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Key Messages on the Future of Transportation

At the current pace of population and economic growth, the demand for transportation is increasing rapidly, especially in emerging economies around the world. Transportation remains among the most challenging sectors to decarbonize, and at the current pace of decarbonization the world is far from meeting the emissions limits required to stabilize the climate with 2o C or less of warming. Innovation is occurring rapidly in the transportation sector, but an accelerated and sustained effort over decades will be required to reconcile the dual challenge of growing transportation demand and reducing emissions to zero before the century's end.

1. Economic, population and urban growth drive increasing transportation demand

By 2050, tripling GDP, 25% growth in global population, and rapidly increasing urbanization (2.5 billion additional people in cities), largely in non-OECD countries, are expected create a two- or three-fold increase in demand for freight (ton-mile) and passenger (passenger-mile) transport. To meet this demand while substantially reducing pollution, cost, time and accidents will require combined innovations in technology, policy, urban planning and finance, with attention to socio-cultural preferences that vary widely around the world.

2. Diversification of transport energy supply

The transportation system of the past was powered largely by energy-dense liquid fossil fuels. Future transportation systems will likely have a diversity of energy supplies: electricity, liquid fossil fuels, hydrogen, biofuels, etc. Driven by reducing battery costs, increased electrification and the need to reduce air pollution, the world will witness deep penetration of electric transportation in sectors such as light-duty vehicles, small delivery trucks, some long-haul trucks and rail. Other sectors involving long-distance transport (e.g., air transport, long-haul truck and maritime transport) will need energy-dense liquid fuels. The global transport system will be sufficiently large to support a diversity of fuel supplies.

3. Efficiency improvements pay large dividends

Improvements in system energy efficiency (defined as passenger-mile and ton-mile per gallon of gasoline equivalent) via advanced engine and power-train design, automation (e.g., platooning) and capacity utilization (e.g., shared services, public transport), increasing the efficiency of the power generation sector, as well as development of scalable and affordable low-emissions fuels will remain critical to reduce emissions, pollution, cost and congestion. Leveraging current infrastructure and supply chains, efficiency improvements can occur more quickly than transitioning to a new energy supply chain, underscoring its importance.

4. Continued and rapid electricity grid decarbonization is required to achieve the environmental benefits of vehicle electrification

Powering electric vehicles with a coal-dominated electricity mix does not reduce global warming emissions compared to driving an internal combustion vehicle. Therefore, accelerated efforts to increase the fraction of lower-emission power generation from sources such as renewable energy, nuclear power and natural

gas are needed. Similarly, while switching to EVs reduces roadway emissions of criteria pollutants such as nitrogen oxide, carbon monoxide and particulates, emissions from fossil fuel-powered generating facilities can offset some of the health benefits of electric vehicles.

5. Technology research and development

R&D should support the diversified energy mix of future transportation systems. Lithium-based battery and fuel cell technologies have plenty of room for performance improvement, cost reduction and recyclability, especially of critical materials. Electrification will likely be a major driver of change in transportation. Wide-area and local coordination of vehicle charging and grid balancing services will be needed to avoid undue stress on the power grid. Processes and infrastructure for producing affordable low-carbon fuels at large scale need a significant R&D effort. Finally, automation for increased safety and mobility, and social acceptance could significantly impact vehicle design and traffic flow. Some trends, such as automated personal vehicles, may lead to increased tolerance for longer drive times and thereby more emissions and congestion. Industry is investing heavily in various levels of autonomous driving while academic research should focus on radically new approaches.

6. Supply chain disruptions

By 2050, the transition from fossil fuels to electrified power trains, from high-emissions to low-emissions fuels and from manual to autonomous transport could produce significant growth of new global supply chains and shrinking of existing ones. Managing these disruptions via private and public sector partnerships, with close attention to employment, will be important to mitigate social dislocations. Nations and regions should also pay close attention to location of new supply chains and diversity of energy and materials supply in order to reduce future security risks for access to affordable energy devices, systems and services.

7. Infrastructure, transportation and urban planning

Infrastructure (e.g., roads, rail, ports, airports) for freight and passenger transport lasts for more than 50 years and requires hundreds of billions of dollars in investments. Access to low-cost, long-term financial capital will remain a critical issue worldwide. We can learn from past experiences (both positive and negative) in developed urban regions. Using these lessons, transportation planners and operators must pay careful attention to infrastructure planning based on urban design, population density, costs, and sociocultural acceptance, while facing tradeoffs between levels of service, land use, air quality and political acceptability. Energy use and carbon dioxide emissions associated with these tradeoffs, while significant, have rarely dictated decision-making. Policy guidance (e.g., urban planning, carbon pricing, efficiency standards) with a long-term view is critical to harmonize energy use and emissions with these other priorities while avoiding disruptions to quality of life.

Recommendations

Simultaneous and coordinated progress across technology R&D, policy, infrastructure planning, and finance are needed to reconcile the growing demand for transportation services with reducing impacts on climate change and air pollution. A blueprint for accelerating and sustaining progress includes the following:

- Increase and sustain government and private sector investment in technology R&D across a wide range of clean transportation solutions.
- To foster innovations, create a stable and robust policy for putting a price on carbon emissions and sensible regulatory frameworks where prices signals are ineffective.
- Reduce the barriers and de-risk investments for clean transportation infrastructure.
- Support international collaboration to leverage worldwide lessons learned from the past and increase technology diffusion to accelerate uptake of clean transportation solutions in emerging economies.