IEA Experts' Group on R&D Priority Setting and Evaluation (EGRD)

Life in the Fast Lane: Evolving Paradigms for Mobility and Transportation Systems of the Future

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Research, development, and deployment of innovative technologies are crucial to meeting future energy challenges. The capacity of countries to apply sound tools in developing effective national research and development (R&D) strategies and programs is becoming increasingly important. The Experts' Group on R&D Priority Setting and Evaluation (EGRD) was established by the IEA Committee on Energy Research and Technology (CERT) to promote development and refinement of analytical approaches to energy technology analysis, R&D priority setting, and assessment of benefits from R&D activities.

Senior experts engaged in national and international R&D efforts collaborate on topical issues through international workshops, information exchange, networking, and outreach. Nineteen countries and the European Commission participate in the current program of work. Results provide a global perspective on national R&D efforts that aim to support the CERT and feed into the IEA Secretariat's analysis.

For further information about EGRD activities, see: https://www.iea.org/about/structure/cert/egrd/

To view the agenda and presentations for this workshop, see: http://www.iea.org/workshops/egrd-evolving-paradigms-for-mobility-and-transportation-systems-of-the-future.html.

This Executive Summary reflects key points that emerged from the discussions held at this workshop. The views expressed in this report do not represent those of the IEA or IEA policy nor do they represent consensus among the discussants.

The full workshop report, including detailed information on individual sessions and presentations, has been prepared by the organisers and may be consulted at http://ieadsm.org/egrd.

Executive Summary

The International Energy Agency's (IEA's) Experts Group on R&D Priority Setting (EGRD) held a workshop titled *Life in the Fast Lane: Evolving Paradigms for Mobility and Transportation Systems of the Future* to help decision makers determine research, development, and deployment (RD&D) priorities and policy needs in support of low carbon, transformative transportation systems. The U.S. Department of Energy (DOE) hosted the workshop 26–27 October 2016 in Washington, DC. The workshop sought to identify novel approaches and RD&D needs, gaps, and opportunities that could accelerate innovation and facilitate market uptake and transformation. Participating technology experts from research entities, academia, and leading agencies across the world offered a wide range of perspectives and insights.

The Transportation Landscape

Advanced technologies and changing business models are transforming the transportation industry. Societal megatrends such as increased automation, greater connectivity, growing electrification, and evolving societal preferences are critical drivers of this change. Collectively, these factors have significant implications for policymakers and impact the energy consumption, safety, security, and equity of a society. Several scenarios emerge which present challenges and opportunities. Governments have the opportunity to shape these scenarios by framing decisions and policies to help deliver significant, cost-effective reductions in greenhouse gas (GHG) emissions. Policymakers need to consider both logistical mobility (reliable, accessible, and time-efficient) and energy efficient mobility.

Transportation use and urbanization are projected to continue to increase over the next few decades. To limit worldwide global warming to 2°C (as agreed by more than 190 countries at the Paris Agreement), transport emissions need to peak and decline within the next ten years, according to the IEA's *Energy Technology Perspectives (2016)*. This will entail decoupling transportation activity from GHG emissions. Successfully transitioning to a low-carbon pathway will require a clearer understanding of these megatrends and the critical linkages between advanced technologies, human behaviour, and energy usage.

Existing efforts and programs are working to adapt their approaches to this rapidly changing landscape. Governments are adopting a more holistic view of the vehicular industry that looks beyond independent and discrete efficient vehicle technologies to explore untapped transportation system-level efficiencies (Figure E-1). New approaches are being adopted: governments, research institutes, and others are shifting away from a prescriptive approach and undertaking a prototyping approach instead, testing, and analysing the results, and considering new deployment scenarios that focus on passenger miles travelled instead of vehicles.

Figure E-1. U.S. DOE's five key pillars of transportation-as-a-system.

Trends Shaping Future Transportation Systems Worldwide

Advanced technologies in development can transform the future of transportation services and significantly reduce GHG emissions of future transportation systems, with implications for transportation demand. However, developing an advanced technology, like autonomous vehicles, does not necessarily translate into its adoption; consumer behaviour remains a critical factor. Delivering GHG reductions and increasing efficiency requires strong economic incentives for consumers and industry. Consideration of the unique economy, demography, and societal preferences of a particular region is critical for successful implementation of incentives or other policies. Economic models focused on understanding consumer behaviour can help policymakers develop more effective policies.

Different countries and regions have effectively deployed a variety of solutions to reduce GHG emissions and criteria emissions of future transportation systems. Norway, which currently has the largest battery electric vehicle (EV) market share in the world, uses a strong tax structure to incentivize GHG emissions reductions. Norway assesses potential and existing policies in part based on a behavioural discrete choice model for automobile purchase coupled with a dynamic stock-flow model predicting how fiscal and regulatory changes might affect GHG emissions. Germany's National Innovation Program on Hydrogen and Fuel Cell Technologies, a program jointly undertaken by several ministries, focuses on RD&D of hydrogen and fuel cell technology and has had a number of accomplishments to date. The European Union has adopted several strategies to promote the use of alternative fuels for transport, including the adoption of union-wide standards for EV charging and the development of several financing mechanisms for funding research and development (R&D) in this space. In the U.S., California's Zero Emission Vehicle (ZEV) Mandate has been a successful driver for EV adoption by creating a market-based trading system for ZEV credits, which incentivises the private sector to develop and sell greater volumes of ZEVs. The private sector also serves a crucial role in advancing innovative vehicle technologies. Programs such as DOE's SuperTruck—which aimed to make drastic improvements in truck efficiency—are testament to the value of private sector participation. The SuperTruck program invited collaboration among government and industry and has provided a springboard for more advanced fuel-saving technology commercialization. Large original equipment manufacturers (OEMs), like General Motors and Toyota, are also independently developing solutions, such as General Motors' Super Cruise feature that will debut in a Cadillac CT6.

Barriers and Solutions

A number of social and technological trends have widened the scope of sustainable transportation R&D. The interconnected nature of an ACES (Automated, Connected, Electrified, Shared) transportation system that receives inputs from several complex linear and non-linear interactions makes it critical for OEMs and policy makers to have a better understanding of these interactions. Vehicles and their respective travellers are no longer the only factor in the equation; researchers and policymakers must now include the entire transportation system along with a built environment to support it. For example, in the U.S., the National Renewable Energy Laboratory (NREL) has adopted a holistic approach to sustainable transportation, viewing it at four discrete levels: traveller, vehicle, transport system, and built environment—rather than just as vehicles and roads (Figure E-2).

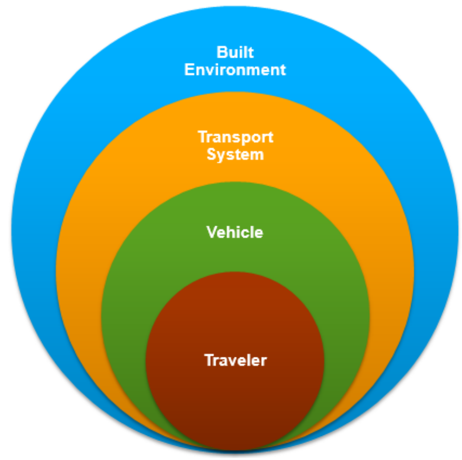

Figure E-2. Visualization of NREL's holistic approach to sustainable transportation research.

One factor inhibiting change is a lack of accurate data and models, specifically regarding consumer decision making and behaviour. Because of rapidly changing social and mobility trends, past predictions of automotive industry change have generally been inaccurate, and complexities inherent to the connected and autonomous vehicle (CAV) adoption timeline indicate that, in the absence of improved data and models, accurate predictions will remain the exception rather than the rule. Analysis of consumer decision making is becoming more complex as consumers face new decisions that do not mirror historical trends. Harnessing future mobility trends requires a better understanding of consumer choice and, therefore, improved methods for customer choice modelling. Furthermore, current modelling of the energy impacts of an ACES transportation system exhibit high levels of uncertainty due to the lack of accurate consumer predictability. Developing models that more accurately predict the energy impacts of these technologies could facilitate development of policies and products that support the shift to a low carbon transportation system.

Many barriers are technical in nature, especially regarding the future of CAVs. Autonomous systems must be able to handle a wide variety of inputs, and operation must be unhindered in all environmental conditions and traffic conditions. Current positioning localization, and sensing and perception systems are not yet capable of handling all driving domains; however, the pace of development of advanced technologies continues to accelerate. Numerous fully commercialized technologies exist that can be utilized and ultimately lead to achieving full-scale CAV deployment.

To respond to the rapid pace of technology advancements, many research efforts have adopted new approaches to respond in real time. For example, Finland's capital city Helsinki serves as a "living lab" that enables a large number of pilots, tests, and demonstrations of smart systems and services. In the U.S., a Smart City Challenge award was won by Columbus, Ohio, which aims to be a model city that plans to fully integrate innovative technologies – connected and automated vehicles, smart sensors – into their transportation network, foster open data standards for analysis, and draw on best practices for future technology deployments. Empirical testing data is not readily available for CAV technology, so industry and governments are utilizing different techniques to advance both the technology itself, as well as the policies to regulate its use.

Supporting Future Transportation Systems

As technology and social trends continue to evolve, policymakers will need to identify the best policy levers—price-based, regulatory, and RD&D—to drive deep decarbonisation. This will require new metrics, increased collaboration, new business models, and consideration of future trends and drivers.

Understanding consumer adoption and behaviour towards new technology and mobility services is important to developing policy and markets that will encourage low-carbon mobility systems. Researchers are working on consumer studies that will help legislators make evidence-based CAV policy decisions. Because the technology is new, unfamiliar, and not available to consumers, there is a need to develop new metrics (e.g., intent to use or consumer acceptance) and interview methodologies to provide valuable data to regulators on consumer perception and behaviour. Surveys by the Texas A&M Transportation Institute revealed that people who would not use a self-driving car if available cited a lack of trust in the technology as the primary reason, followed by safety and cost. These results demonstrate the types of barriers that future policies and incentives will need to account for although more data is needed to provide quantitative policy guidance.

Collaboration between governments and industry will be essential to ensure effective RD&D and policy decisions. Governments can learn from each other's experience by looking to EV market leaders such as Norway, the Netherlands, and California for regulatory guidance. For example, China's 2014 EV mandate, which was based on California's zero-emission EV mandate structure, has caused the largest increase in EV sales to date. In addition, Netherlands has invested in the deployment of connected and cooperative driving, platooning, and automated passenger vehicles, and it aims to be a "living lab" test bed for these new technologies. The results from these research efforts will provide critical knowledge that can benefit countries around the world.

As technology and social trends continue to evolve, standard automotive business models will need to change. There is currently little to no financial incentive for vehicle OEMs to improve fuel efficiency outside of regulation. A step change in energy efficiency is needed, but to do so, energy efficiency must become a profitable part of a working business model.

Policies also need to consider the changes that will accompany increased automation; the mobility field will look drastically different going forward. If CAVs become a dominant transportation form, there could be an increase in overall vehicle miles travelled, resulting in more congestion. Next generation urban transport systems may be massively networked, dynamically priced, user-centred, integrated, and fully reliant on new models of private–public collaboration. Understanding this potential future is critical for developing efficient and effective solutions.

Conclusion

The policy decisions made today will shape the future of the transportation industry. Creating a low-carbon future will require policymakers to understand the potential energy implications of new technologies and the key interactions between consumer behaviour and decision making. As business models and consumer preferences shift, mobility will need to be examined from different perspectives and measured against different metrics. Policymakers need to assess the industry at a system-level vantage point, rather than as individual and separate vehicular entities.

RD&D in several areas will serve a critical role in unravelling the complexities of this emerging landscape. Research is needed to develop technical solutions, including batteries with larger storage capacities and enhanced sensing and perception systems, and ensuring that the system is secure. However, many barriers are psychological and legal rather than technological, necessitating research that examines customer decision making and behaviour towards new technology.

Policies and regulatory frameworks must allow room for creativity and innovation, and these policies need to be designed such that they avoid lock-in of technologies. Innovative policies grounded in an understanding of consumer behaviour are needed to accelerate the deployment of new, low-carbon technologies. Governments will be critical in providing the right incentives and policies to nudge the behaviour of both consumers and industry to deliver the safe, secure, and low-carbon outcomes.