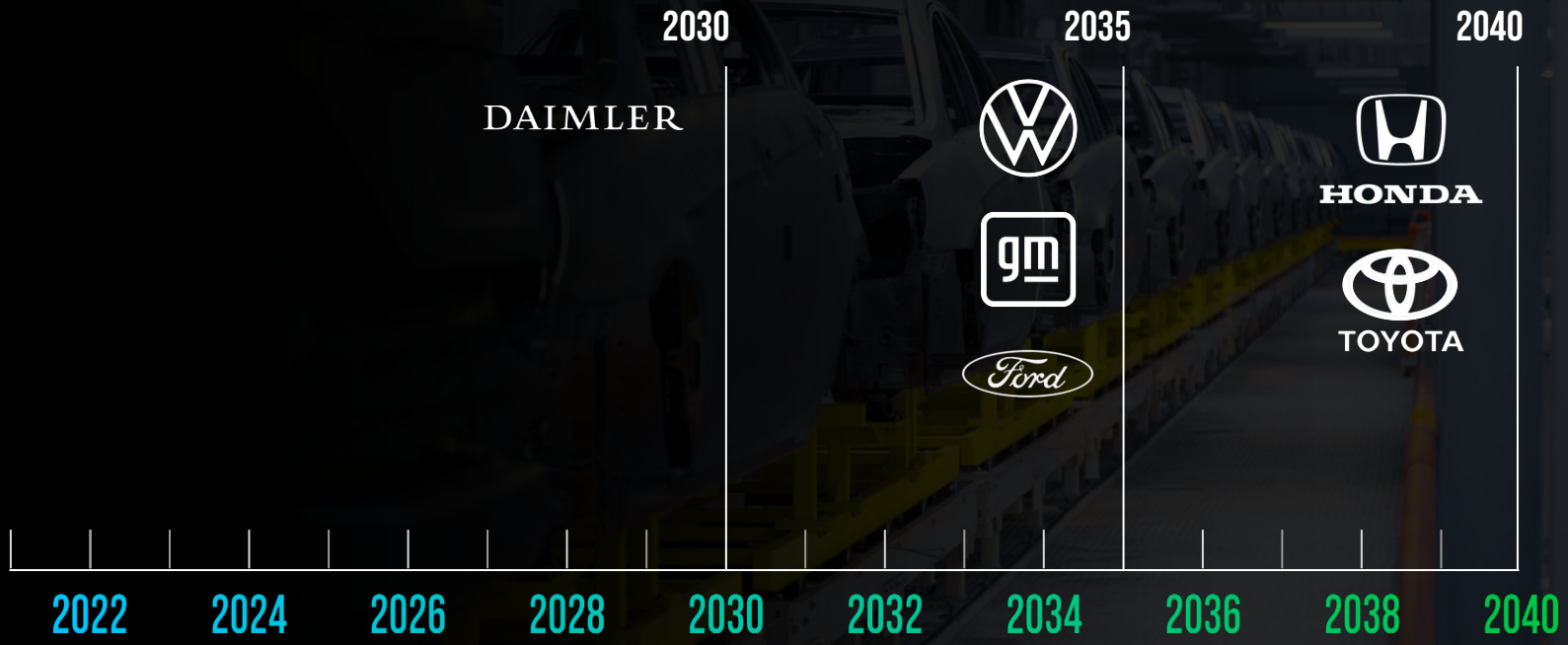
In billion USD



Source: UP.Partners analysis based on data from the European Union's February 2023 announcements, Euronews, Heise Magazine

AUTOMAKERS GO ALL IN ON ELECTRIC

Announced years until top six car makers plan to phase out all gasoline vehicles

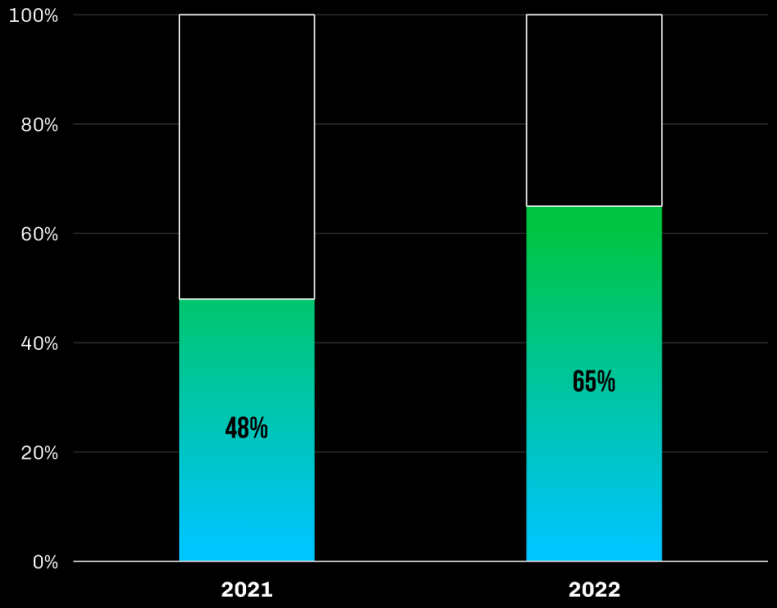


Source: UP.Partners analysis based on press releases, interviews

ELECTRIC VEHICLES ARE A ONE-WAY STREET FOR CONSUMERS, FOR NOW...

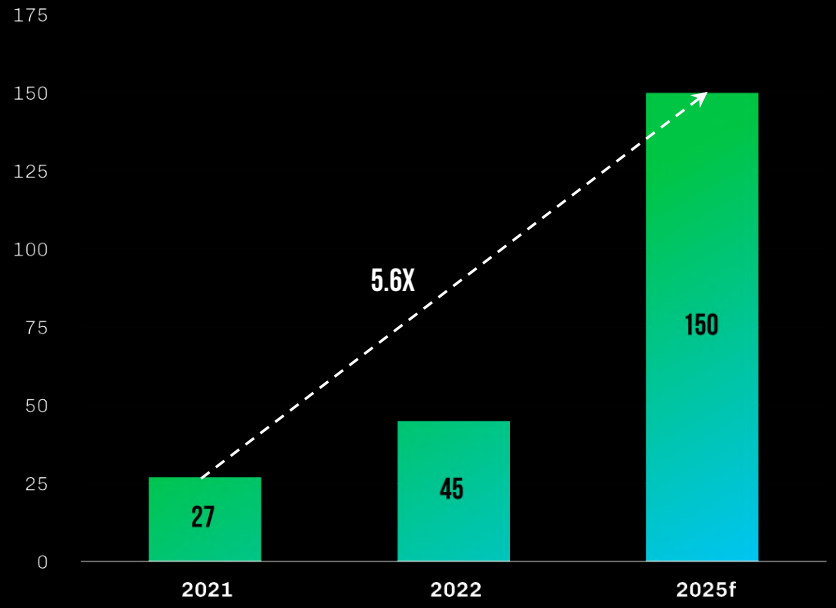
LOYALTY

Share of EV households in the U.S. who bought another EV



SELECTION

Number of available EV models in the U.S.



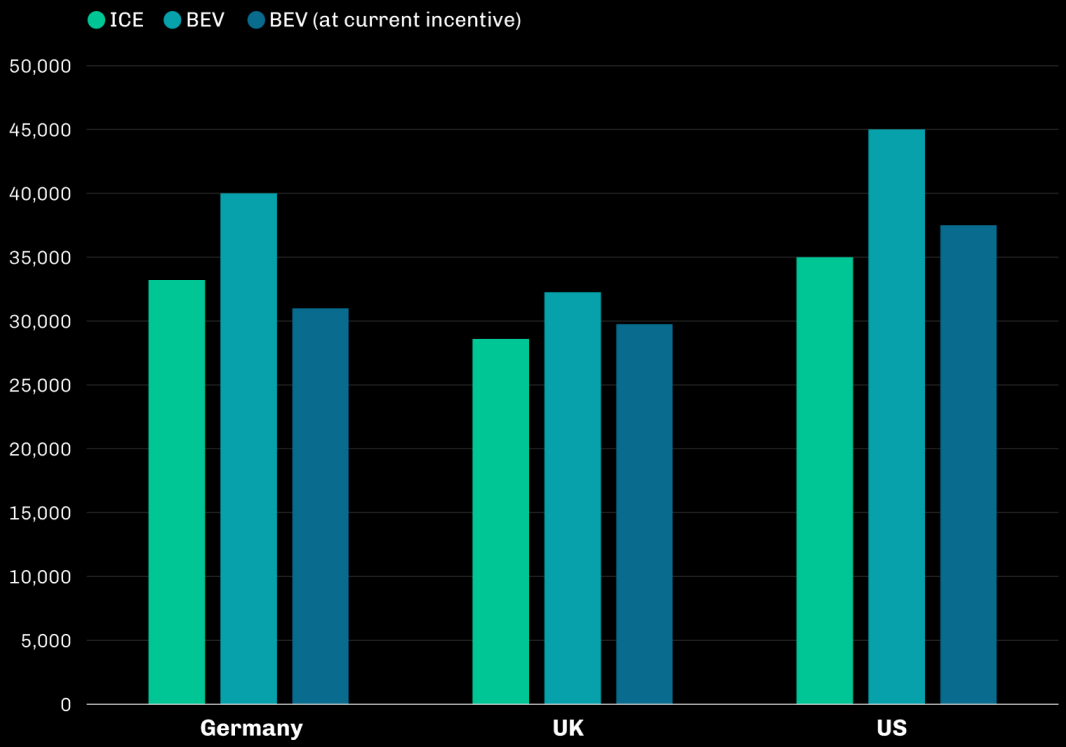
Source: Axios, S&P Global Mobility

AS A RESULT, EVS HAVE ALMOST REACHED COST PARITY WITH THEIR ICE PEERS. WILL THIS LAST?

As the prices associated with EV batteries have declined significantly in recent years, costs are no longer the biggest obstacle to consumer adoption. In most developed car markets, the cost of ownership for both internal combustion engine vehicles (ICE) and full battery electric vehicles (BEV) is more or less the same. While the initial investment for a BEV is usually higher, electric vehicles are cheaper to maintain and cost on average 40% less to service, according to the U.S. Department of Energy's Argonne National Laboratory. However, as battery costs for electric cars rose in 2022 for the first time in over a decade, price parity could be in danger as more than 40% of the value of an electric vehicle usually lies in its battery.

OWNERSHIP COSTS OF CARS WITH INTERNAL COMBUSTION ENGINE (ICE) VS. BATTERY ELECTRIC VEHICLES (BEV) IN 2022

In local currency



Source: Goldman Sachs

2.2 MICROMOBILITY IS HERE TO STAY-IN VARIOUS FORMS

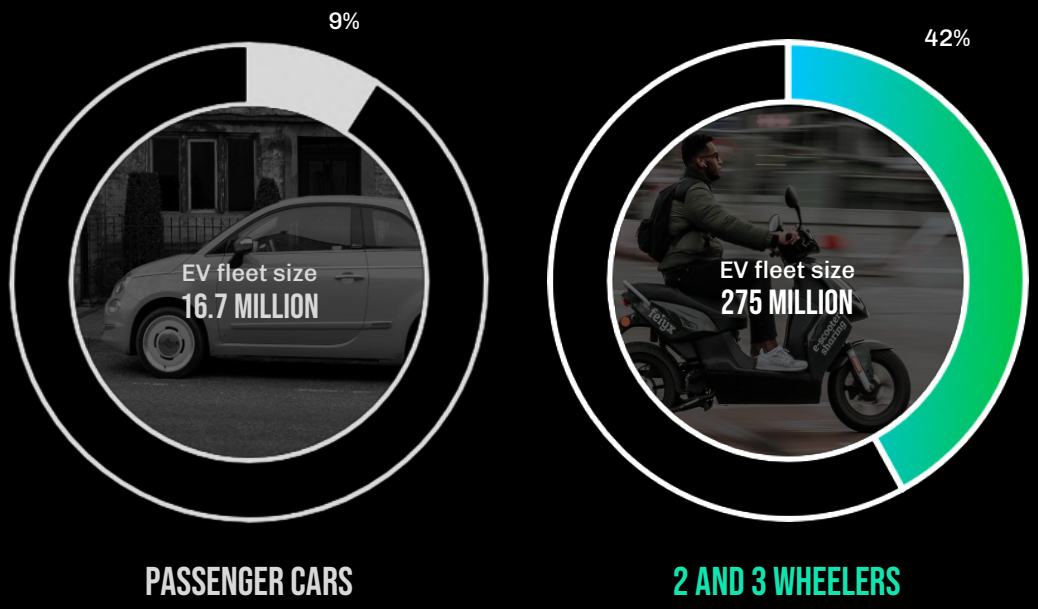
COMPARED TO AUTOMOBILES, MICROMOBILITY HAS, THUS FAR, ELECTRIFIED A LOT FASTER

Micromobility solutions are becoming increasingly popular for short-distance urban travel. This type of transportation includes a range of lightweight two and three-wheeler vehicles, such as scooters, bikes, and mopeds, all of which can be accessed through private ownership or shared business models.

These types of vehicles offer an easy way for people to get around. More than that, micromobility vehicles offer a cost-effective alternative to cars and public transportation. They are also much more eco-friendly than cars. Plus, they provide a convenient way to navigate congested city streets without having to worry about finding parking spaces or navigating traffic jams.

Interestingly, the electrification of two- and three-wheelers is far more advanced than it is for cars. This leads to massive benefits for the environment. Let's take a look.

GLOBAL EV MARKET SHARE OF NEW VEHICLES IN 2021



Source: BloombergNEF

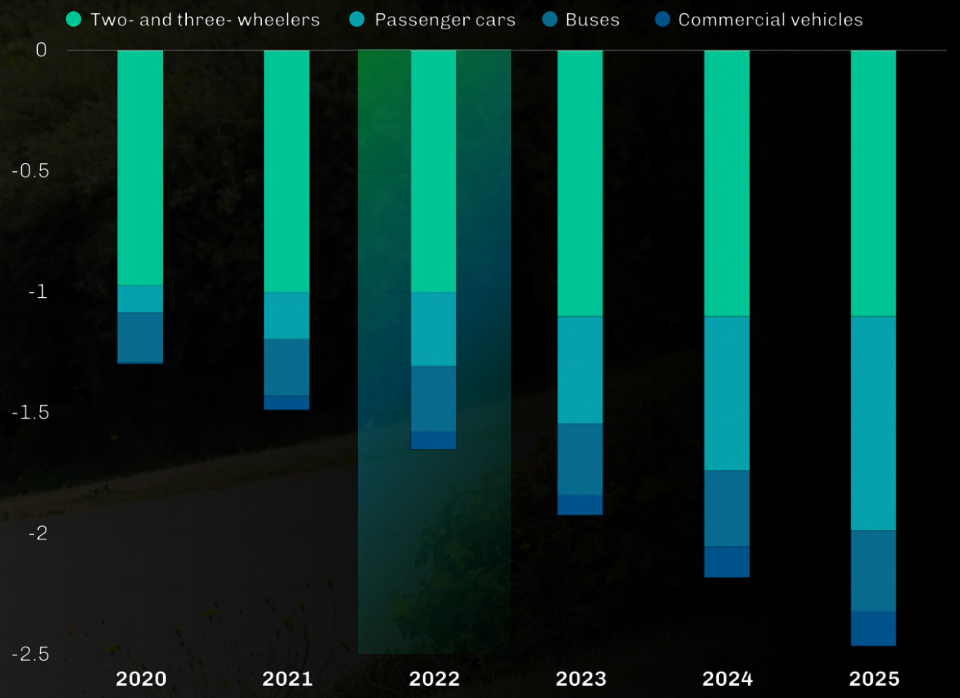
ELECTRIC 2 AND 3-WHEELERS ARE ALREADY DISPLACING 1 MILLION BARRELS OF OIL A DAY

According to BNEF, worldwide sales of internal combustion engine vehicles peaked in 2017 and are now in permanent decline. The global fleet of combustion cars on the roads will actually start to shrink from 2024 on. In their place, all types of electric transport modes will move people from A to B, whether in the form of two- and three-wheelers, buses, passenger or commercial vehicles.

The micromobility modes in the form of two- and three-wheelers have the biggest immediate impact on reducing CO2 emissions. Therefore, their role in the future of (urban) mobility cannot be emphasized enough. Already today, electric scooters, bikes, and mopeds eliminate one million barrels of oil per day.

REDUCTION IN OIL CONSUMPTION DUE TO ELECTRIFIED VEHICLES GLOBALLY

In million barrels of oil avoided per day

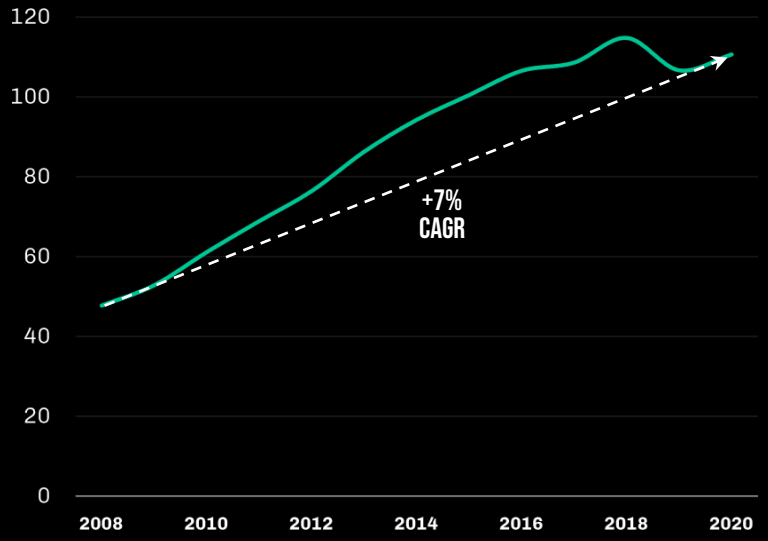


Source: BloombergNEF

IN SOUTHEAST ASIA, THE POTENTIAL FOR TWO-WHEELERS TO BECOME ELECTRIC IS GIGANTIC

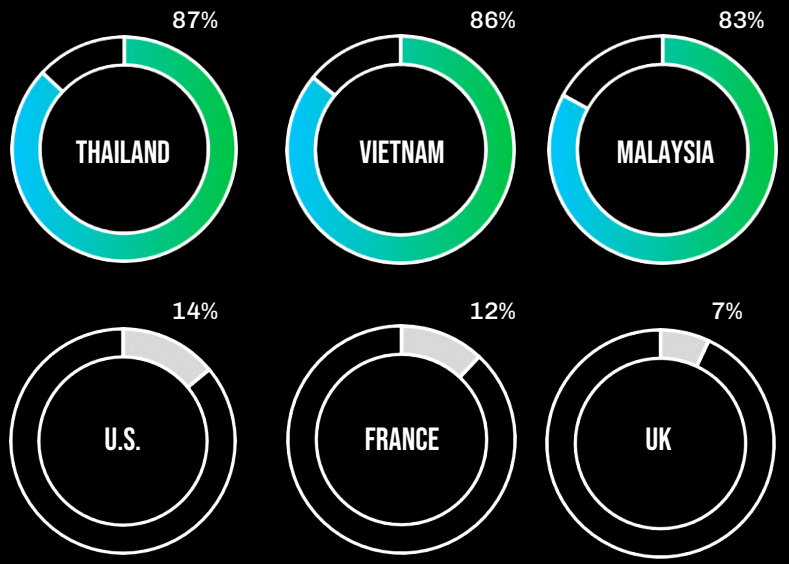
85% OF HOUSEHOLDS IN INDONESIA OWN AT LEAST ONE MOTORCYCLE

Total number of registered motorcycles in Indonesia (in million)



THE MOTORIZED 2-WHEELER IS A STANDARD HOUSEHOLD ITEM IN MOST SEA COUNTRIES

Share of households that own a motorbike



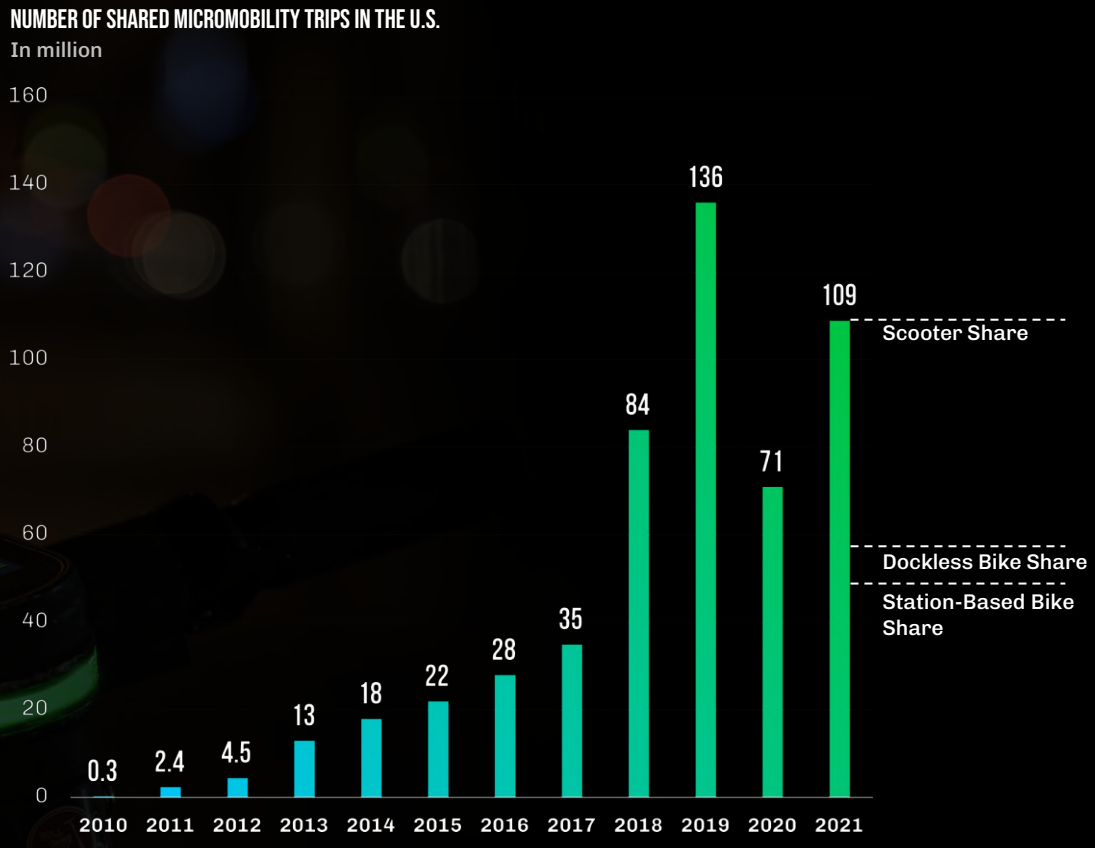
Source: ASEANstats, Pew Research Center, press articles

IN DEVELOPED NATIONS, SUCH AS IN THE U.S., SHARED MICROMOBILITY HAS FOUND ITS WAY

While micromobility in Southeast Asia will mostly come to life in the form of people buying electric motorbikes, the sharing model of micromobility has taken over in most advanced economies, such as the U.S.

Here, the rise of shared micromobility has been nothing short of remarkable with an estimated 136 million trips per year in 2019. When the pandemic hit in 2020, trips on every mode of transportation, including scooters and bikes, sharply dropped. However, shared micromobility usage rapidly recovered as it turned out to be a safer mode of transportation than sharing an Uber or taking public transit.

As cities continue to grow denser than ever before, thanks to rapid population growth, micromobility looks set to play an even bigger role in our lives moving forward.



Source: UP.Partners analysis based on data from NACTO and NABSA

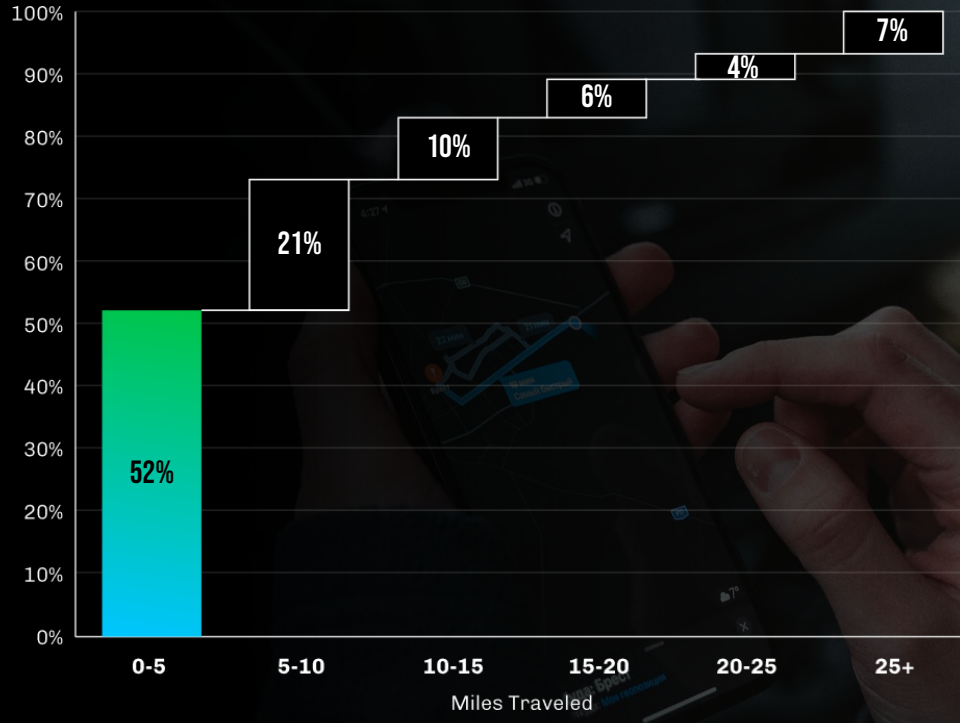
MORE THAN HALF OF ALL CAR TRIPS ARE VERY SHORT AND RIPE FOR SUBSTITUTION

Shared micromobility trips are short. In 2019, they averaged 11 to 12 minutes in length and one to one-and-a-half miles in distance, according to the National Association of City Transportation Officials in the U.S.

These short trips are important, given that they can replace the majority of car trips. In fact, 52% of all U.S. car trips are under five miles long. It's both environmentally and economically unsustainable to use gas-guzzling vehicles for these short distances.

Therefore, the potential of micromobility modes to replace cars and transform the mobility landscape as we know it is massive. By replacing car trips with micromobility trips, cities can reduce traffic congestion, improve air quality, and increase access for those who don't have access to traditional transportation options.

SHARE OF U.S. CAR TRIPS BY DISTANCE
In 5 mile bins



Source: Micromobility Industries

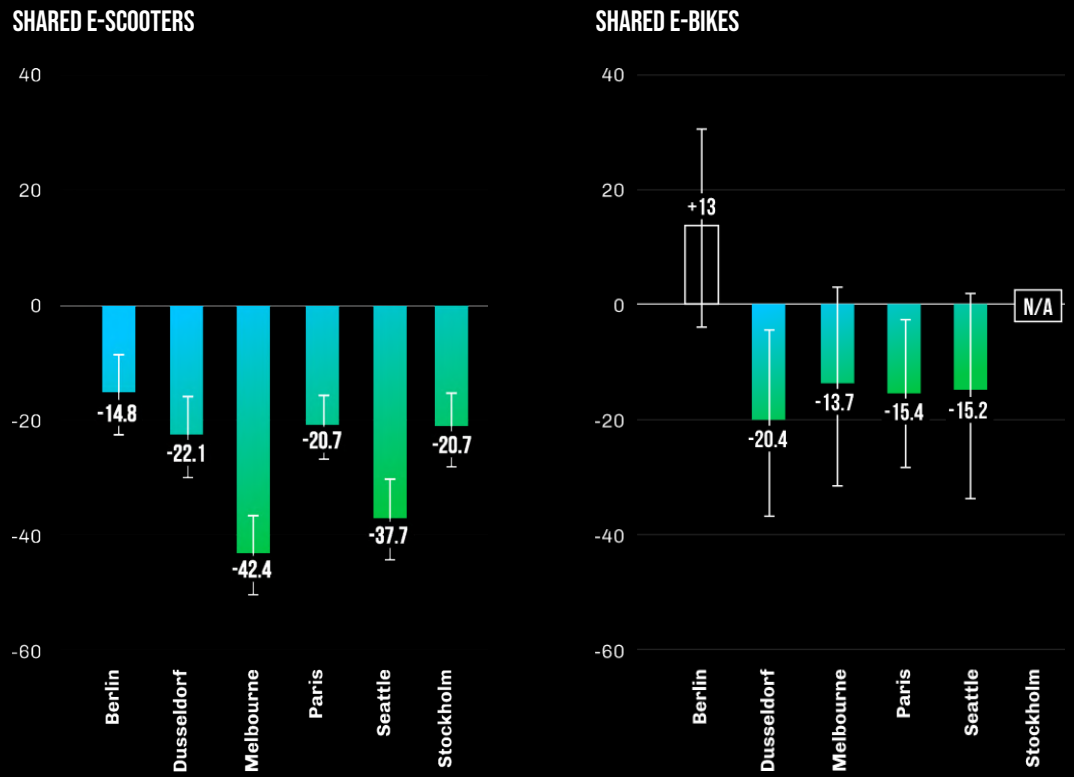
LATEST STUDIES SHOW THAT SHARED MICROMOBILITY REDUCES CITIES' EMISSIONS

In recent years, critics have argued that the introduction of shared micromobility modes has done more harm than good for the environment. This is because such services would generally replace trips with normal bicycles rather than cars. As well, given that first-generation scooters have notoriously lasted just a few weeks before becoming too damaged to ride, they had to be thrown away.

However, a new study is challenging the myth that micromobility doesn't cut car travel or reduce more emissions than the modes they tend to replace. Researchers at the Fraunhofer Institute for Systems and Innovation Research found that greenhouse gases actually decreased as a result of shared scooters and e-bikes being introduced. In all cities under investigation, except for shared e-bikes in Berlin, shared micromobility modes reduced the carbon emissions of cities' transportation systems.

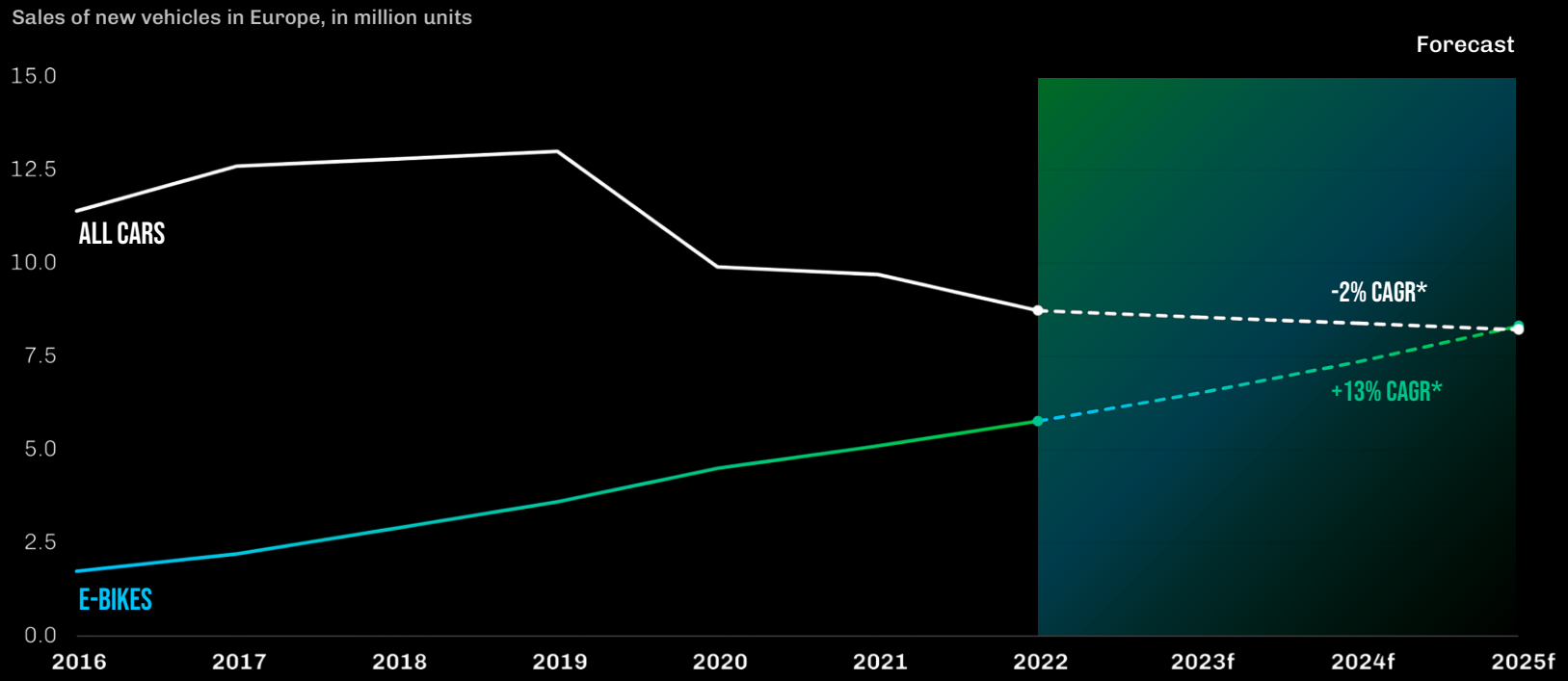
NET IMPACT IN EMISSIONS OF LATEST-GENERATION SHARED MICROMOBILITY ON CITY LEVEL

In CO2e 2022 (g/pkm)



Source: Fraunhofer Institute for Systems and Innovation Research

PERSONAL OWNERSHIP OF E-BIKES LOOKS PARTICULARLY PROMISING, ESPECIALLY IN EUROPE



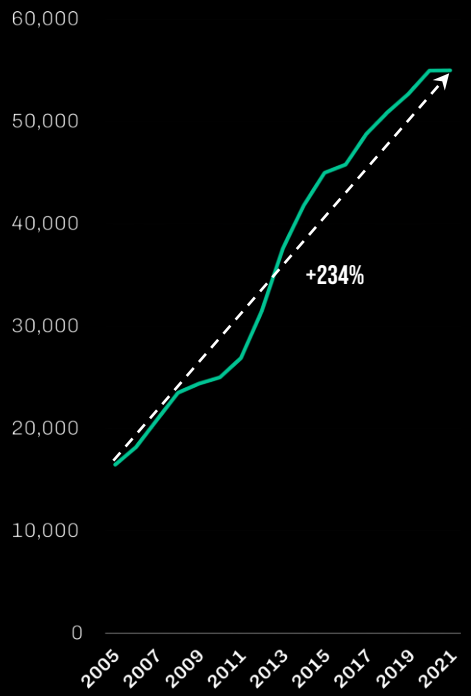
Source: UP.Partners analysis, ZIV, Conebi, ACEA
*Forecasts based on respective 2020-2022 growth rates

CITIES NEED TO RETHINK INFRASTRUCTURE TO HANDLE A RISING NUMBER OF BIKERS

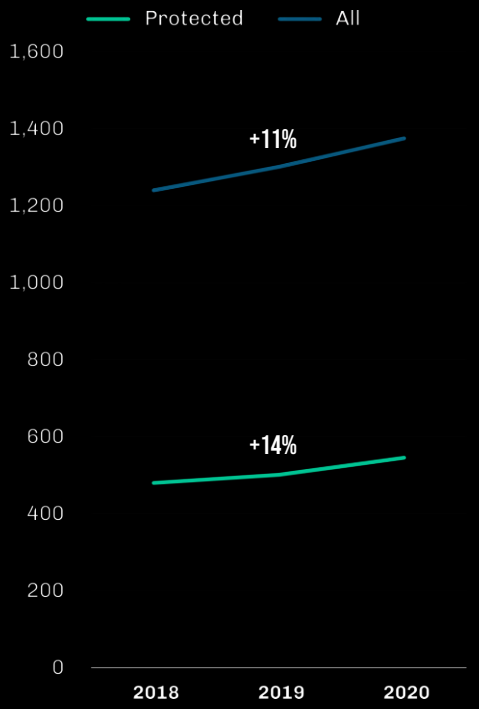
With sustainable transportation becoming increasingly important, cities around the world are facing an unprecedented challenge to keep up with the proliferation of micromobility. Because many roads were not originally designed for the safety and convenience of cyclists, investments in new infrastructure, such as additional bike lanes, must be made. This is necessary in order to adequately support the rising numbers of bikers who contribute significantly towards reducing emissions levels.

To foster a healthier mobility landscape, traditional urban commuting strategies must be reengineered, which will ultimately pave the way for success in promoting eco-friendly journeys that benefit us all.

NUMBER OF DAILY COMMUTERS WHO BIKE TO WORK IN NYC



TOTAL BIKE LANE MILES INSTALLED IN NYC

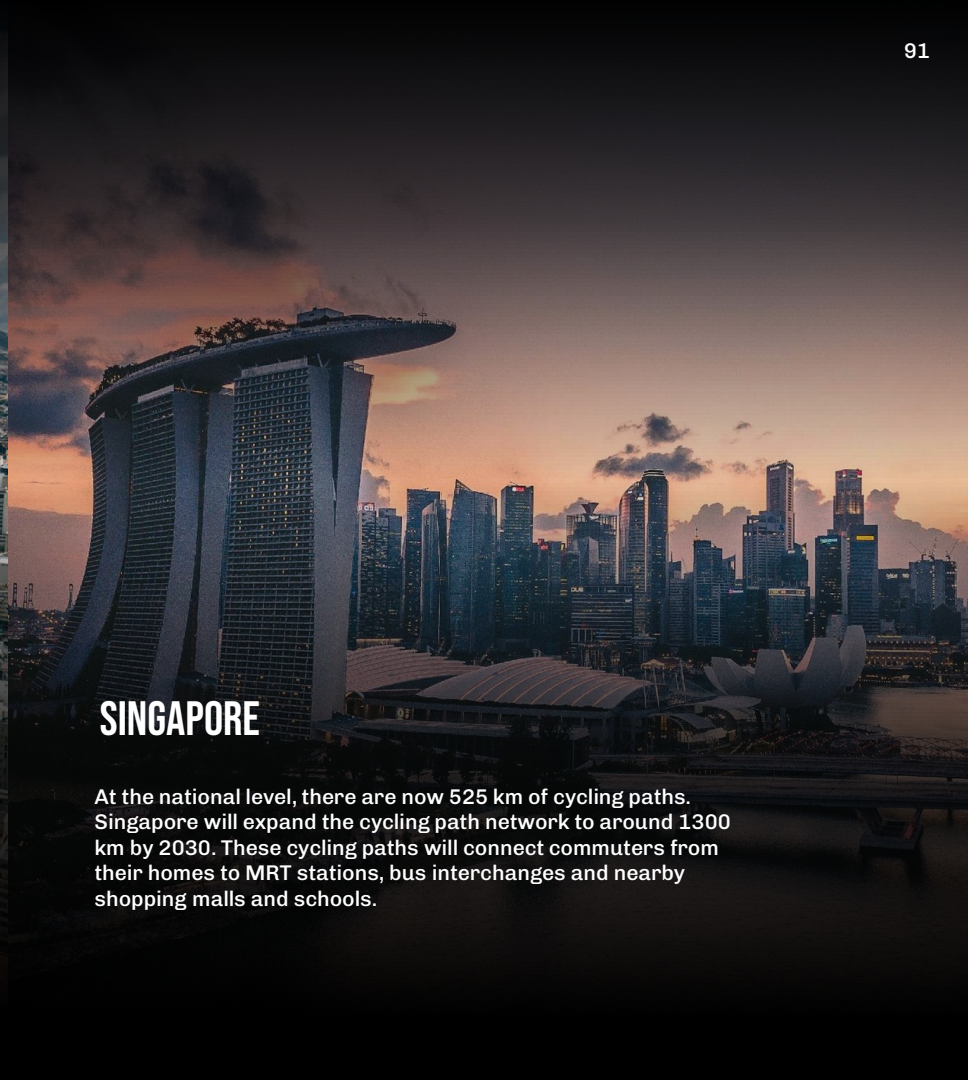


Source: The City of New York

A FEW CITIES SHOW HOW TO DO IT RIGHT

BOGOTÁ

In recent years, Bogotá has become one of the leading cities for urban cycling. Between 2015 and 2021 alone, the bicycle infrastructure was expanded by an impressive 33% from 443 km to 590 km. Bogotá's 2020-24 Strategic Plan includes the goal to further expand bike routes to 830 km by 2024.



SINGAPORE

At the national level, there are now 525 km of cycling paths. Singapore will expand the cycling path network to around 1300 km by 2030. These cycling paths will connect commuters from their homes to MRT stations, bus interchanges and nearby shopping malls and schools.

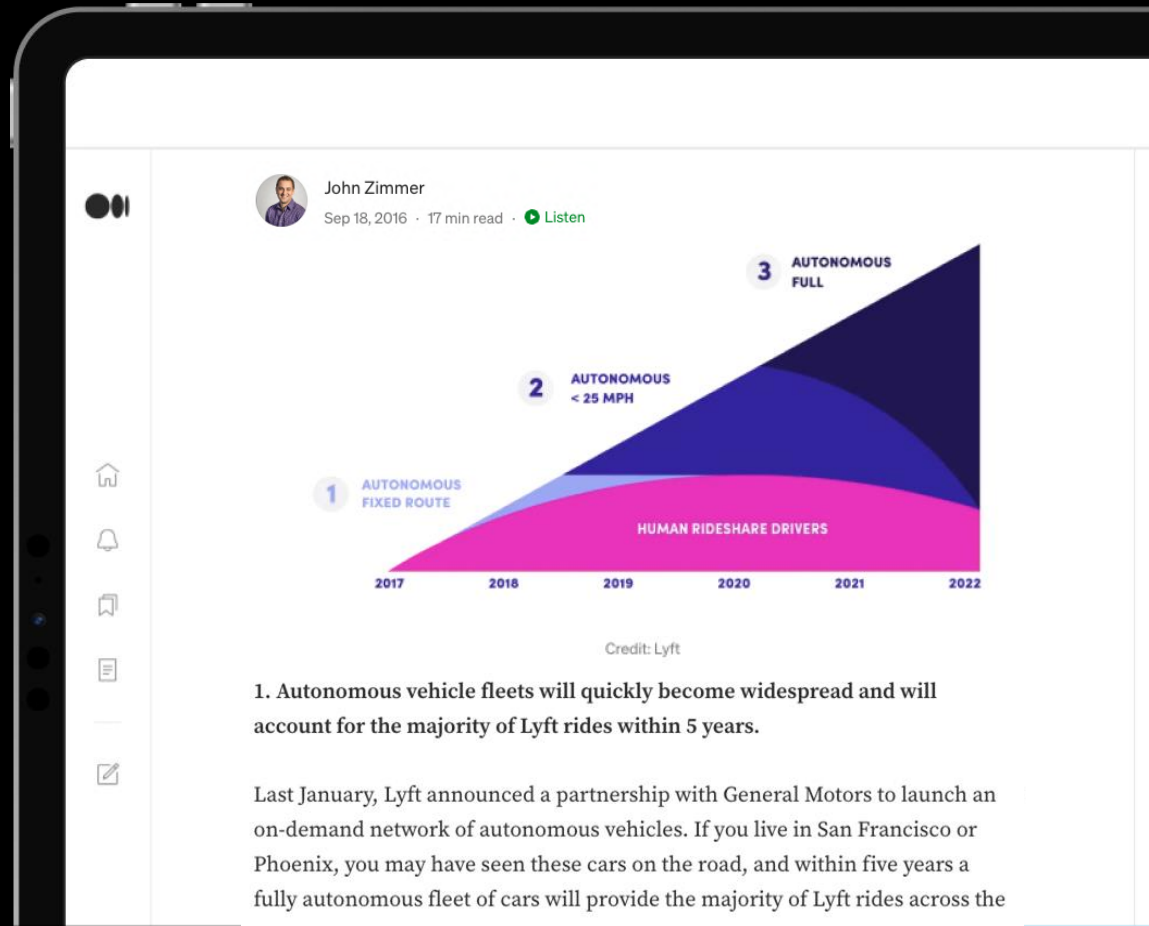
Source: UP.Partners research based on TUMI, Singapore Land Transport Authority

2.3 FULLY AUTONOMOUS DRIVING REMAINS A MYTH, FOR NOW

WE SHOULD ALL HAVE BEEN CRUISING AROUND IN SELF-DRIVING CARS BY NOW

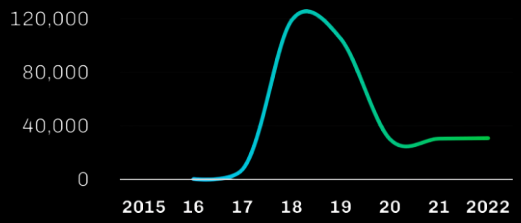
Self-driving cars have long been predicted to revolutionize transportation and make roads safer. Engineers, policymakers, startup founders, and futurists have all been dreaming of a future in which cars do not require drivers. In this vision of tomorrow, accidents are diminished due to flawless safety features and convenience takes over with point-to-point travel where no human touch is necessary. While this future was anticipated to arrive by the early 2020s, we are significantly off track from realizing autonomous vehicles as a mainstream part of daily life on public roads anytime soon. Instead, what's happening is a brutal shakedown among hyped-up companies, all of which are trying to bring the technology to life. In early 2023, it appears that only two of the top companies, Alphabet's Waymo and Cruise, are pressing ahead. Both companies are experimenting with driverless robotaxi services in small areas in a few select cities across the U.S. Thus far, viable business models are not in sight.

Source: Lyft Co-Founder John Zimmer on Medium

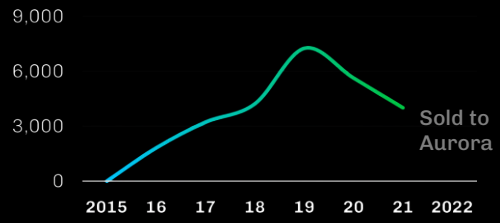


SELF-DRIVING CAR COMPANY VALUATIONS HAVE DROPPED PRECIPITOUSLY

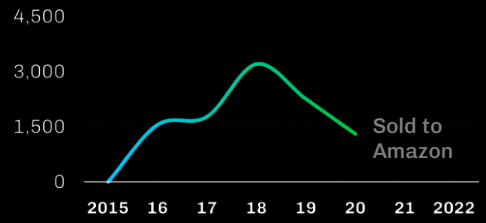
WAYMO
Company valuation in million USD



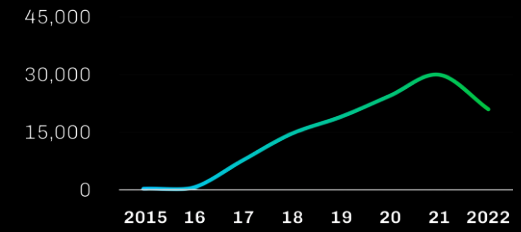
UBER (SELF-DRIVING DIVISION)
Company valuation in million USD



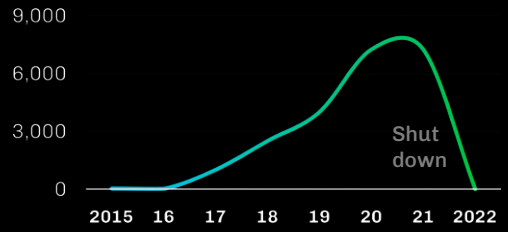
ZOOX
Company valuation in million USD



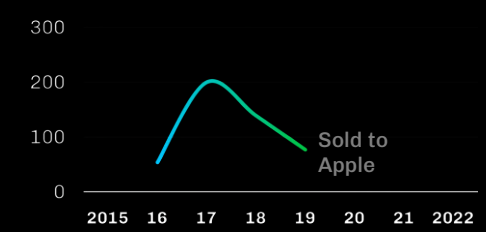
CRUISE
Company valuation in million USD



ARGO AI
Company valuation in million USD



DRIVE.AI
Company valuation in million USD



Source: UP.Partners analysis based on data from PitchBook Data Inc., Crunchbase, press releases

FOR NOW, AUTONOMOUS ONLY BECOMES COMMERCIALLY RELEVANT IN PROTECTED ENVIRONMENTS

Teleo

Teleo turns construction equipment into “supervised” autonomous robots. One operator remotely controls two or more pieces of heavy equipment at the same time.

vay

Vay offers a teledrive-first approach to autonomous driving by enabling a person (“the teledriver”) to control a vehicle remotely (“teledriving”) while gradually introducing more autonomous driving functionalities.

amazonrobotics

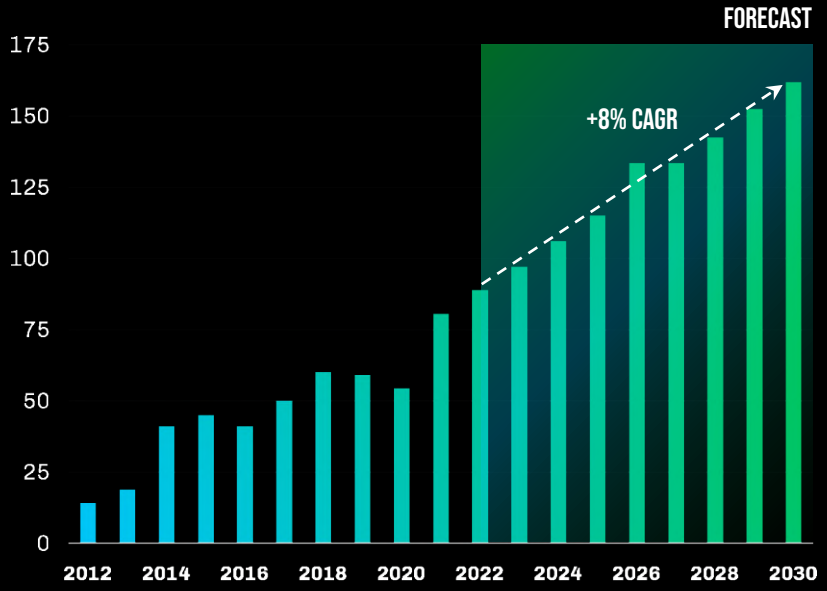
Amazon Robotics has deployed more than 520,000 robotic drive units across its fulfillment and sort centers. Most recently, Amazon presented Proteus, which is an autonomous floor system that helps with the lifting and movement of cargo carts.

Source: UP.Partners research

ALSO, IT'S STILL A LONG ROAD TO DRIVERLESS TRUCKS EVEN THOUGH THEY ARE URGENTLY NEEDED

THE ECONOMIC PRESSURE TO OVERCOME THE DRIVER SHORTAGE IS EXTREMELY HIGH

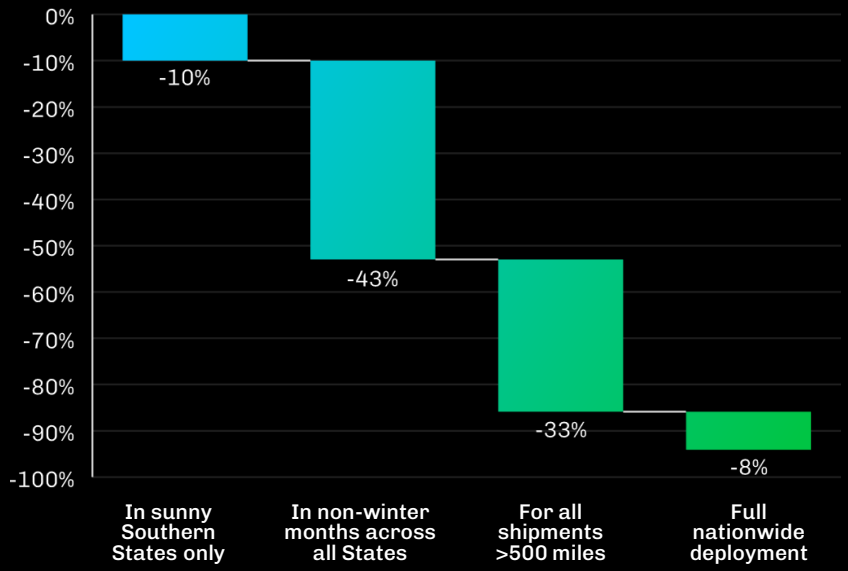
Number of truck drivers needed in the U.S. (in thousand)



Source: ATRI, Statista estimates

AUTONOMOUS TRUCKS ON INTERSTATE ROUTES COULD SOFTEN THE DRIVER SHORTAGE SIGNIFICANTLY

Share of truck operator hours to be impacted by autonomous driving in different deployment scenarios within the U.S.



Source: Mohan and Vaishnav from Carnegie Mellon University & University of Michigan

AUTOMAKERS HAVE GIVEN UP FULL AUTONOMY FOR NOW—INSTEAD EYEING L2 AND L3 ADAS

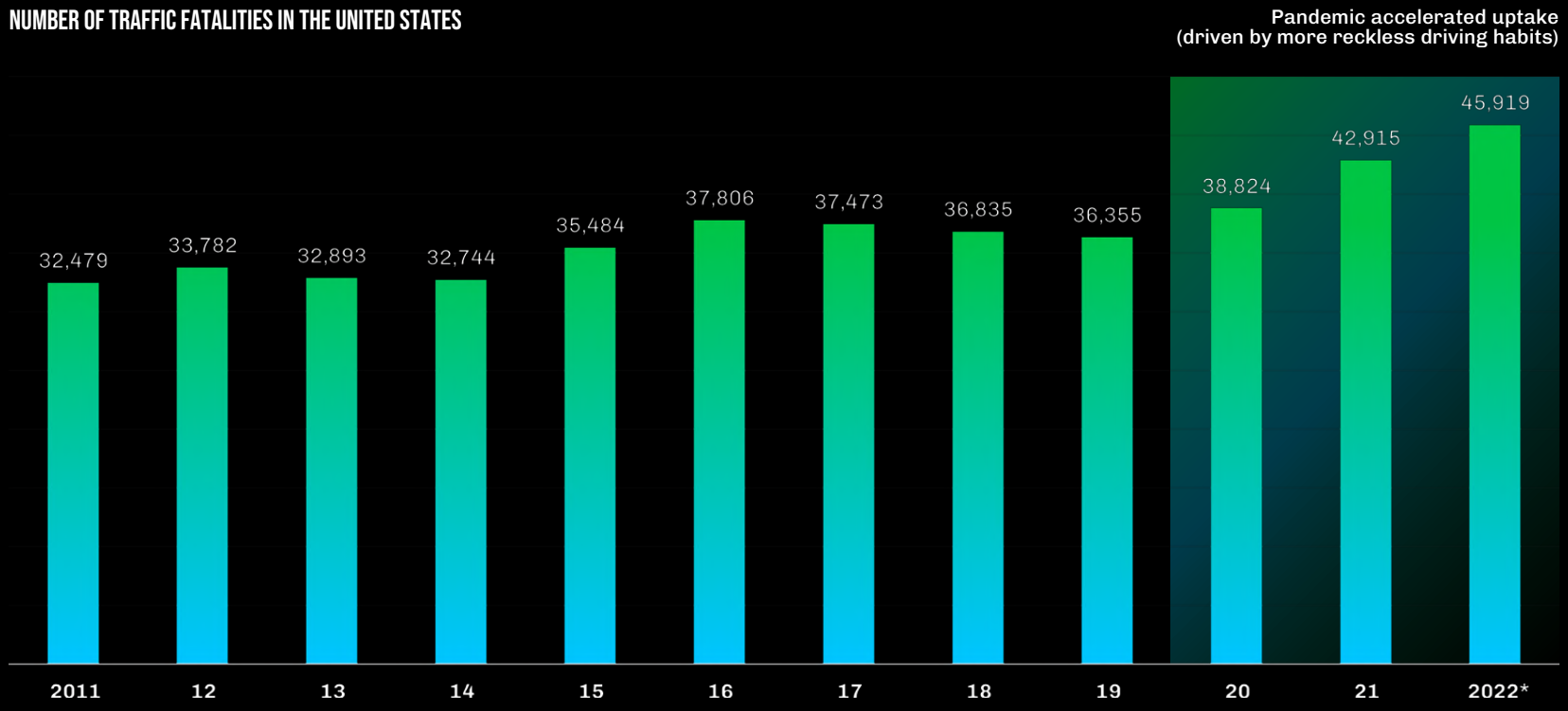
LATEST ADVANCED DRIVER-ASSISTANCE SYSTEMS (ADAS) BY SELECTED AUTOMOTIVE COMPANIES

Not all-encompassing

	Mercedes Benz	BMW	XPENG	Li Auto	NIO	Ford	gm	TESLA	VW
NAME	Drive Pilot	Drive Pilot	XPILOT 3.5 (planned)	AD Max (planned)	Nio Pilot/Nio NAD (planned)	Blue Cruis	Super Cruise	Autopilot FSD (Beta)	Travel Assist 2.5
SAE LEVEL	L3	L2+ / (L3 in 2023)	L3	L3	L2	L2	L2	L2	L2
ODD	Selected highways	Selected highways	Selected cities & highways	Selected cities & highways	Selected cities & highways	Selected highways	Selected highways	Selected cities & highways	Highways + country roads
LIDAR	Valeo	Innoviz	Livox	Hesai	Innovusion	N/A	Cepton	N/a	N/A
COMPUTING	Nvidia	Mobileye	Nvidia	Nvidia	Nvidia	Mobileye	Qualcomm	Tesla	Mobileye
MODELS	S-Class	BMW i7	P5, P7, G9 (planned)	L9 (planned)	ES/EC6, ES8, ET7, ET5	Mach-E, F150	Bolt EUV, Escalade, Silverado	Models S, Model X, Model 3, Model Y	ID.4, ID.5, ID.BUZZ
REGION	EU (US)	EU (US)	CN	CN	CN	US	US	US	EU

Source: Augustin Friedel research

SAFER ROAD TRANSPORT IS MISSION-CRITICAL AS TRAFFIC FATALITIES CONTINUE TO RISE

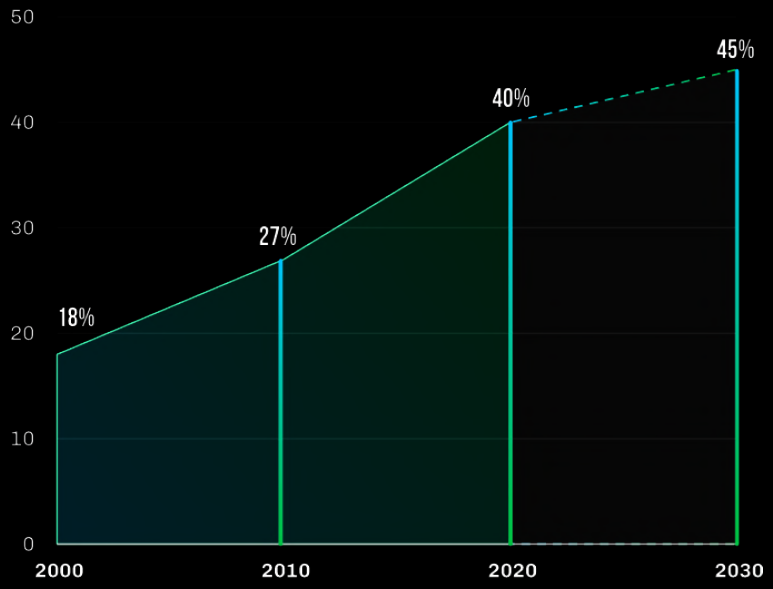


Source: UP.Partners analysis based on data from NHTSA
*2022 estimate extrapolated via YoY growth rate in Q12022 vs. Q12021

NEVERTHELESS, CARS WILL BECOME INCREASINGLY CONNECTED AND INTELLIGENT...

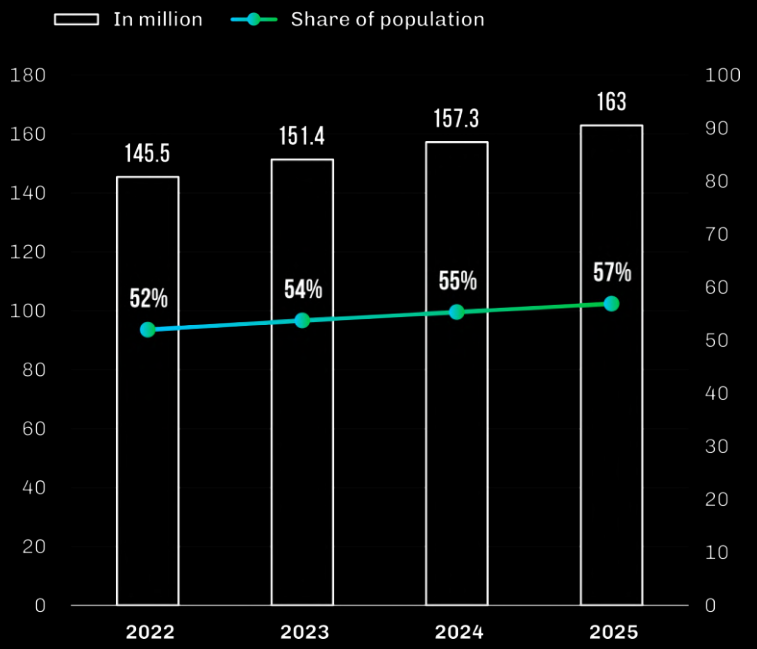
SHARE OF ICE CAR COSTS ASSOCIATED WITH ELECTRONIC COMPONENTS

Forecasts from 2020 on



Source: Silicon Valley Bank

CONNECTED CAR DRIVERS IN THE U.S.



Source: Insider Intelligence (emarketer)

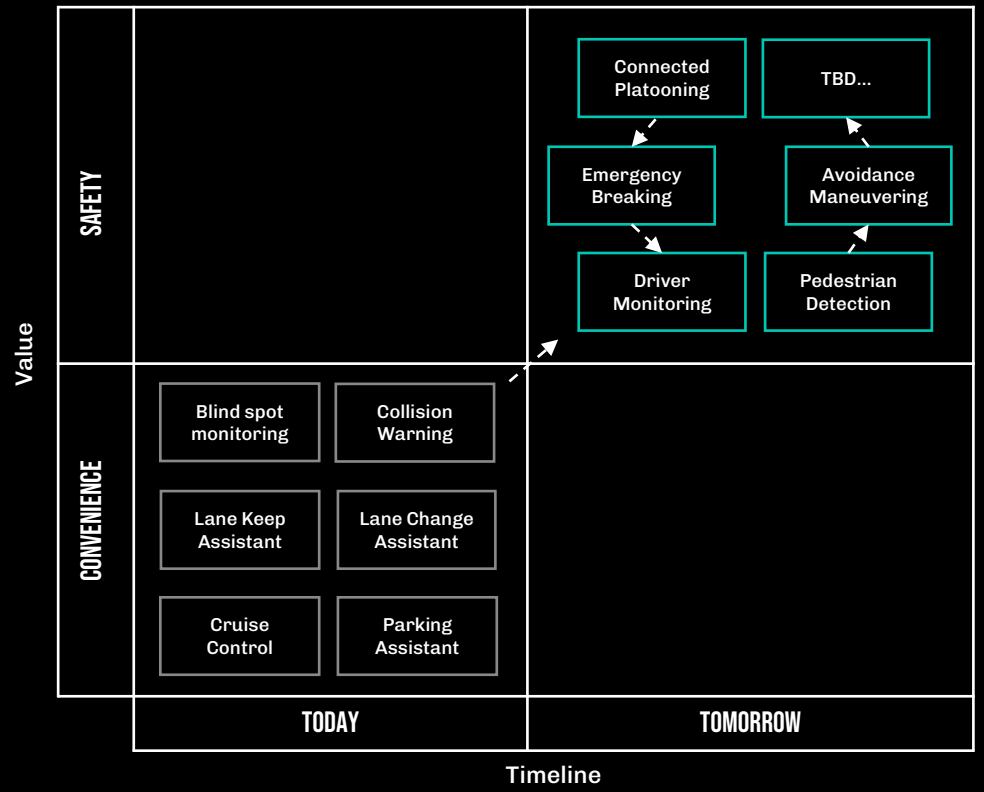
...THIS WILL UPGRADE ADAS FROM CONVENIENCE FEATURES INTO ACTUAL LIFE SAVERS

Car companies are striving to paint a picture of our future with zero collisions, touting their ongoing efforts in Advanced Driver Assistance Systems (ADAS) as the key to realizing this dream. However, despite these ambitious promises, American roadway fatalities have seen an unprecedented surge–expected to reach more than 45,000 deaths in 2022, an 18% growth over 2020 alone–casting doubt on how advanced modern technology truly is in delivering salvation from catastrophes that befall drivers and pedestrians alike every day.

As ADAS components become the defining features of today's cars, they must advance beyond mostly providing convenience and extra comfort. Soon, their true potential will be evident: to become a legitimate safety measure that protects lives thanks to advancements in Embedded Vision and advanced Sensor Fusion. The latter uses multiple types of sensors for the same application to enable smarter car monitoring, no matter the road conditions.

MAPPING MAJOR ADVANCED DRIVER ASSISTANCE SYSTEM FEATURES

Illustrative



Source: UP.Partners analysis

SUMMARY OF SECTION 2

In Section 2, this report explored the future of road transportation in more detail. Close to 80% of CO2 emissions from transportation are generated “on the road,” mostly from conventional cars and trucks. Therefore, the electrification of the automobile is the most important step towards lower emissions.

To illustrate how fast the auto market could be electrified, we zoomed in on Norway. The Nordic country is arguably the most advanced electric auto market in the world. 88% of all cars sold in Norway in 2022 were electric. The electric vehicle adoption in Norway seems difficult to mimic. However, we believe that the world’s two biggest auto markets, the U.S. and China, are not far behind. Both countries have recently passed the critical 5% market adoption milestone, which is expected to unlock exponential growth in the next few years. With this, we expect half of America’s new car sales to be electric well before the end of 2030—something that long seemed out of reach.

For this to happen, it’s mission-critical that the world overcomes major roadblocks that currently stand in the way of more rapid EV adoption.

These include:

- EV charger growth in many countries, such as the U.S., is still way too low. China’s fast-current charging network is more than 30 times larger than the one in the U.S. and it also continues to grow much faster.
- Battery demand to power millions of EVs in the future will grow ten times larger by 2030, which will lead to a threatening raw-material shortage, especially metals such as Lithium, Cobalt, and Nickel–the main components of a battery. In fact, the lithium price is already spiking today due to demand outstripping supply.
- Another major challenge that could jeopardize the success story of electric vehicles is the fact that charging them could challenge electricity grid operations. This is especially the case in places that rely heavily on renewable energy as electricity supply fluctuates heavily throughout the day, which could be further intensified by millions of EV drivers charging their cars during the night.

In all fairness, there are also trends that could help further accelerate EV growth. For instance, there has been massive government funding to support the EV transition as demonstrated by the $130 billion USD towards direct mobility support, which is part of the Inflation Reduction Act in the U.S.

Furthermore, the steady learning curve of battery production has led to cheaper prices and higher energy density levels over the past decade. These advancements will, ultimately, make EVs cheaper than their ICE counterparts, as long as the raw-material shortage for EV batteries can be mitigated.

Looking beyond the auto market, electric vehicles are not the only form of cleaner road transportation to get excited about. Micromobility modes, such as electric bikes, e-scooters and e-mopeds, already displace more than one million barrels of oil every single day.

Southeast Asia is a region that is particularly promising for the future of electric two-wheelers. Up to 90% of households in countries like Thailand depend on motorbikes to get around town. In advanced economies like the U.S., shared micromobility has found its way to mass-market transportation with more than 100 million trips per year. This figure is expected to further increase as more than half of all car trips in the U.S. are shorter than 5 miles and look ripe for substitution by micromobility. Such a scenario would reduce a city’s CO2 emissions, as evidenced by the latest research studies from well-known academic institutions.

Whether or not micromobility in the form of shared business models will remain the dominant use case is too early to tell. Most shared micromobility providers continue to have a tough time finding a viable business model. Personal ownership of electric bikes, for instance in bike-heavy markets like Europe, might turn out to be more viable. Here, the sale of new e-bikes is expected to beat the total volume of new cars by 2025.

SUMMARY OF SECTION 2

Finding sustainable commercial models to operate shared e-bike and scooter fleets is challenging as it is. Developing fully autonomous cars is even more daunting. Self-driving cars have long been predicted to revolutionize transportation and make roads safer. Engineers, policymakers, startup founders, and futurists have all been dreaming of a future in which cars do not require drivers.

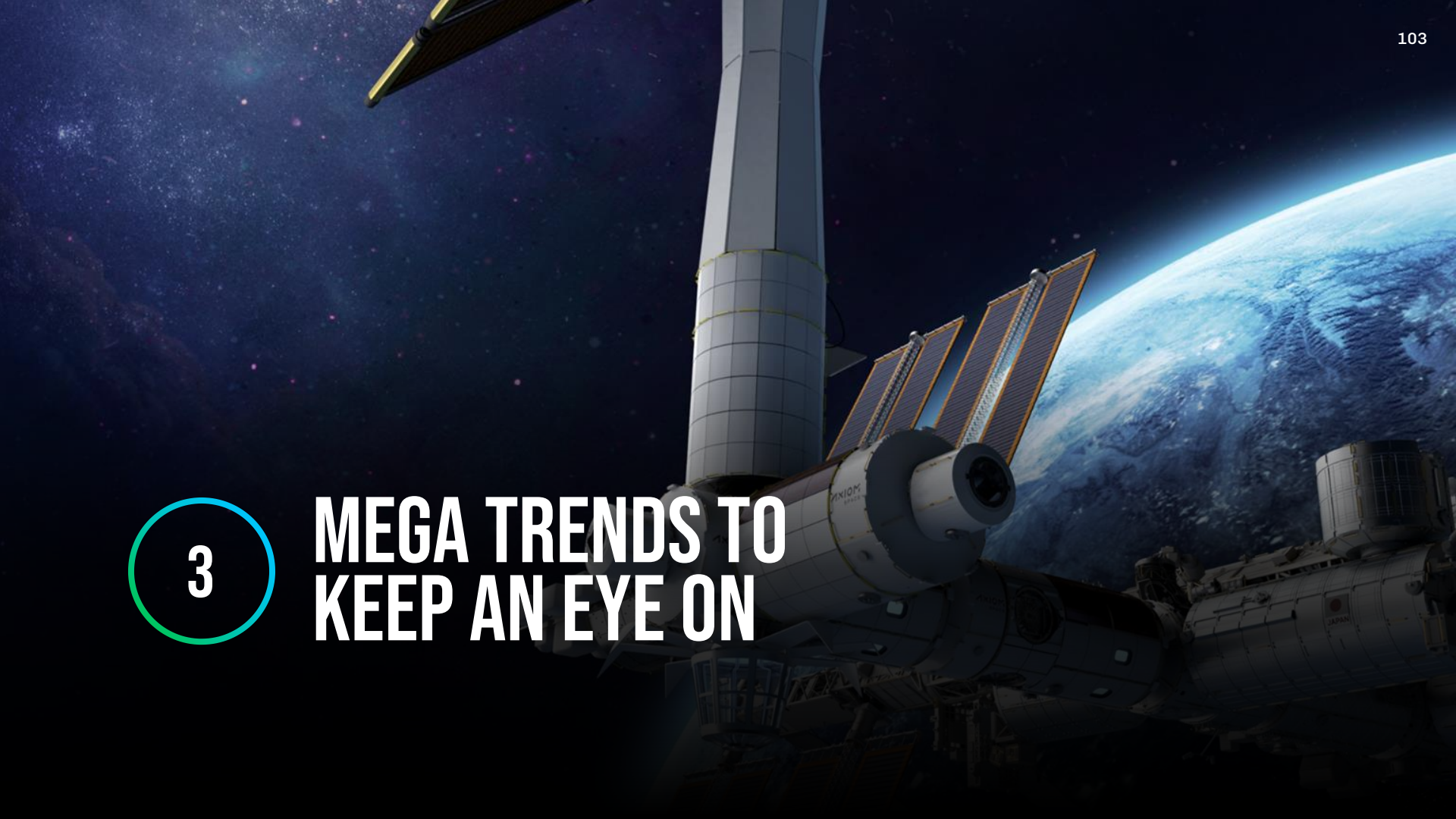
While this future was anticipated to arrive by the early 2020s, we are significantly off track from realizing autonomous vehicles as a mainstream part of daily life on public roads anytime soon. Instead, what's happening is a brutal shakedown among hyped-up companies, all of which are trying to bring the technology to life. As a consequence, in the near future, we only expect autonomous vehicles to become market ready in so-called "protected environments" as in the case of tele-supervised autonomous construction vehicles.

However, for a safer and more efficient future of transportation, the need and value of autonomous vehicles remains significant. Autonomous trucks, in particular, are urgently needed to overcome the driver shortage that grows by the day. In the U.S alone, more than 150,000 additional truck drivers will be needed by the end of the decade.

At the same time, safer road transportation is mission-critical to stop the accelerating trend of growing traffic fatalities. As automakers have given up full autonomy for now, they are instead focusing on better Level 2 and Level 3 Advanced Driver-Assistance Systems (ADAS).

As ADAS components become the defining features of today's cars, they must advance beyond mostly providing convenience and extra comfort. Soon, their true potential will be evident: to become a legitimate safety measure that protects lives.

This will be an important step towards safer road transportation as 2022 is expected to have become another record-year for traffic fatalities in the U.S.



3 MEGA TRENDS TO KEEP AN EYE ON

THREE MEGA TRENDS THAT MAY TRANSFORM THE FUTURE OF MOBILITY

Innovation

DISRUPTIVE

INCREMENTAL

BATTERY RECYCLING

HYPERSONIC TRAVEL

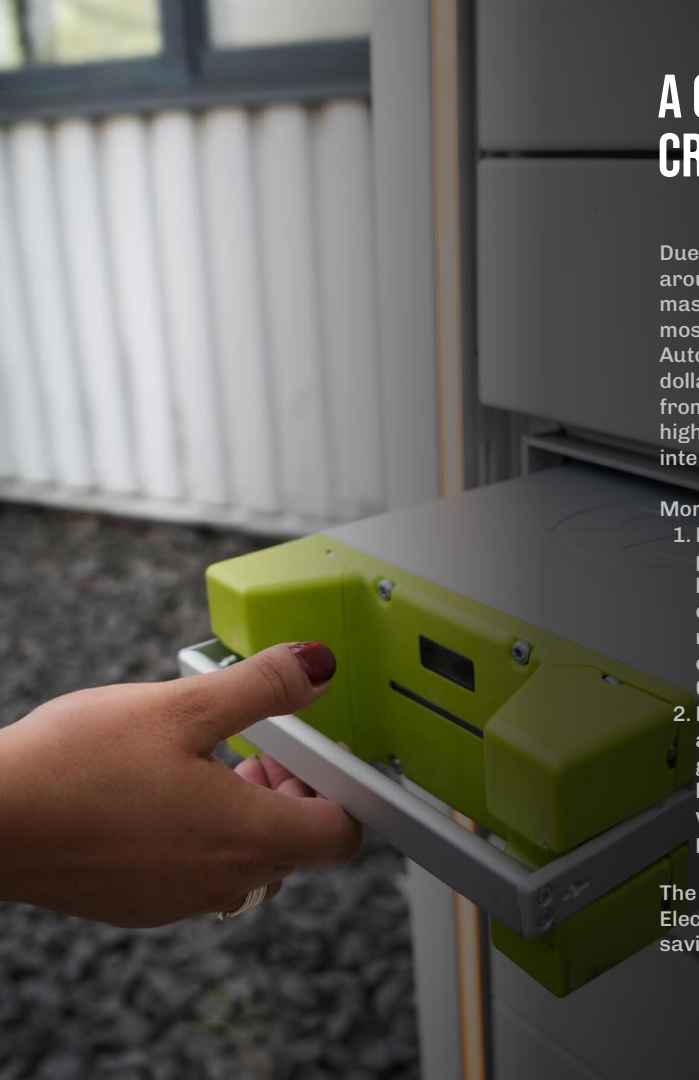
THE LUNAR ECONOMY

Timeline

SHORT-TERM

LONG-TERM

Source: UP.Partners analysis



A CIRCULAR BATTERY ECONOMY IS MISSION-CRITICAL FOR THE FUTURE OF MOBILITY

Due to the electrification of transport systems around the world, battery demand will increase massively over the next decade. This uptake is mostly due to the rise of electric vehicles. Automakers plan to spend hundreds of billions of dollars in the next ten years to transition away from the internal combustion engine. As previously highlighted, four of the top-six global carmakers intend to phase out gasoline vehicles by 2035.

More batteries mean essentially two things:

1. More raw materials will be needed. In particular, lithium will be required. This will likely lead to a long-lasting lithium supply crunch as we showed in Section II. In fact, the raw material shortage can already be observed in China today, which refines about 65% of the world's lithium capacity.
2. More battery waste will be generated. Industry analysts estimate that, in 2020, China already generated some 500,000 metric tons of used lithium-ion batteries and that, by 2030, the worldwide number will hit 2 million metric tons per year.

The latter, especially, is extremely worrisome. Electric cars produce significant environmental savings through decreased emissions.

However, if these vehicles do not have a proper recycling plan in place then much of that advantage could be lost.

If current trends for handling spent batteries continue, most of them will end up in landfills even though lithium-ion batteries can be recycled. These popular power packs contain valuable metals and other materials that can be recovered, processed, and reused. With this in mind, the lithium-ion battery industry lacks a clear path to large-scale economical recycling. This presents a tremendous opportunity for startups to address this shortcoming by enabling a circular battery economy.

Companies like Northvolt, a Swedish battery maker set up by a pair of ex-Tesla executives, have recently started focusing on the recycling of used batteries to create new ones. Their latest battery factories aim at obtaining up to half their raw materials, including scarce substances such as lithium, cobalt, and nickel, from recycled batteries. If Northvolt (and others) succeed in meeting such ambitious targets, this will be a big step towards circular manufacturing, a long-held dream in which firms make new products by recycling their old ones. In turn, this will greatly reduce environmental footprints and overcome raw-material shortages.

THE WORLD IS GOING TO NEED AT LEAST 3X MORE LITHIUM BY THE END OF THE DECADE

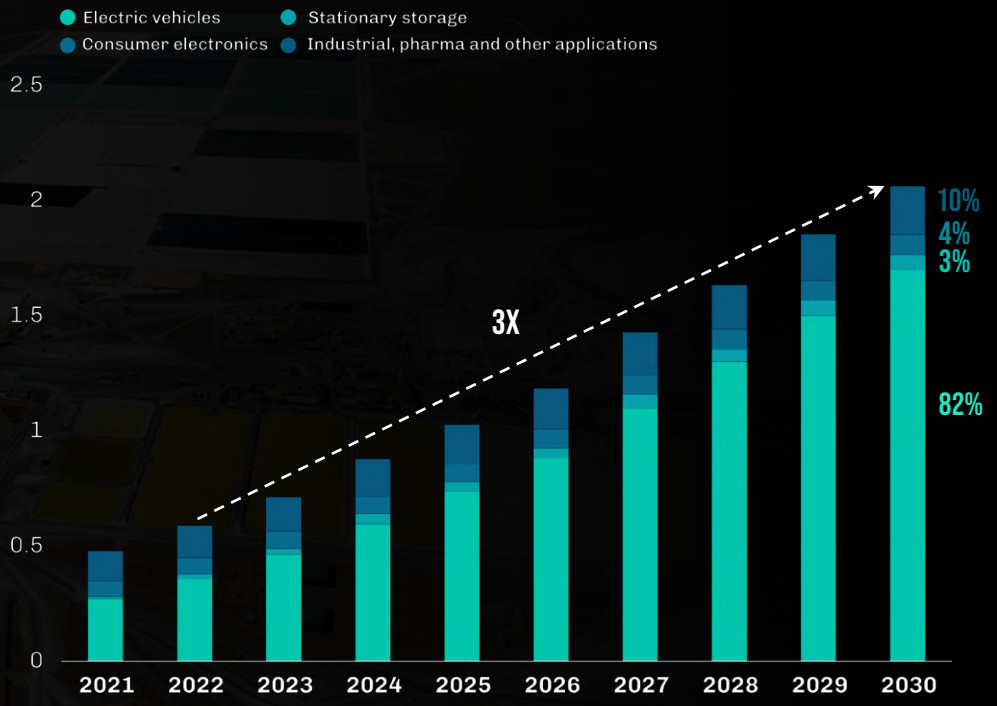
As we have illustrated in Section II, lithium is one of the most sought-after materials on the market as demand for electric vehicles continues to rise.

Bloomberg estimates that more than two million tons of lithium carbonate will be needed by the end of the decade, of which more than 80% will be used for electric vehicles. However, the wonder metal at the heart of the global shift to electric cars is in a full-blown crisis that could dent the transportation industry's chances of meeting its climate goals.

The shortage of lithium is so acute that, in China, which makes between 60 and 80% of the world's lithium-ion batteries, the government corralled suppliers and manufacturers to demand "a rational return" to lower prices earlier this year.

EXPECTED DEMAND FOR LITHIUM

In million tons of lithium carbonate equivalent (LCE)



Source: BloombergNEF

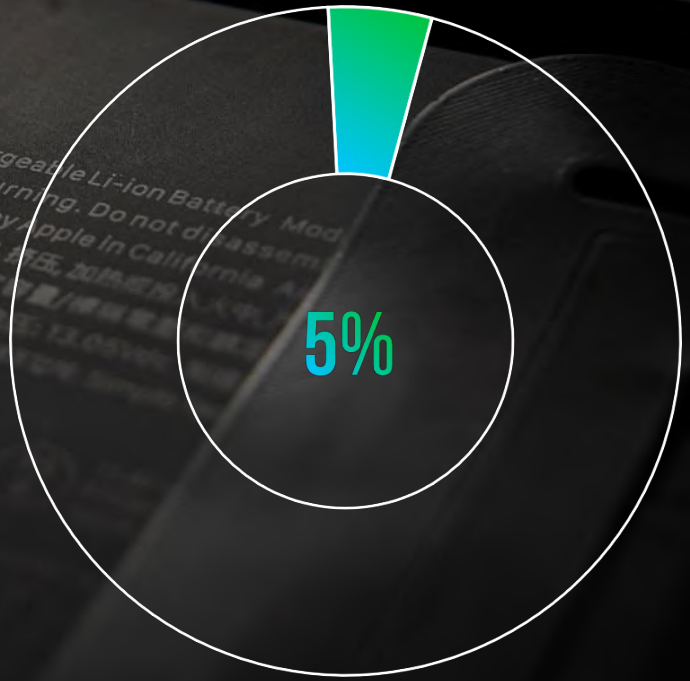
THE VAST MAJORITY OF LI-ION BATTERIES CURRENTLY END UP IN LANDFILLS

The consequences of failure to produce enough lithium are potentially devastating for the future of electric vehicles and cleaner transportation as a whole. However, growing concerns over the worsening lithium shortage appear bizarre when considering that lithium and other precious metals could be recycled from used batteries.

Recycling can reduce the need to mine new materials and limit dependence on imports. But lithium-ion battery recycling is barely in use today. Most industry experts confirm that not more than 5% of used lithium batteries are currently being recycled.

While used batteries are likely to contain materials of value, significant battery design variability and the lack of technological convergence contribute to the challenges faced with recycling. This makes the automation of recycling processes difficult and costly.

SHARE OF USED LITHIUM-ION BATTERIES IN THE U.S. CURRENTLY BEING RECYCLED



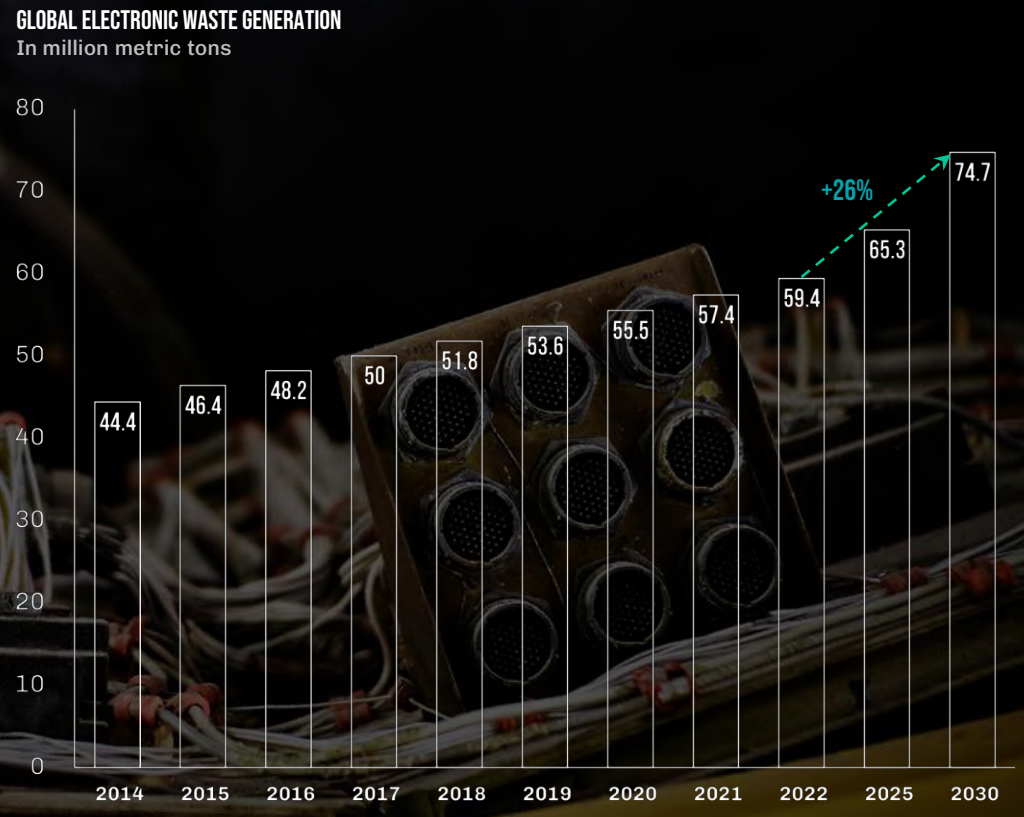
Source: American Chemical Society (CAS)

ELECTRONIC WASTE, IN GENERAL, IS THE FASTEST-GROWING WASTE STREAM

The reckless disposal of lithium-ion batteries is part of a larger trend. The annual output of electronic waste as a whole has been steadily expanding over the past ten years. E-waste contains a mixture of valuable materials that can be recycled (but usually aren't) and toxic materials such as lead, mercury, and cadmium, which can be hazardous to our health and the environment.

It is estimated that 59.4 million Mt of e-waste was generated globally in 2022. This output is expected to grow another 26% by 2030, making e-waste the fastest-growing waste stream in the world.

The explosion in popularity of electric cars with ever-increasing battery sizes, in tandem with the rapid disposal of smartphones and other electronics, are the underlying causes.

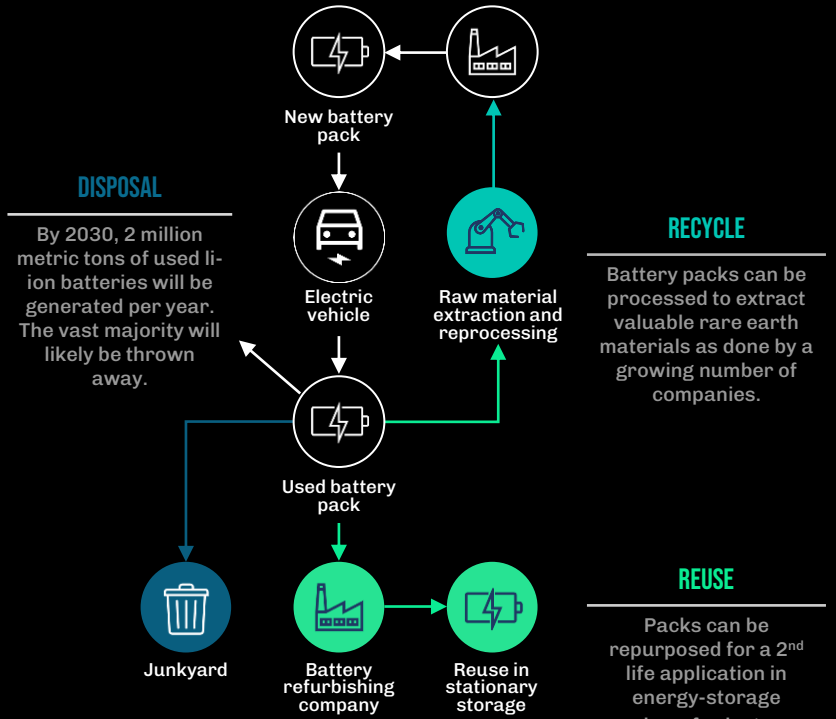


Source: E-Waste Monitor, The Roundup

IT'S HIGH TIME TO BUILD A CIRCULAR BATTERY ECONOMY AND RAMP UP STATIONARY STORAGE

ELECTRIC-VEHICLE BATTERY LIFE CYCLE

Illustrative



DISPOSAL

By 2030, 2 million metric tons of used li-ion batteries will be generated per year. The vast majority will likely be thrown away.

RECYCLE

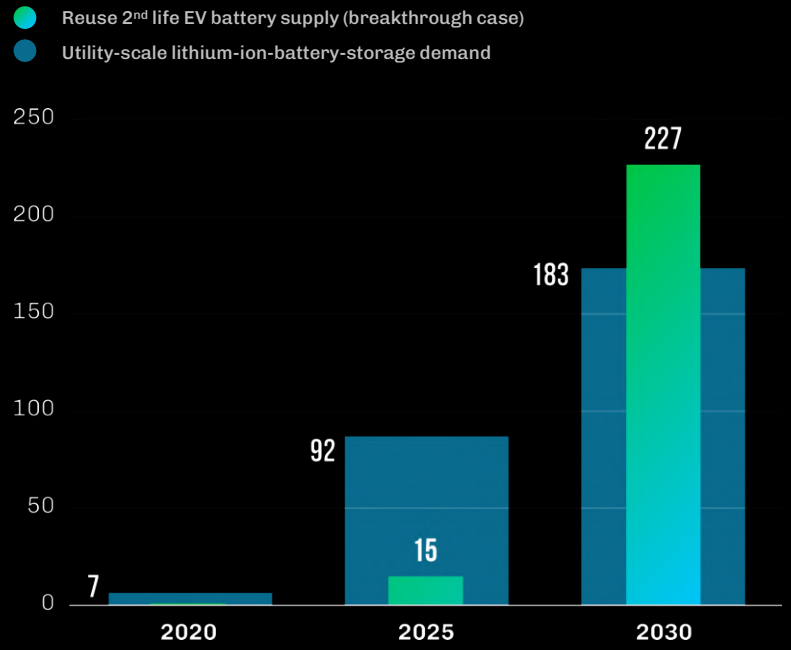
Battery packs can be processed to extract valuable rare earth materials as done by a growing number of companies.

REUSE

Packs can be repurposed for a 2nd life application in energy-storage services, for instance.

2ND LIFE EV BATTERY SUPPLY VS. UTILITY-SCALE LITHIUM-ION-BATTERY-STORAGE DEMAND

In GWh/year



Source: McKinsey

BATTERY RECYCLING WILL PROTECT THE EV INDUSTRY FROM FALLING OFF THE CLIFF

OVERVIEW OF POST-2014 FOUNDED BATTERY-RECYCLING COMPANIES

Not all-encompassing

	REDWOOD MATERIALS	Li-Cycle	Lithion	ASCEND ELEMENTS	AQUA METALS
COMPANY NAME	Redwood Materials	Li-Cycle	Lithion	Ascend Elements	Aqua Metals
HQ LOCATION	Carson City, United States	Toronto, Canada	Montreal, Canada	Westborough, United States	Reno, United States
COMPANY STATUS	Private (late stage)	Publicly held	Private (late stage)	Private (late stage)	Publicly held
TOTAL FUNDING	1 billion USD	774 million USD	140 million USD	93 million USD	50 million USD
DETAILS	The firm is developing a fully closed loop system that recycles and process scrap from battery cell production and post-consumer packs into anode and cathode materials directly usable by cell manufacturing companies in the US and elsewhere.	The company processes manufacturing scrap and end-of-life batteries to produce "black mass" and other intermediate products to recover raw materials, including lithium carbonate, cobalt sulphate and nickel sulphate.	Provider of lithium-ion battery recycling service intended to offer a combination of hydro and electrometallurgy-based extraction processes. The result is a size and chemistry agnostic process emitting very low GHG emissions.	Manufacturer of advanced battery materials using elements reclaimed from spent lithium-ion batteries using hydro process recycling and direct recycling that takes old cathode material down to the atomic level to create new cathode materials.	Self-proclaimed producer of a commercially proven sustainable, closed-loop metal recycling process that is capable of producing the world's purest metals through a patent-pending process called AquaRefining.

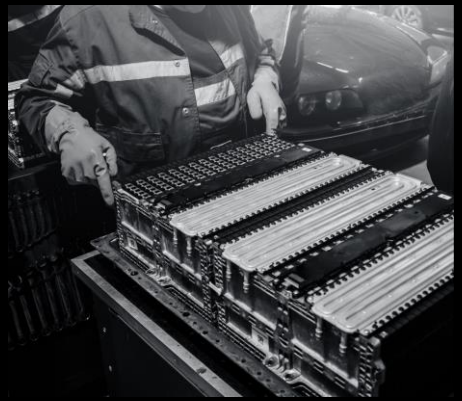
Source: UP.Partners research based on PitchBook Data Inc., Crunchbase, company websites

THREE MEGA TRENDS THAT WILL TRANSFORM THE FUTURE OF MOBILITY

Innovation

DISRUPTIVE

INCREMENTAL



BATTERY RECYCLING

HYPERSONIC TRAVEL

THE LUNAR ECONOMY

Timeline

SHORT-TERM

LONG-TERM

Source: UP.Partners analysis

HYPERSONIC TRANSPORT COULD REIMAGINE THE WAY WE TRAVEL FROM A TO B

While two decades have passed since the Concorde retired, supersonic aircraft have not returned to passenger air travel. This is not a technology challenge but a business issue, one that just doesn't make sense. The time benefits for travelers in supersonic jets are not great enough to outweigh higher prices and less comfort. This is especially the case when airlines are not interested in adding supersonic jets to their fleets amid rising sustainability concerns. This topic will make airlines focus on more efficient and less polluting aircraft than entirely new aircraft models with higher speeds.

However, hypersonic air travel, which happens at speeds of Mach 5 or greater (five times the speed of sound or more), will ultimately become a reality in commercial aviation. Why? Humankind has always progressed towards more comfort, convenience, and most importantly, more efficient use of time and money. Hypersonic air travel will eliminate the pain of being stuck in a metal tube forever, allowing people to get from New York to London in just 90 minutes. This is much faster considering it took about three hours for the Concorde to make the trip and between six to seven hours for a regular passenger jet to do the same.

The technology will ultimately get there. At present, rockets and unmanned drones fly at hypersonic speed. Hypersonic passenger planes could take off from a conventional airport at subsonic speeds before streaking into the wild blue yonder to the edge of the atmosphere (170,000 feet or 52 kilometers) while in hypersonic mode. This will also mitigate the sonic boom heard on the ground.

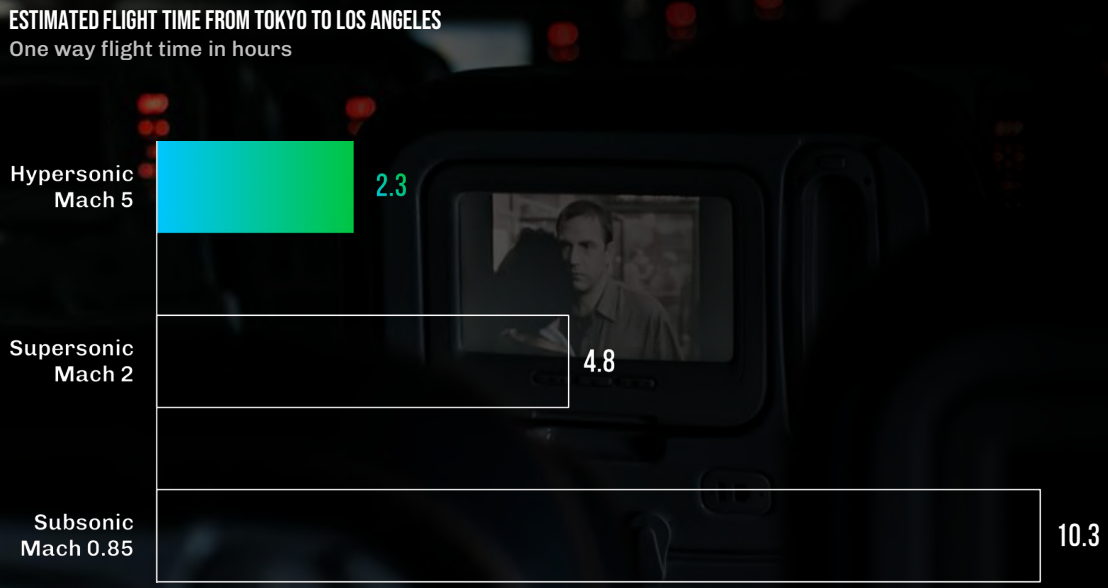
In addition, hypersonic jets could ultimately reach a state where they become more fuel efficient than traditional commercial aircraft due to high-altitude flying, even though this development is still many decades away in the future.

The momentum for hypersonic high tech is growing. Regulatory changes and governmental imperatives might propel innovation dynamics. The U.S. Department of Defense, for instance, is already seeking to leverage private investment in commercial hypersonic vehicle technology to demonstrate a high-speed test aircraft.

HYPERSONIC AIR TRAVEL WOULD LITERALLY BRING THE WORLD CLOSER TOGETHER

The primary benefit of hypersonic jets would be the drastically reduced travel times between destinations. This would allow business travelers and vacationers alike to make better use of their time while still reaching their destination safely and comfortably.

While private planes already save passengers significant time on short-haul flights, they fail to do so for long-haul flights. This is another unmet need that hypersonic flight would be able to fulfill. Based on economic models by ARK Invest, passengers might be willing to pay about $100,000 to save 12 hours on a two-hour private hypersonic flight from New York City to Japan. This hypothesis is based on the observation that today's private passengers on short-haul flights are willing to pay roughly $15,000 for every two hours saved via private planes. This would open up a gigantic market opportunity for hypersonic travel providers.



Source: Spaceworks

A GROWING NUMBER OF FIRMS ANNOUNCED PLANS TO BUILD COMMERCIAL HYPERSONIC JETS

OVERVIEW OF HYPERSONIC COMPANIES

Not all-encompassing

COMPANY	PROJECT	APPLICATION	SPEED	PROPULSION	FIRST FLIGHT	ANNOUNCED FUNDING
Dawn Aerospace	Aurora MK II	Spaceplane	Mach 5+	Rocket engines	TBA	$22 million
Destinus	Hyperlane	Transport	Mach 15	Rocketplane	2024-2025	$29 million
Hermeus	Quarterhorse/ Halcyon	Transport	Mach 5	Gas turbine-scramjet	2023	$176 million
Hypersonix	Delta Velos	Space Launch	Mach 12	Rocket-scramjet-rocket	2024	$50.1 million
New Frontier Aerospace	TBA	Transport	Mach 8	Liquid natural gas rockets	TBA	$1.1 million
Polaris	Aurora	Space Launch	Orbital	Rockets	TBA	Undisclosed
Radian Aerospace	Radian one	Crewed Space Launch	Orbital	Rockets	2030	$32 million
Reaction Engines	TBA	Transport	Mach 5	Air-breathing-rocket	TBA	$161.7 million
Space Engine Systems	Sexbomb/Hello-1/-2	Space Launch	Mach 5	Air launch-ramjet	2023	Undisclosed
Space X	Starship (Suborbital)	Transport	Mach 20	Rockets	2023	Undisclosed
Stratolaunch	Talon-A	Testbed	Mach 6	Air launch-ramjet	2023	Undisclosed
Velontra	Bronco	Space Launch	Mach 5	Turbine-based combined -cycle	2024-25	$1.5 million
Venus Aerospace	TBA	Transport	Mach 12	Rocket-hypersonic glide vehicle turbine	TBA	$33 million

Source: Aviation Week Network (updated by UP.Partners)

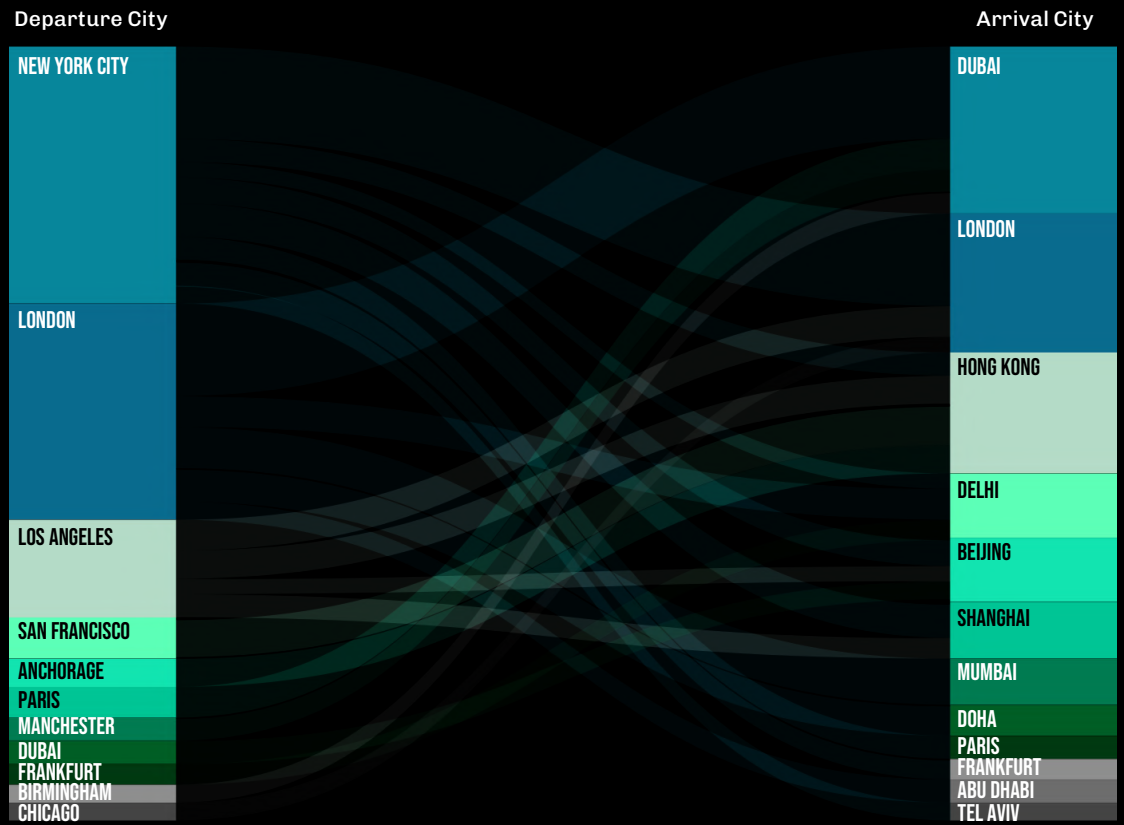
THE HYPERSONIC TRAVEL NETWORK OF THE FUTURE WILL BE HIGHLY CONCENTRATED

NASA has long studied the fundamental physics and technologies to support the development of hypersonic aircraft. In 2021, the space agency also commissioned independent studies to evaluate the potential market for commercial hypersonic transportation.

In one of those studies, conducted by SAIC and BryceTech, the researchers modeled future passenger demand for hypersonic air travel and projected the top 25 routes based on revenue.

The top three routes turned out to be London to Dubai, New York City to London, and San Francisco to Hong Kong. In general, the researchers assessed more than 800 city pairs and concluded that the number of commercially viable hypersonic routes decreased the more aircraft speed increased due to rising operation costs.

TOP CITY PAIRS FOR HYPERSONIC TRAVEL BY ESTIMATED 2050 REVENUE



Source: SAIC & BryceTech (commissioned by NASA)

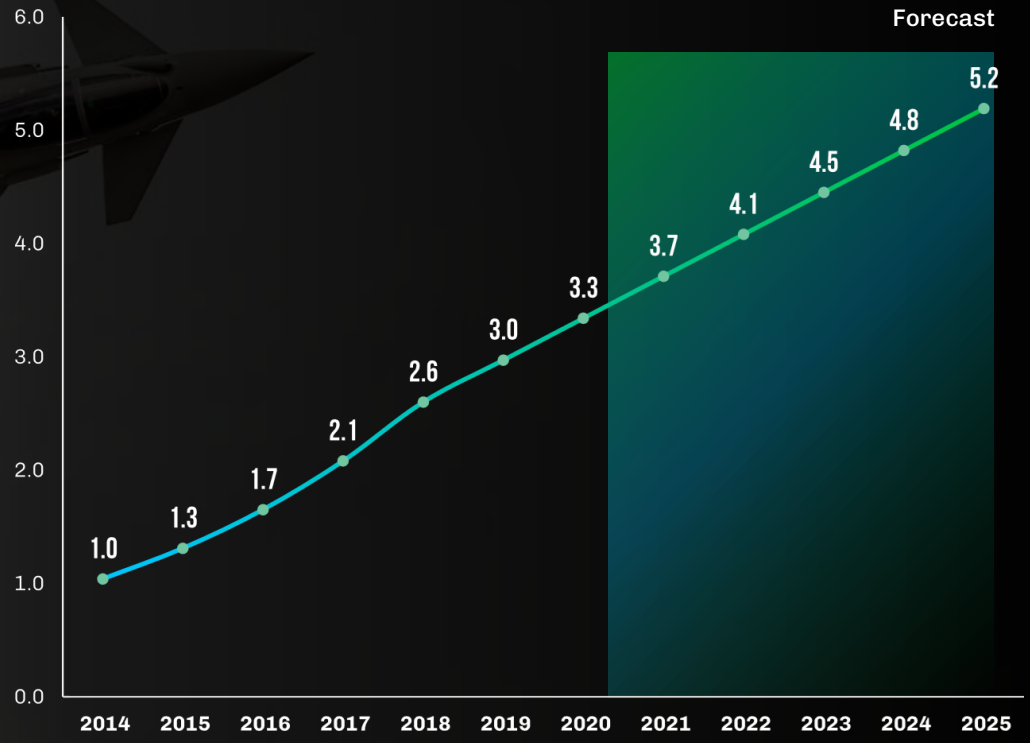
INITIALLY, THE HYPERSONIC MARKET WILL FOCUS ON MILITARY APPLICATIONS

The adoption of hypersonic flight will be a transformational event for the moving world. Although the rise of hypersonic commercial air travel is still decades away, the technological foundation is being laid today. In fact, advances in hypersonic technology are quickly accelerating. For instance, applications in the defense context are already becoming operational.

According to Deloitte, today's hypersonic market is concentrated on national defense: offensive weapons and associated countermeasures. Annual unclassified defense spending requests for hypersonic technology reached more than $3 billion USD in 2020 with a 26% compound annual growth rate since 2014.

These types of investments into hypersonic technologies will likely flourish in the coming years. This is especially the case in response to changing geopolitics and military buildup in many regions of the world.

ANNUAL UNCLASSIFIED DEFENSE SPENDING REQUESTS FOR HYPERSONIC TECHNOLOGY
In billion USD



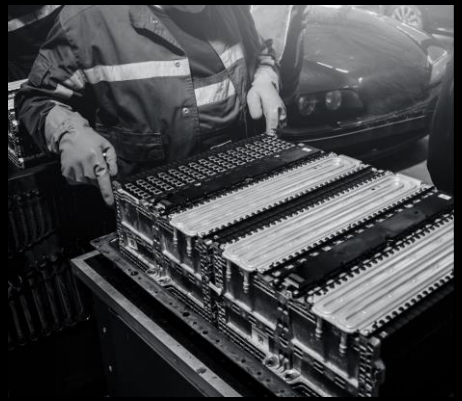
Source: UP.Partners analysis based on data from Deloitte, CNBC, J.P. Morgan

THREE MEGA TRENDS THAT WILL TRANSFORM THE FUTURE OF MOBILITY

Innovation

DISRUPTIVE

INCREMENTAL



BATTERY RECYCLING

HYPERSONIC TRAVEL

THE LUNAR ECONOMY

Timeline

SHORT-TERM

LONG-TERM

Source: UP.Partners analysis

LUNAR EXPLORATION WILL OPEN UP NEW OPPORTUNITIES BEYOND OUR IMAGINATION

One of the biggest commercial opportunities in Space Tech is building infrastructure on the Moon, such as gas stations, which will ultimately enable further space voyages to Mars. This is the case given that potential rocket launches from the Moon would take less energy than those from Earth.

As a result, the vision of a permanent human presence on the Moon is highly desirable. The Moon has native compounds, such as water molecules (mostly at the Moon's south pole), that could be mined to provide liquid water for drinking and plant propagation. Water could also be split into hydrogen and oxygen by solar panel-equipped electric power stations or a nuclear generator, providing breathable oxygen, alongside the components of rocket fuel.

Therefore, NASA and private space companies, such as SpaceX, eagerly aim to return humans to the Moon by mid-century, setting up permanent camps over the next ten years as bases for further Mars expeditions in the 2030s.

The U.S. is not alone in its endeavors. Many of the technological breakthroughs in space are being pursued by China, a country that is also geared towards putting down stakes on the Moon, ensuring its own long-term presence that could support commercial ventures (as well as military applications).

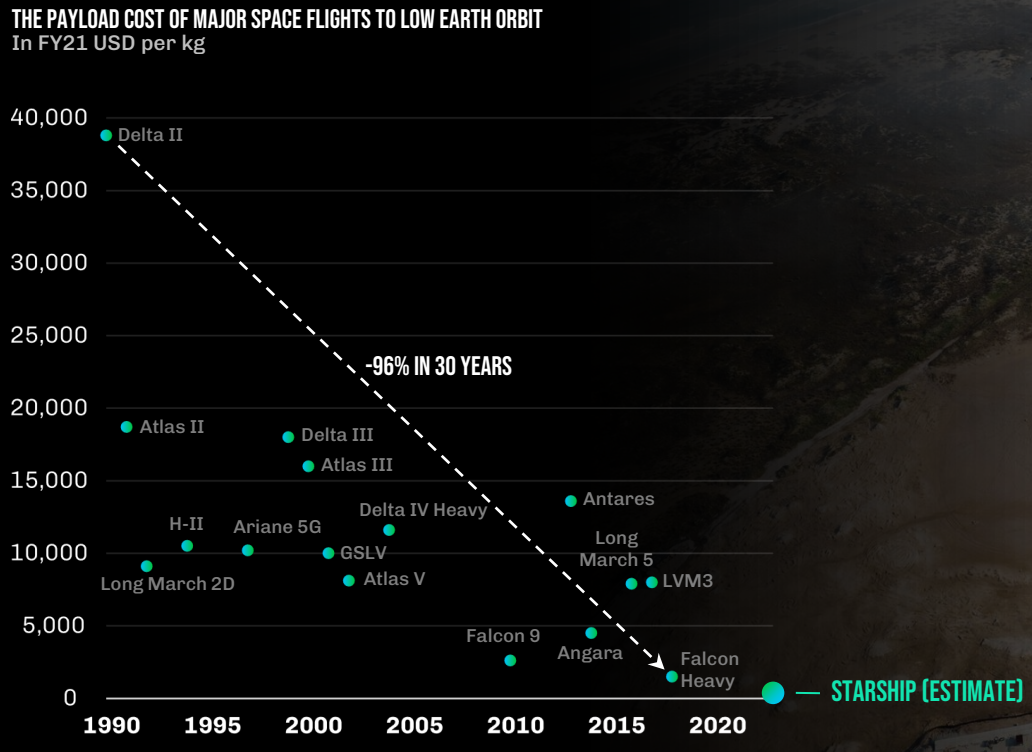
If the vision of establishing a permanent presence on the Moon becomes successful, it will lay the foundation for a full-blown lunar economy.

A lunar economy would include the general economic activity associated with the production, use, and exchange of lunar resources on the Moon's surface, in lunar orbit, and on Earth. In fact, every industry will start operating in space at some point in the future.

While there are a huge variety of potential activities that fit into the definition of a lunar economy, transportation would certainly be one of the key applications. This could include travel routes between Earth and the Moon and exploiting on-moon resources, which involves mining and extracting resources, manufacturing products, building infrastructure, and exporting goods and materials.

Therefore, the lunar exploration ecosystem clearly extends beyond space agencies, involving private actors and non-space industries, which leads to a transportation market worth hundreds of billions of dollars over the next few decades.

ONE DRIVER FOR THE LUNAR ECONOMY IS FALLING COSTS DUE TO REUSABLE ROCKETS



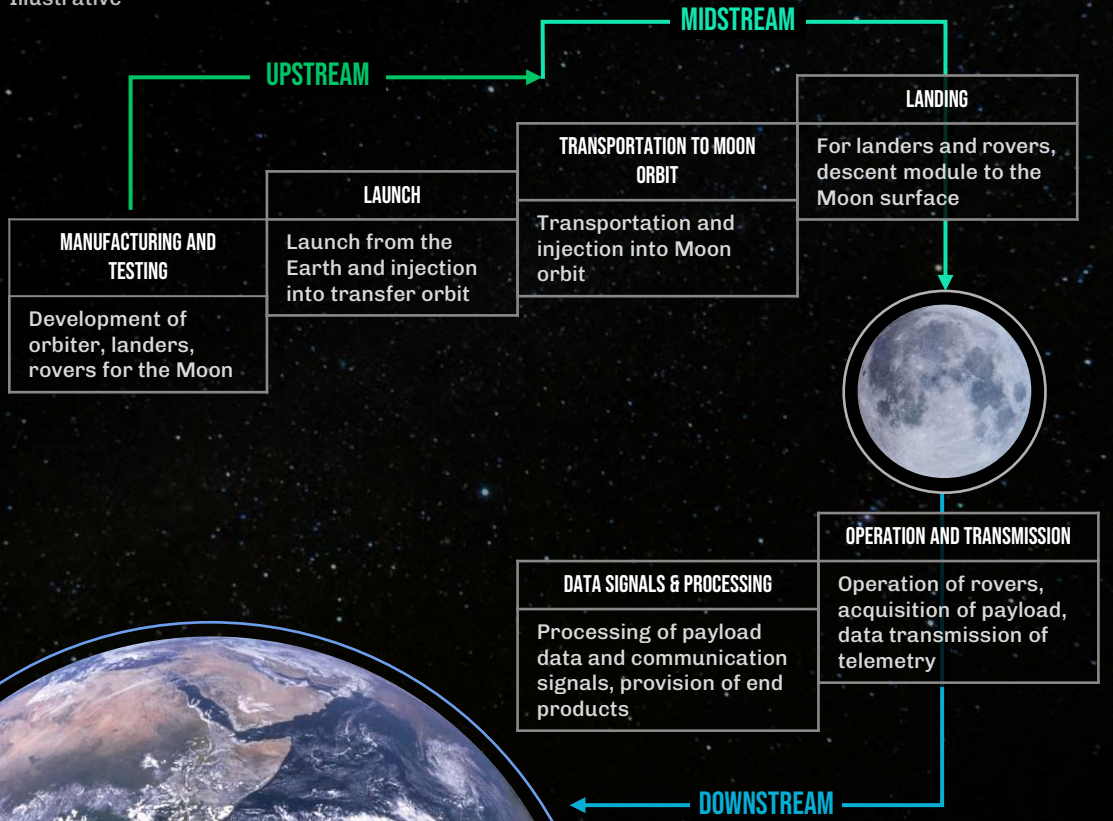
Source: Center for Strategic and International Studies

TRANSPORTATION IS A MAJOR KEYSTONE TO UNLOCKING AN ECONOMY ON THE MOON

The development of a sustainable lunar economy relies heavily on the ability to transport people and resources effectively between Earth, cislunar space, and the Moon's surface. Actors interested in expanding humanity's presence beyond our planet rely on elaborate transportation means that will enable them to traverse orbital pathways between Earth and the Moon, as well as landers for descent onto its rocky terrain. These actors will also require rovers at their disposal to explore varied areas once settled.

Ultimately, this interstellar vision will lead to an entirely new era of exploration. Autonomous rovers and drones will weave their way through stark and untouched landscapes, spiderwebbed with roadways leading toward areas rich in water or mineral wealth. The lunar surface is poised to become much busier in the coming decades.

HIGH-LEVEL VALUE CHAIN FOR THE LUNAR TRANSPORTATION MARKET
Illustrative



Source: UP.Partners illustration inspired by PWC

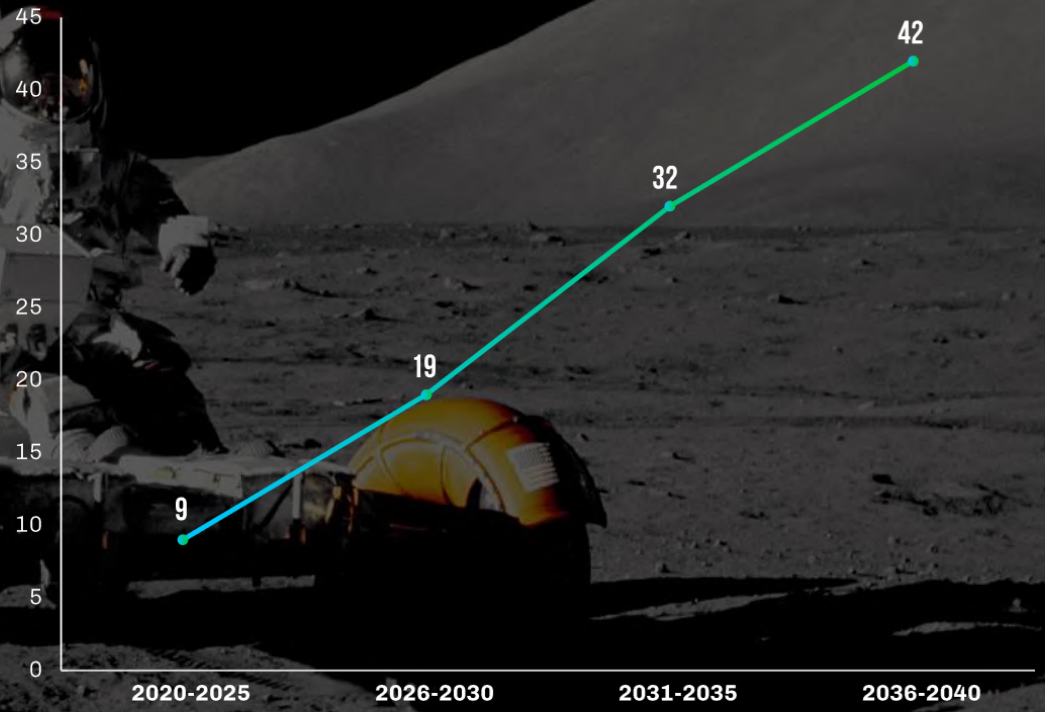
TRANSPORTATION IS ON A SPACE RACE TO MAKE BILLIONS

According to PWC, the global lunar transportation market payload mass (cumulative) between 2020 and 2040 is expected to reach 230 tons in an optimistic scenario. This leads to a total transportation market size of 102 billion USD over the next 20 years.

From a regional perspective, the future evolution of this market is expected to be driven mainly by the U.S., which is anticipated to represent between half and two-thirds of the total market. This is largely driven by the Artemis Program and the growing number of private U.S. companies honing capabilities for space exploration, including spacecraft design, payload transport capabilities, launcher capabilities, resource identification and mining as well as astronaut shuttling.

China's ambition to dominate outer space should not be underestimated as the geopolitics of space are now mirroring the competition on Earth, pitting the U.S. and its allies against China and Russia.

ESTIMATED MARKET SIZE FOR THE LUNAR TRANSPORTATION MARKET
In billion USD, in optimistic scenario



Source: PWC

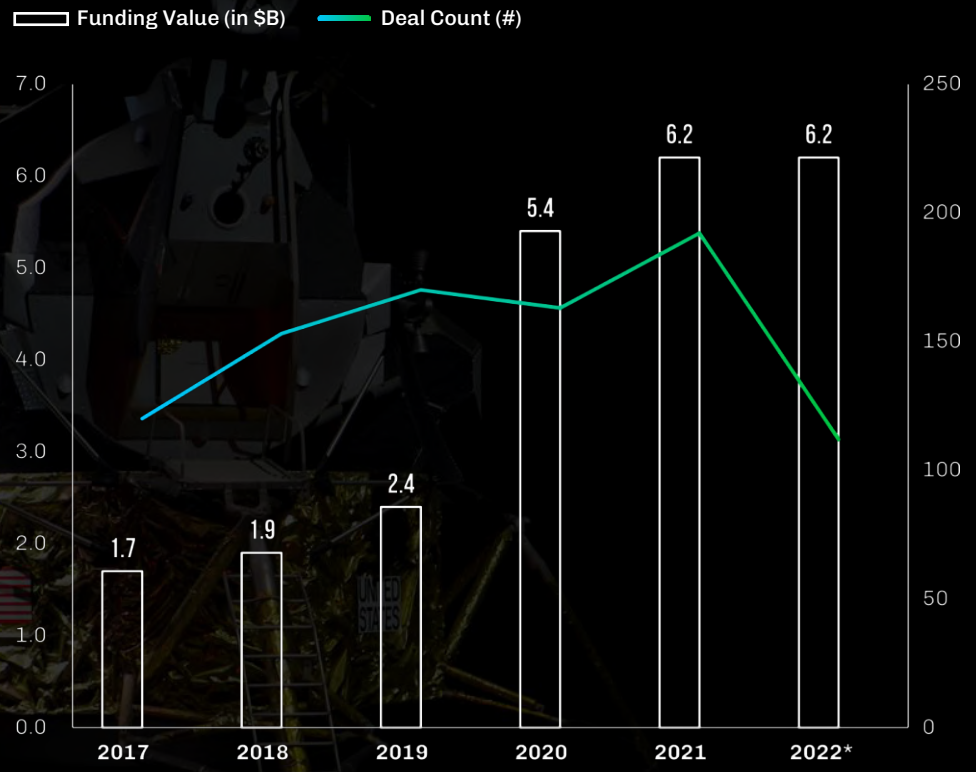
NO WONDER, SPACE TECH HAS SECURED ANOTHER RECORD YEAR OF VC INVESTMENTS

Given the momentum of space exploration and the promises of a billion-dollar lunar economy, VC investments in Space Tech startups hit a new record high in 2022, further accelerating innovation dynamics.

This funding record is particularly impressive, given the turbulent macro environment that has severely hurt the overall tech ecosystem as we have shown in Section I of this report. Space-Tech startups appear resilient to some of these macro market conditions. Last year, the startups that raised funding included those offering a wide range of services from commercial space launches to geospatial intelligence, lunar landers, remote sensing, and satellite communications.

However, as has been the case in the past, a handful of mega deals into category leaders, such as SpaceX, primarily drive category funding. SpaceX alone raised multiple rounds for a total of more than $3.6 billion USD in 2022.

VC INVESTMENT ACTIVITY IN SPACE-TECH STARTUPS



Source: PitchBook Data Inc.
*Data as of Oct 24, 2022

SUMMARY OF SECTION 3

In the final section of the report, we took a more holistic look at the future of mobility.

For this, we identified three mega trends that may unlock never-before-seen opportunities for the mobility sector, expanding our industry beyond its current imagination.

In the short-term, we predict a circular battery economy will come to life. As of today, the lithium-ion battery industry lacks a clear path to large-scale economical recycling. This presents a tremendous opportunity for startups to address this shortcoming by enabling a circular battery economy. This will be a big step towards circular manufacturing, a long-held dream in which firms make new products by recycling old ones. In turn, this will greatly reduce environmental footprints and overcome raw-material shortages.

In the medium-term future, we imagine hypersonic transport to reimagine the way we travel from A to B. Hypersonic air travel, which happens at speeds of Mach 5 or greater (five times the speed of sound and more), will ultimately become a reality in commercial aviation. This is the case given that humankind has always progressed towards more comfort, convenience, and most importantly, more efficient use of time and money. Hypersonic air travel will eliminate the pain of being stuck in a metal tube forever, allowing people to get from New York to London in just 90 minutes.

In the ultra-long-term future, we predict lunar exploration to open up new opportunities beyond our imagination. Building infrastructure on the Moon is one of the biggest commercial opportunities in Space Tech.

This will ultimately enable further space voyages to Mars. If the vision of establishing a permanent presence on the Moon becomes successful, it will lay the foundation for a full-blown lunar economy.

While there are a huge variety of potential activities that fit into the definition of a lunar economy, transportation would certainly be one of the key applications. This could include travel routes between Earth and the Moon and exploiting on-moon resources, which involves mining and extracting resources, manufacturing products, building infrastructure, and exporting goods and materials.

THE END

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