SINGAPORE AND EU EXPLORING SOLUTIONS TO SUSTAINABLE TRANSPORTATION CHALLENGES

EUROCHAM POSITION PAPER 2022–2023

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OVERVIEW

When one community of environmentalists worldwide expressed grave concern over the rise of the mean global temperature in 2021, another group praised the transformation of the transport sector as it is one of the primary emission-intensive industries. The changing landscape of the mobility industry—from internal combustion engines (ICEs) to electric vehicles (EVs) and shared mobility—was a silver lining in the dark cloud amid the mounting challenge of climate change.

Despite inherent uncertainty in temperature measurements, 2021 was the sixth warmest year in the past 171 years, according to Berkeley Earth. The year's average global temperature rose to 1.2°C above pre-industrial levels, close to the Paris Climate Agreement's 1.5°C aspirations. Nearly 23% of the global population—which translates to more than 1.8 billion people—residing in 25 countries experienced a record-warm year in 2021.

Various sectors, including the transport industry, are primarily responsible for the rise in global temperature and climate change. They emit carbon dioxide (CO2) and carbon monoxide (CO) into the atmosphere, creating the greenhouse gas effect, which leads to a rise in the global temperature. According to the interagency report on sustainable transport, developed by the United Nations Department of Economic and Social Affairs (DESA) and other UN agencies, the mobility sector produces 25% of all energy-related emissions. It also revealed that fossil fuels provide 95% of global transport energy.

The global call for action to limit global warming on a 1.5°C pathway by lowering greenhouse gas emissions makes the transformation of the transport sector indispensable. Countries' commitment to a carbon-neutral world by 2050 and the need to meet the 2030 Agenda for Sustainable Development also supercharge the sustainable transport transition.

Along with emissions and climate change, the persisting challenges of rapid urbanization and traffic congestion continuously push economies to adopt sustainable transport and shared mobility models. The rising environmental consciousness among people and access to mobility based on need also encourage economies to focus on EVs and shared mobility.

Additionally, technological advancement and innovative technologies are vital to driving sustainable mobility. Features such as safety, eco-friendly fuels, and a robust digital mobility ecosystem play a central role in meeting an economic-specific land transport master plan/roadmap.

For instance, leveraging such immersive technologies, Singapore envisions developing a future city where all of its land transport networks are well-connected, convenient, and fast to access. With shared mobility and electric initiatives, the country aims to lower travel time significantly, ensuring healthy lives and safe journeys.

In this regard, the European Union (EU) is ahead of Singapore. With its Sustainable Urban Mobility policy, the EU aims to:

- Reduce transport-related greenhouse gas emissions by 90% by 2050.
- Adopt new initiatives for sustainable and smart mobility.
- Focus on active modes of travel as part of the Efficient and Green Mobility Package.

Singapore and the EU focus on addressing urban mobility challenges, but Europe has the upper hand in furthering its sustainable mobility goals. This presents a unique opportunity for Singapore and the EU to work together. Singapore and Europe can share information, address challenges, and provide feedback to government bodies and stakeholders to promote sustainable transport and mitigate climate change.

SECTION 1: ASSESSING THE LANDSCAPE OF SHARED MOBILITY

Up until two years ago, intensifying urbanization was the norm, with cities confronting challenges related to congestion, pollution, and overstretched mobility networks. Fast forward to the present, where urbanization and mobility trends have been transformed by the COVID-19 pandemic. In addition to the pandemic and change in mobility patterns due to hybrid working, the mobility sector is heavily influenced by advanced technologies and innovations to enable a "sharing economy" paradigm in society. Shared mobility is an umbrella term that is used to describe any mobility mode, including two-wheelers, three-wheelers or four-wheelers, shared by multiple people.

Shared mobility encompasses:

- Carsharing modes that include traditional, peer-to-peer and corporate.
- Ridesharing, ridehailing and public taxi services.
- Alternative transit (e.g., "paratransit," shuttle services).
- Micromobility sharing services like bike sharing, kick scooter sharing and moped sharing.
- Mobility-as-a-Service (MaaS), which is a single app that is used to plan, book and pay for services, including public transport services.

These services enable people to access mobility on an "as-needed basis" rather than owning a car, and the shift to an electric fleet is also becoming more common. The shared mobility segment has grown consistently post-pandemic, with utilization levels almost back to pre-pandemic levels. Cities globally are more cognizant of wanting to reduce emissions and are promoting shared electric modes of mobility. This shift has been a key priority in both Singapore and the EU, and the expanding infrastructure of shared mobility provides benefits for sustainability.

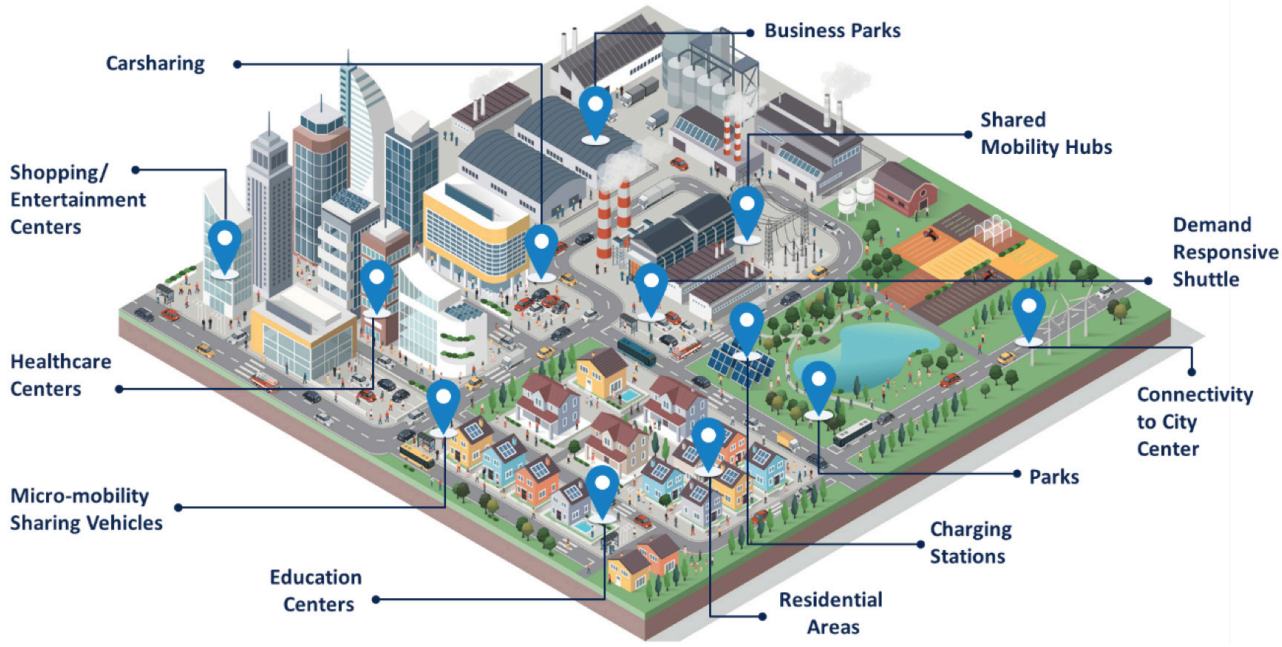
SINGAPORE: LAND TRANSPORT MASTER PLAN 2040 (LTMP 2040)

The land transport plan envisions a future city where all land transport networks are well connected, convenient and fast to access. The plan is to build a more inclusive city that contributes to safe journeys and better health for all.

- **20-minute town and 45-minute cities** – The plan is to build a city that takes no more than 20 minutes for a person to travel between their homes and the nearest neighborhood center where places of retail and leisure are located. Further, it should not take more than 45 minutes to complete peak-period journeys, which includes commuting. This can be achieved by promoting active modes of travel, developing integrated mobility hubs and integrating the mobility options available in the cities. The plan is to increase the cycling paths to almost 700 kms by 2030.

This concept of 15-20-minute cities is gaining a lot of traction across cities globally. The C40 Cities Climate Leadership Group, a network of about 100 global mayors, is partnering with alternative asset manager Nordic Real Estate Partners (NREP) to develop the 15-minute city concept in a handful of cities globally.

Fig. 1 – Depiction of 15-20-minute City



Source: Frost & Sullivan

- **Healthy Lives and Safer Journeys** – An upgraded land transport system entails transitioning to greener fleets and new technology for safety, like collision warning systems in buses. The Land Transport Authority (LTA) aims to have half of its public bus fleet become electric by 2030, which is about 3,000 buses. This is also in line with LTMP 2040, where LTA has committed to a 100% cleaner energy public bus fleet by 2040. In addition, according to the Singapore Green Plan 2030, Singapore wants to cut down the carbon emissions from the mobility sector by 80%. Combining this trend with electric shared mobility can unlock the potential of the transportation industry to become even more sustainable. Several shared mobility operators in Singapore have already started electrifying their fleets, as shown below.

Shared Mobility Operators	Electric Initiatives
BlueSG (Carsharing)	Plans to launch 500 electric Opel Corsa-e hatchbacks gradually from Q4 2022
GetGo (Carsharing)	Plans to add more electric vehicles to its more than 1,000-strong fleet
Grab (Taxi)	Plans to transition to low-emission vehicles to achieve carbon neutrality by 2040
ComfortDelGro (Taxi)	Plans to have 1,000 electric taxis by the end of 2023

Another big aspect that will contribute to the shift toward more sustainable shared modes is the uptake of hybrid working models. A majority of firms have been advised to keep a hybrid work approach; SNEF advises against reverting to pre-pandemic arrangements. What this means to the mobility landscape is that commuting patterns would become more unpredictable and spread throughout the week. Employees are also demanding safer, flexible modes of transport if they must return to work. Countries in Europe have taken the lead in implementing remote working regulations. Several countries, including the G5 countries in Europe, are amending regulations to give employees the right to request flexible working options, supporting the move to hybrid working models.

EUROPEAN UNION: SUSTAINABLE SHARED URBAN MOBILITY

The European Commission (EC) has implemented its Sustainable Urban Mobility policy, which focuses on having member states commit to action on urban mobility. For example:

- The **European Green Deal** includes a target to **reduce transport-related greenhouse gas emissions by 90% by 2050**. The commission plans to adopt a comprehensive strategy that includes increasing the uptake of electric vehicles, making alternative mobility solutions available to businesses, supporting automation and improving connectivity.
- The commission has also **adopted new initiatives for sustainable and smart mobility**, expanding the availability

of EU-wide real-time traffic data for city authorities and mobility operators to plan better. The coverage will be expanded to regional and urban roads and include additional data types like vehicle access restrictions.

- Increased focus on active modes of travel is part of the **Efficient and Green Mobility package**. Cities that are identified as urban nodes by the European Commission will be required to draw up sustainable urban mobility plans (SUMPs) that have **a clear framework for increasing the city's modal share of active transport modes, such as urban cycling**.
- The **Connecting Europe Facility (CEF) Transport program makes available €7 billion** for projects that focus on innovative, new, and sustainable European transport infrastructure. Plus, **€5.175 billion will be set aside to finance projects on the Core and Comprehensive Trans-European Transport Network (TEN-T)**. The project includes upgrading railways, roadways, passenger hubs and interconnected transport networks.
- The European Commission has promoted multi-modal journey planners across the EU for more than a decade. It launched the **Multimodal Passenger Mobility Forum** as a platform for active dialogue and cooperation between Union Member States and relevant public and private stakeholders like the MaaS alliance, Polis, Voi and Tier Mobility. MaaS initiatives are progressing in the EU, driven mainly by the public sector initiative to link up with private-sector technologies against the background of advances in ICT and IoT.

ANALYSIS

Singapore and the EU are focusing on addressing urban mobility challenges, but Europe has the upper hand in furthering its sustainable mobility goals. This presents a unique opportunity for Singapore and the EU to work together. Singapore and Europe can share information, address challenges, and provide feedback to government bodies and stakeholders. **Singapore's acceleration toward EVs is well underway, with the number of electric cars increasing by 50% in H1 of 2022** while the number of ICE cars decreased. Furthermore, both parties are progressing toward transforming their public transport system, aiming for zero-emission vehicles. Once again, Singapore and the EU can share information toward achieving synergy in their efforts.

Singapore lags slightly in the implementation of shared mobility solutions compared to Europe. Ridehailing and bikesharing are the most mature segments, while others are still in the nascent phase. The **ridehailing market** is more mature, with an overall fleet of **80,000 connected taxis**. Singapore, to a large extent, has formulated a successful model for ridehailing based on current market parameters and an adaptive one that evolves constantly with technology and market developments. The bikesharing market is also regulated by LTA and has a total fleet of 36,000 bikes distributed between Anywheel, SG Bike and HelloRide. The carsharing market has grown at a low, stable rate in the past few years, with an overall fleet of about 3,000 cars in Singapore. The most recent player, Hellobike from China, to enter the market, with a fleet of over 1,000 cars. However, when compared to Europe, the uptake for shared mobility is much higher in Europe compared to Singapore.

Many countries in Europe have passed a number of regulations that promote the use of sustainable modes of transport for companies and employees. For example, in Belgium, it is a mandate to offer employees a mobility budget as an alternative to a corporate car. In Italy and France, the concepts of mobility managers and a sustainable allowance are also becoming pertinent. Demand-responsive shuttles are another business model popular in Europe for commuting and intra-city travel and can provide first- and last-mile connectivity. While this was trialed by operators like Beeline and Grab Shuttle, it was not sustainable due to the high cost of operations.

Cities have spent huge amounts on improving the public transport infrastructure to increase ridership. However, they have not been successful because public transport development is restricted to certain areas, causing limited connectivity to the destination. While shared and integrated mobility will be a sure way to encourage the use of sustainable modes, disincentivizing the use of cars through road pricing, congestion charges, and access restrictions has made a substantial impact on reducing the use of private cars. The London congestion charge is a fee charged to most cars and motor vehicles driven within the Congestion Charge Zone (CCZ) in Central London during peak traffic. This has helped London decrease the modal share by private cars and reduce congestion by 30% between 2000 and 2019. More recently, the Mayor of London has considered expanding the ULEZ to cover Greater London's 33 boroughs and implementing a daily Clean Air Charge for most vehicles. The objective behind this is not to increase revenues for TFL but rather to reduce the miles covered by the private car.

Singapore also implements this measure, but the policies aim to raise revenues. An electronic road pricing system implemented in Singapore has been effective and generates roughly 10% of the local transport authority's income. In addition, the revenue collected from COE's auctions in 2019 was higher than all the local transport authority's revenue sources. Prices in the Open Category, which can be used for any vehicle type but is used mainly for large cars, hit an all-time high of $114,001 in July.

Therefore, a more integrated approach toward mobility will be able to drive the use of sustainable shared mobility. An integrated mobility model with the involvement of all stakeholders, combined with car usage reduction schemes, is necessary to drive the shift toward sustainability.

RECOMMENDATIONS

- Extensive consultations must be carried out between stakeholders to understand the best practices that are implemented and that work to ensure that all interests and needs are accounted for; collaboration is key.
- The Singapore Green Plan 2030 focuses primarily on the adoption of EVs in private, public, and shared fleets. It should also set up a detailed plan that can improve the transport infrastructure; for instance, setting up shared mobility hubs, improving cycling infrastructure, and providing better intermodal connectivity.
- Set up a conducive regulatory framework for the uptake of shared modes, especially in the corporate mobility space. Singapore can emulate the regulations and taxation policies adopted by European countries, like France and Belgium.
- Cost and convenience are primary factors for road users' decision-making in switching over to sustainable modes of transport. A reduction of road taxes for both electric vehicles and autonomous vehicles (AVs) should be considered.
- AVs will be an important part of Singapore's Smart Mobility solutions and can complement public transport and act as ideal first- and last-mile connectivity solutions (autonomous shuttles). Singapore's legislative advantage is the presence of clear standards and definitions regarding autonomous vehicle development and operations. Singapore's autonomous vehicle testing center, CETRAN, attracts manufacturers, start-ups, and autonomous technology companies globally to run pilot programs in a controlled area that can mimic most urban conditions. By 2030, 25% of Singapore's population will be older than 65. Driverless mobility options will fulfill the demand for preserving the freedom of individual mobility for the elderly in the city-state.

SECTION 2: ASSESSING THE ELECTRIC MOBILITY LANDSCAPE

The electric vehicle value chain has experienced a complete transformation in the past 12 years. Considering the transformational shift, the market is doubling in less than three years, which is strong evidence of EV growth. In the current scenario, 6.7 million units were sold. Of these, 70.7% were battery electric vehicles (BEVs), and 29.1% were plug-in hybrid electric vehicles (PHEVs) in 2021. Technological advancements in batteries and charging infrastructure have been crucial in the overall development of the electric vehicle market. In 2022, based on Frost & Sullivan's analysis, the total EV sales are estimated to be 11.1 million, of which 71.3% will be BEV, and the remaining will be PHEV and fuel cell electric vehicles (FCEV). Advanced features, such as V2G services, business intelligence, blockchain technology, and suggestive charging pattern, will be available and preferred by network operators in the next five years of management/aggregator cloud platforms. Leading battery manufacturers (BYD, CATL, and LG Chem) and OEMs (BYD, Daimler, and VW) are now looking at next-generation battery technology. It focuses on module-less battery pack technology, integrating cells directly into the pack without packing them into modules. The future of the electric vehicle market is based on the following factors, which are the backbone of the EV value chain:

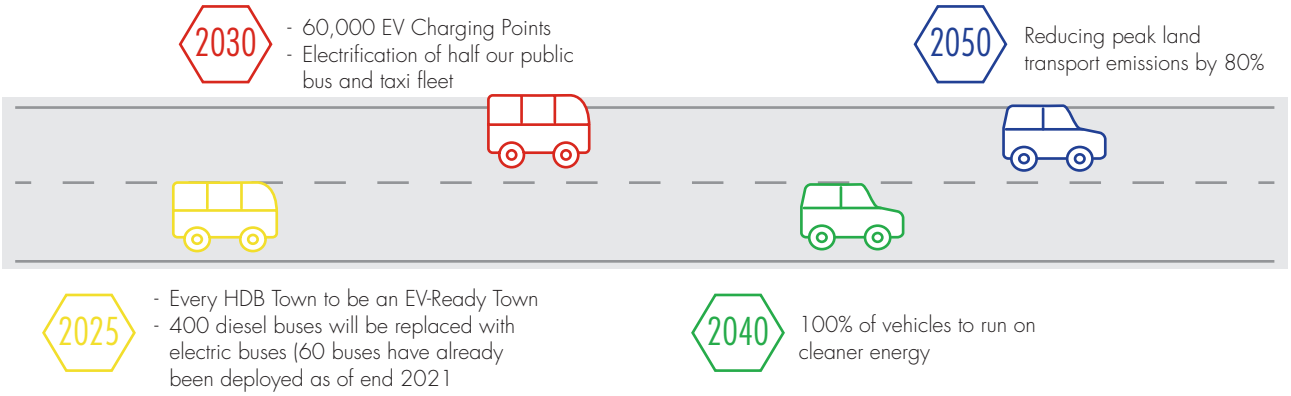
- Emergence of gigafactories.
- Development of charging infrastructure.
- Advancement of battery technology.
- Rapid decarbonization targets.
- Emerging business models.

In the trends discussed above, China leads in the establishment of gigafactories, supplying a majority of the battery packs on a global scale, predominantly catering to the Asian, European and American markets. In terms of the development of charging infrastructure, Europe is at the forefront of establishing high-power, ultrafast charging stations, which will likely be adopted in the American market. With most European countries banning ICE vehicles by 2035, they are moving toward a carbon-neutral state by 2050.

SINGAPORE: ELECTRIC VEHICLE REVOLUTION

The Singapore Government aims to phase out petrol and diesel cars as early as 2030, starting with the taxi fleet. To achieve this milestone, the National Electric Vehicle Centre was established to promote electric vehicles and includes industry stakeholders and government agencies.

Fig. 2 – Electric Vehicle Vision in Singapore



Source: Land Transport Authority

The government has placed incentives and tax subsidies on the purchase of electric vehicles. The incentives and subsidies are in line with the European policy, which offers various categories focusing on the following:

- Vehicle taxes and purchase incentives.
- Regulation and technical standards.
- Infrastructure developments.
- Stakeholder collaboration.

The market started booming in Singapore in 2021, which experienced 201% growth compared to 2020, with sales of 3,357 units. The main reason for the growth is the government policies in Singapore. In terms of the charging infrastructure, the country has approximately 2,100 charging points and aims to have more than 60,000 points by 2030. The government is also offering purchase incentives, including:

- Early Adopter Incentive – Electric vehicles will not have to pay an additional registration fee, which is a minimum of $5,000. The incentive was introduced in January 2022 and will end in December 2023.
- Vehicle Emissions Scheme – EV drivers will receive $15,000 or $25,000, depending on the model.

ANALYSIS

Car ownership in Singapore is different than in other countries. Vehicles are purchased in the form of a certificate of entitlement (CoE), which has a validity of 10 years to monitor the flow of incoming cars into urban areas. The CoE depends on the size, engine capacity and type of usage, which are categorized accordingly, and, in some cases, it can be higher than the price of the car. To increase EV adoption, EVs are classified in category A, which attracts the lowest CoE fee. Such steps from the government indicate that the electric vehicle market will grow in coming years to become 100% emission-free by 2040. However, Singapore lacks charging infrastructure. This is still a challenge on a global scale and will continue to affect the market for the next three to four years since the government aims to install over 60,000 points in the next seven years. There are limited private players in the EV charging infrastructure space, which has some big names like Shell Recharge, Blue SG, SP Group, Greenlots and Caltex that are focusing on establishing robust charging infrastructure with a mix of AC and DC charging stations. To support the development, the government mandated public housing to have a minimum of three spaces reserved for EV charging, which will result in a major transformation in the EV charging infrastructure market. According to the Frost & Sullivan forecast, there will be approximately 5,100 EVs sold by the end of 2022, compared to 3,357 in 2021, with a majority being BEVs due to the incentives and subsidies.

RECOMMENDATIONS

- Market participants should follow in the footsteps of the European market and adopt best practices from proven business models established by others in the value chain. This would relate to major areas such as EV component manufacturing, the complete battery lifecycle, and establishing charging infrastructure.
- The incentives offered for EVs should be more attractive since factors like the CoE and purchase incentives will continue to be the backbone of the EV industry in Singapore.
- A robust charging infrastructure must be established because it posed a great challenge in key EV markets. While the global average of location-to-charging point stands at 1:3, the vehicle-to-charging point ratio is 1:15 in key EV markets. Considering the

high density of vehicle movement in Singapore, the average in Singapore will have to be much better than the global average.
- There must be a collaborative effort between the important stakeholders in the value chain since there is a high density of non-traditional automotive businesses entering the EV arena with innovative solutions and business models challenging the traditional established players.

SECTION 3: THE EVOLVING ADVANCED AIR MOBILITY (AAM) ECOSYSTEM

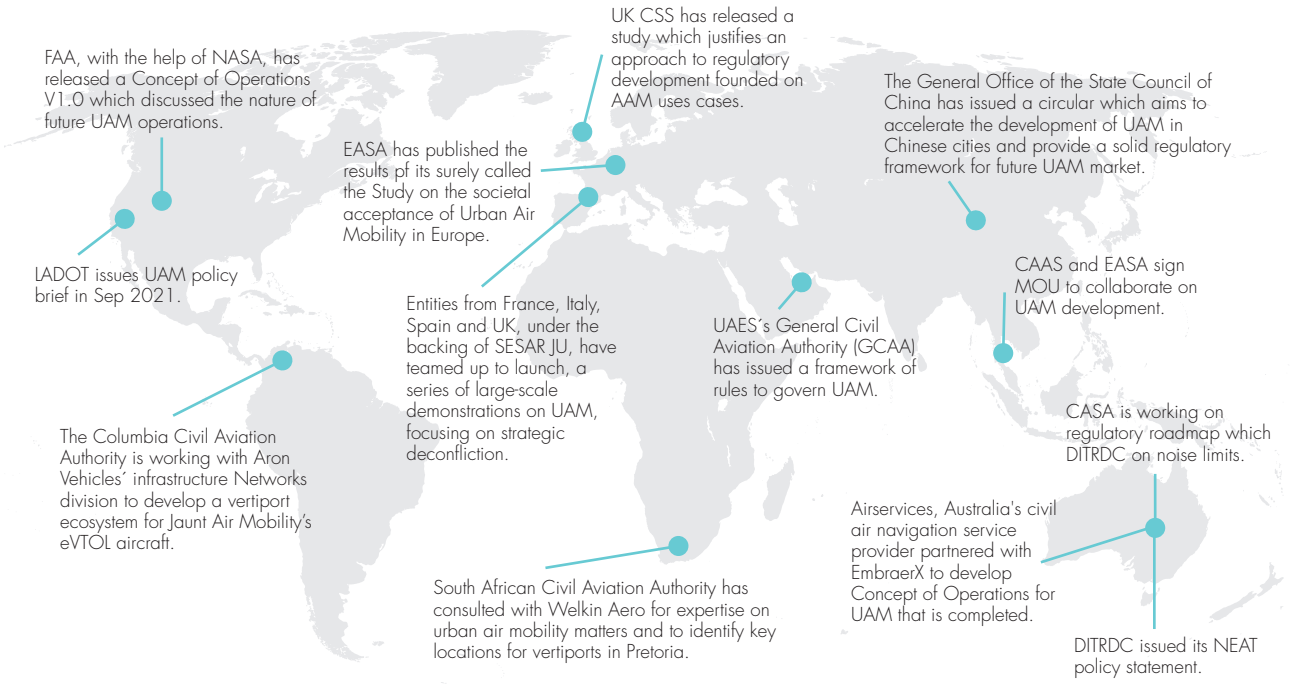
Advanced air mobility (AAM) is setting a new paradigm in air transportation as never before. In the past few years, we have been exposed to various elements of AAM ecosystem such as manned and unmanned e-VTOL (electric vertical takeoff and landing) platforms, supporting physical and digital infrastructure and operators who are willing to bring reality to the AAM landscape. Air travel has completed a full circle in its evolution since its inception in early 1920s where flying evolved from the general aviation into commercial airline and further to business aviation. Business charters were less accessible for large masses which can change rapidly with on-demand flying provided by AAM platforms like never before. Point-to-point commercial flying over short distances is going to take an altogether different meaning, where it would be accessible to the masses like never before. Frost & Sullivan estimates that at least 2,000 AAM platforms would fly around the world by the year 2027, exceeding manufacturing revenues above $ 10 billion. The AAM services industry is estimated to generate another $ 4 billion in revenues a year if certifications and regulatory hurdles are overcome. By 2038-2040, AAM services revenues may well exceed commercial airline revenues—while this is a bold step to fathom, it is very likely to happen if we could harness the full potential of AAM.

Frost & Sullivan is working with global market participants and evaluating the market potential, customer perception, typical journey profile, price point, and possible applications of the AAM market. There are other supporting elements such as regulatory aspects, the evolving value chain, and key technological enablers. Various regulatory initiatives are being taken by leading civil aviation authorities and supporting government agencies. For example, FAA, with the help of NASA, had released a Vision Concept of Operations for its Urban Air Mobility (UAM) Maturity Level-4 in early 2021, which discusses the nature of future urban air mobility (UAM) operations. Another study published in 2021 by EASA was the result of a survey from "Study on the societal acceptance of Urban Air Mobility in Europe." Similar work is being done in other jurisdictions, for instance, Air Services Australia has partnered with EmbraerX to develop Concept of Operations for UAM. Another study was based on the framework of rules to govern UAM in UAE's General Civil Aviation Authority (GCAA).

Quite a few things are happening in China. The General Office of the State Council of China issued a circular, which aimed to accelerate the development of UAM in Chinese cities and provide a solid regulatory framework. Civil Aviation Administration of China (CAAC) announced the creation of the first unmanned civil aviation experimental zones (UCAEZs) across multiple cities. More recently, EHang the e-VTOL manufacturer headquartered in China, after completing more than 30,000 safe trial flights, has updated on its approval of certification plan for its Type Certification (TC) schedule. CAAC has also published the 14th Five-Year Plan for General Aviation Development in early 2022 that has a roadmap for urban air mobility, UTM (unmanned traffic management) and drone operational development. Given the various initiatives, we expect the market to build up quickly in China following certifications and regulatory approvals.

Several initiatives at the city level are being undertaken by civil aviation agencies, road transport authorities, Ministry of Transport, and city authorities in other regions. Ministry of Land, Infrastructure, Transport and Tourism in Japan has planned to open a 'Next Generation Air Mobility Office' for commercialization of flying cars by 2023. The Civil Aviation Authority of Singapore (CAAS) and EASA have signed a memorandum of understanding (MOU) to collaborate on the development, deployment, and safe operation of urban air mobility (UAM) platforms with the European Union Aviation Safety Agency (EASA) in October 2022. CAAS and EASA intend to collaborate on development of certification and operation procedures for UAM platforms, infrastructure, and operations. Earlier in 2021, Ministry of Transport in Singapore had awarded a contract to Nova Systems and OneSky to establish a traffic management system for UAM. Another similar initiative is from the Los Angeles Department of Transportation (LADOT) that released the UAM policy brief in September 2021. Another similar initiative is from the Road Transport Authority of Dubai which signed an agreement with Dubai Air Navigation Services to map out air corridors and sky lanes for flying taxis. We see quite a few initiatives across major cities of the world that are preparing for UAM operations in the near future.

Global Snapshot: Regional Initiatives by Aviation Authority and Government Departments



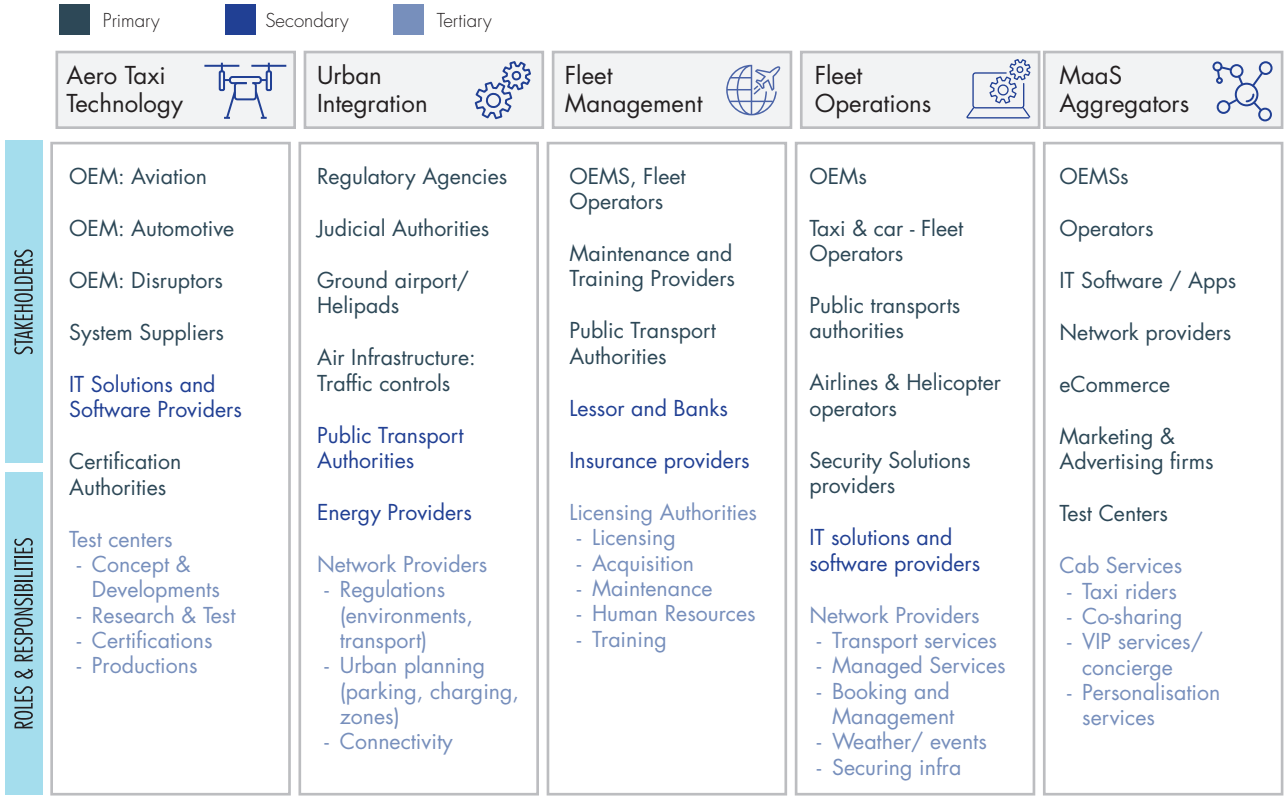
Source: Frost & Sullivan

UAM ECOSYSTEM AND INFRASTRUCTURE

As we delve deeper into the inter-relationships of how various entities in the ecosystem are working toward realization of the UAM framework, it becomes evident that the collective effort of various entities is working behind the scenes to lead to fruition of the UAM ecosystem. While engine maker Rolls Royce is collaborating as the key propulsion provider with CityAirbus and Vertical Aerospace, HALO has placed orders with Embraer's EVE Mobility for operations in the UK. Robotic Skies is working with Skyports on maintenance and training services. Helicopter operator London Heli Shuttle is expected to operate UAMs in the future and is putting together the necessary infrastructure framework with airports such as Bigginhill, Falcon, and Edmiston airports. Lilium has selected London as a development location for its software engineering team. In UAE, entities such as Roads & Transport Authority (RTA) and Dubai Air Navigation Services are working together on UAM navigation framework. In the past, RTA has also been working with Volocopter and Ehang to support the trials.

We understand that the UAM ecosystem is composed of multitude of entities each fulfilling a unique role and have divided the overall ecosystem into five main categories: aero taxi technology, urban integration, fleet management, fleet operations, and mobility-as-a-service (MaaS) aggregators. Aero taxi technology providers may come from an aviation or automotive pedigree or could have been a technology disruptor startup. There are other supporting technology providers beyond UAM platform integrators such as IT solution providers, certification authorities, and test centers. Other major categories are composed of entities that are creating the necessary urban integration layer such as infrastructure developers, public transport authorities, regulatory and judicial authorities. Other entities include fleet management providers, maintenance and training providers, and licensing and financial authorities. Fleet operations would be managed by OEMs themselves, public transport operators or existing taxi operators or helicopter operators. MaaS aggregators will play the crucial role of connecting customers with the applications and in turn with service providers. This role can be fulfilled by OEMs, operators, IT providers or ecommerce platforms. We also understand that there would be further segregation into primary, secondary, and tertiary roles among these providers. There are multiple examples of similar entities that are coming together to form the ecosystem. We saw that Geely Auto (the parent company of Volvo) has invested in Volocopter while Hyundai, another UAM integrator, is working closely with the Coventry city council and Urban Air Port to put up UAM physical infrastructure. Uber Elevate, which was bought over by Joby Aviation, intends to integrate ground and air travel into a single seamless application enabling multi-modal travel. Traditional airlines such as Japan Airlines, is working with Volocopter, and expanding its partnership to introduce UAM platform to Japanese cities. Infrastructure company Skyports is working with Volocopter to build vertiports in Germany and is also working with Group ADP in France. Public transport authority RATP in France is working with Ehang and Vertical Aerospace for test trials to mention a few.

MARKET OVERVIEW FOR ADVANCES AIR MOBILITY



Source: Frost & Sullivan

We have traditional aerospace companies such as Diehl aviation, Honeywell, Thales, and Garmin, which will provide necessary aerospace solutions to UAM integrators. At the same time, there are communication companies such as SK Telecom and mass transport companies such as Korea Transport that are working with Korea Airports Corporation and Hanwha Systems to test and build communication network models for UAM. Volocopter performed a series of tests with three different leading UTM service providers–AirMap, Altitude Angel, and Unifly.

TECHNOLOGY PARTNERSHIPS

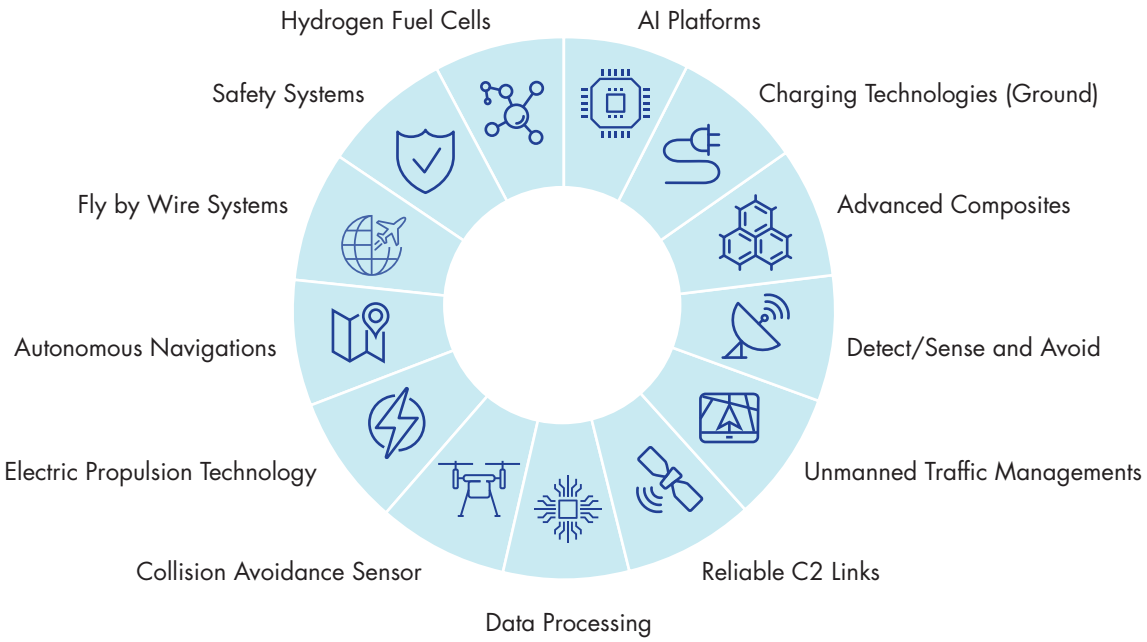
While studying trending patterns to determine the Top 10 players in the UAM market, we found that the top companies on our list were those that have so far stayed ahead from the rest in terms of their platform development and certification process maturity. Maturity would mean an aggregation of various factors such as development phase, testing, certifications, commercial launch, and funding. Some noticeable ones were Ehang, Volocopter, Lilium, Joby Aviation, Eve, Vertical Aerospace, Airbus, Terrafugia, Archer, Electra, and Wisk.

Among those platforms, we observed that majority are VTOL platforms and a few are STOL or fixed wing airplane type. Further, the main type is transitional or multi-rotor rather than other types. When it comes to propulsion, it was mainly electric or hybrid. In terms of number of seats, most integrators are building 1-2-seater platforms or 4-5 seaters. Though autonomous operations are a future aspiration, due to regulations that may be hard to achieve, only manned operations seem to be only the way forward. In terms of range, we are looking at both inter-city and intra city with many platforms working on 0-99 kms range for intra-city commute. There is another evolving market for inter-city and cargo, which are not too far but in the range of 100-250 kms. In terms of certification, majority are not certified and only a few have received special flight permit such as Ehang with CAAC or some others under Part 23. Finally, in terms of development phase, majority of the platforms are in prototype phase with few going through various phases of certification. When we look at the technology framework, the key components that are going through maximum development are avionics, propulsion, power source, flight controls, and interiors. Beyond the platform itself, we see significant developments in air traffic control and management, infrastructure comprising vertiports, charging stations as well as the customer interface.

To cite a few examples, we notice that companies such as Denso, Honeywell, and Rolls Royce are working in the propulsion segment while Honeywell and AIRMAP are among those working in the data and communication segment. Other examples would be Diehl Aviation working on flight controls and Garmin, Daedalean, LIGNEX1, and Insitu working in the avionics segment. We also see companies such as Uber, Blade, and Ascent catering to development of air taxi booking interface.

Urban Aeronautics, which is an Israel-based aircraft developer, is working with HyPoint to incorporate hydrogen power and then we have Micron that has invested in Volocopter for which it will provide data storage solutions needed for an autonomous aircraft. Another such instance is that of Caltech and Jump Aero working together to develop an electronic parachute for JA-1 eVTOL aircraft. This is also connected to the Agility Prime program of the United States Air Force (USAF). Few core technologies such as hydrogen fuel cells, collision avoidance systems, safety systems, unmanned traffic management, and reliable command and control links are gaining importance in the realm of UAM operations.. Honeywell is providing collision avoidance systems, Micron is working on data processing, Daedalean is focusing on sense-avoid technologies, and Diehl aviation is catering to fly-by-wire systems.

KEY ENABLING TECHNOLOGIES IN ADVANCED AIR MOBILITY



RECOMMENDATIONS

While we estimate that a large volume of UAM platforms is expected to become reality by the 2026-2027, significant infrastructure capacity needs to be built ahead of it, throughout the city where these e-VTOL platforms can be maintained, charged, and stored. These points available throughout the city would serve as point-to-point network or hub-and-spoke arrangement for UAM operations.

When the e-VTOL platforms fly, they would also need to undergo maintenance and repair activities. The KPIs of MRO operations remain quick turn-around-time (TAT), economical rates, and quality repair services. While traditional MROs may compete in this space, many new age MRO service providers will come into action and either branch out from OEMs, or from infrastructure players, helicopter operators, or existing UAV maintenance providers.

One of the most critical aspect would be cybersecurity. With so many of UAM platforms flying within the city, end point security is of paramount importance. Other aspects of digital infrastructure would be safe air navigation, efficient traffic flow management, and real-time communication.

Pilot training programs to qualify the pilots and train ground handling staff, as well as creating maintenance training programs are critical support services to be worked upon.

The final, but most critical component is the evolving supply chain. While many components will come from traditional aerospace players, some would come from technological disruptors. So high volume manufacturing, quality control, material handling, and engineering services that will enable safe and efficient e-VTOL operations in the future are key aspects to investigate.

SECTION 4: SUSTAINABLE FUEL AVIATION

The aviation industry contributes about 2% to 3% of all CO2 emissions. At the current pace, without any intervention, it is expected to reach more than 20% by 2050. Governments and agencies have launched multiple initiatives to reduce emissions linked to the aviation industry. The goal of the industry is to reach net-zero by 2050. To support this goal, the aviation industry is adopting multiple initiatives, such as sustainable aviation fuels (SAFs) in the short term, hybrid aircraft in the medium term and hydrogen/electric aircraft in the long term.

SAF can be produced using various types of feedstocks, including waste cooking oil and fats, biodegradable waste, and non-food crops. It can also be produced synthetically via a process that captures carbon directly from the air and a few other ways.

As of 2022, as per IATA, 450,000 flights have flown with SAF, 150 million liters of SAF are produced per year, and more than 32 countries have clearly defined SAF policies.

Major drivers for SAFs include:

- Rising fuel costs: Most airlines spend about 60% on fuel, and with rising fuel costs, this percentage share is rising and squeezing margins, eventually leading to higher ticket prices. Airlines are constantly looking at reducing fuel costs and, in the long term, the use of electric/hydrogen as a propulsion method will drastically lower fuel costs. However, in the meantime, SAF would be an option for airlines to consider if the cost of SAF drops drastically.
- Net-zero goals set by the government: Government and regulatory agencies have set up mandates/directives/policies to limit and reduce Co2 emissions from the aviation industry. Currently, the readily deployable solutions include SAF, making it the most sought-after solution by airlines to achieve net-zero targets in the short term.
- Passengers increasingly focusing on sustainability: Passengers are concerned about their carbon footprint and are choosing alternate travel methods or opting not to travel. To support this change in customer mindset, airlines are trying to reduce each passenger's carbon footprint and make travel more appealing.

SAF, although at a nascent stage, is the only readily available and usable solution to support sustainability in aviation. SAF can be used in existing aircraft without the need for any major modifications. SAF is used for a limited number of flights by a few airlines globally but contributes to less than 1% of the total jet fuel used.

For the industry to achieve its desired goals of net-zero by 2050, IATA estimated that 449 billion liters of SAF must be produced.

For SAF to replace conventional jet fuel, there are multiple hurdles that need to be addressed, including:

- Production: The infrastructure required and the access to feedstock to produce is limited and currently is only a fraction of the percent compared to the demand. An increased number of production facilities across the regions will be required. Preferential and continuous access to feedstock will be crucial to increase production capacity and move toward matching supply levels of conventional jet fuel.

- Logistics: Distributing the SAF remains a major challenge. To be used on a large scale, enough of it needs to be available at arriving and departing airports to fully use SAF. Moreover, having a sustainable and robust supply chain is crucial.
- Price: SAF costs about two to four times the cost of jet fuel, and until the cost of the SAF decreases to match jet fuel, it will be difficult to justify the increased cost without drastically changing ticket prices.

To achieve net-zero industry goals by 2050, the industry would need more than 500 billion liters, but to achieve this in the next three decades, a few key aspects must be leveraged.

KEY SUCCESS FACTORS IN LARGE-SCALE USE AND DEPLOYMENT OF SAFS

- New business models: Airlines, in collaboration with SAF producers and other stakeholders such as OEMs, need to develop new business models to support the adoption of high-cost SAF. New business models also include some of the additional costs being passed on to passengers in various forms, such as a point scheme or having options to pay extra.
- Industry partnerships: Partnerships will be key, whether between airline and airport, airline and SAF supplier, or any other stakeholders. Forming strategic partnerships with various industry stakeholders will lead to newer solutions and ways to address major challenges that exist to support the high uptake of SAF.
- Increase localized productions: For SAF to be available in all locations, it needs to be produced closer to use to avoid delays and additional costs of transportation. Having major airport hubs produce their own SAF will lead to higher usage rates, reduced costs, and increased availability.
- Incentives: Government incentives will be a key driving force in increasing production by supporting additional investments in setting up new facilities and new players entering the industry.
- Policies/Regulations: Governments implementing policies and mandates that dictate a certain percentage of blending for the industry with a certain growth in the same percentage until 2050 will be the push the industry needs to achieve net-zero goals.

Collaboration among industry stakeholders and involvement through the value chain will be crucial in achieving wide-scale use of SAF and reaching the set goals. Each stakeholder must play their part, and some of the possible actions may include:

- Airlines: Build business models to support the higher cost of SAF and set up a sustainability blueprint to support the move toward net-zero operations.
- Airports: Develop infrastructure to support storage/production of SAF to support more airlines' move to adopt the use of SAF.
- OEM/Manufacturers: Many are working toward certifying their aircraft for 100% SAF use while conducting R&D to support the increased use of SAF along with other sustainable solutions.
- SAF suppliers: Work with the government and private sector to increase production capacity by investing in new production plants across regions.
- Governments: Lay out net-zero master plans that provide guidance for industry participants to follow. The launch of new initiatives may offer certain benefits, leading to higher adoption of sustainability solutions such as SAF and continuous funding opportunities.
- Regulatory agencies: Work on further deploying net-zero mandates and regulations, especially for the industry, which will increase investments from stakeholders and give the much-required push for all industry players to achieve net-zero goals.

OUTLOOK OF SAF IN ASIA PACIFIC

Given the mature state of the SAF industry in Europe and North America, these regions are expected to achieve emission targets sooner than other regions. Asia joined the initiative later but is catching up with multiple airlines—both FSCs and LCCs—trying out SAF and setting clear plans to fully become net-zero by 2050. SAF suppliers are establishing plants and supplying to airports in the region. Regulatory authorities and agencies have also started rolling out guidelines for the net-zero targets.

CONCLUSION

Sustainability underpins the future of our planet, and sustainable mobility is one of the measures to address urban challenges and achieve carbon neutrality. The call for a sustainable transport transition requires integrating different factors and bringing in a number of concerned stakeholders to achieve common goals. This encourages a comprehensive, end-to-end analysis of various components, such as environmental consequences, which leads to the innovation of integrated sustainable solutions. Multimodal is a prominent feature of sustainable solutions that optimally incorporate the merits of various transport modes. However, implementing such integrated solutions calls for coordination among players such as governments, science and technology, digital infrastructure, and more to achieve the expected output.

With technological advancement and its massive use in mobility, sustainable transport is already gaining momentum globally. The increasing deployment of eco-friendly fuels and engines, the digitization of vehicles, and smart mobility ecosystem characterize the mobility innovation landscape. Despite this, the digital divide and development gap between urban and rural areas impede the adoption of sustainable mobility. Hence, economies should focus on best practices, collaborate with private sectors, and share information to expedite sustainable mobility adoption.

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