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King Abdullah Petroleum Studies and Research Center

Policy Levers for Promoting Fuel-Efficient Mobility

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About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into energy economics, policy, technology and the environment, across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

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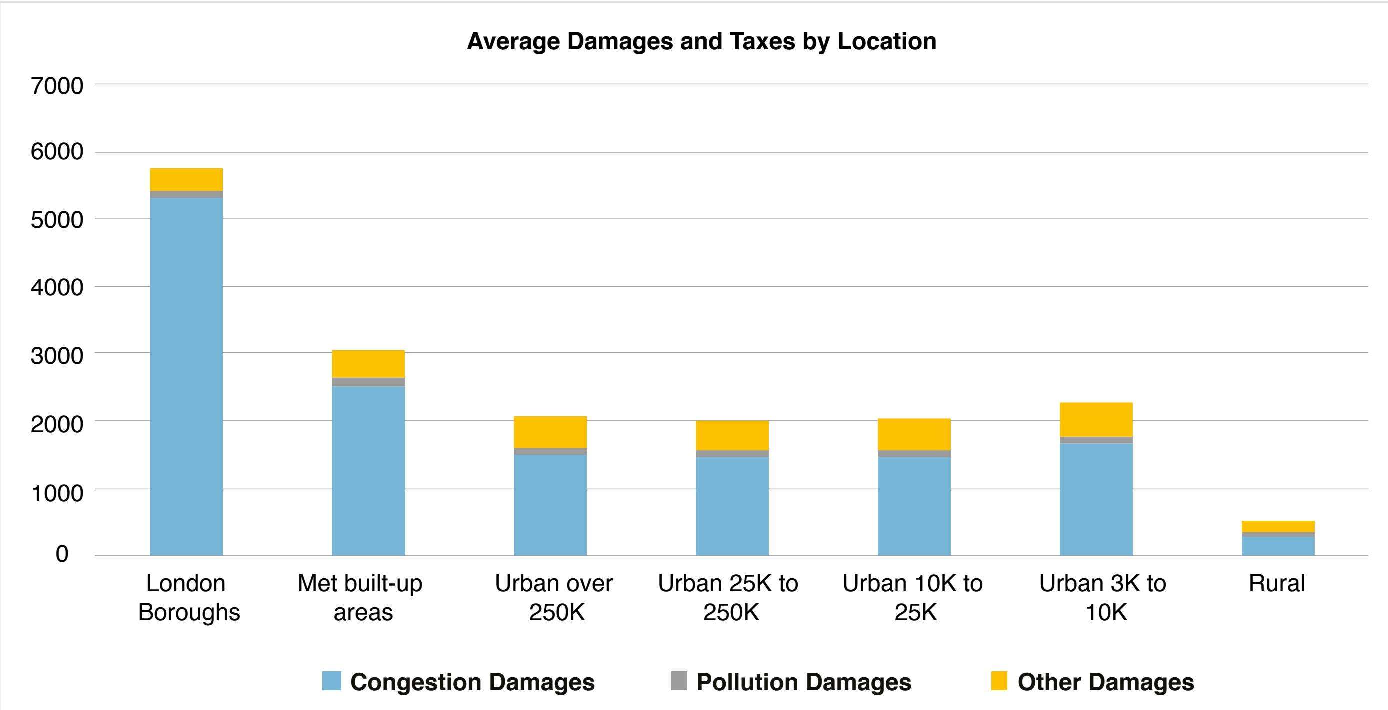
Key Points

Personal automotive travel is associated with many negative externalities, including air pollution, greenhouse gas (GHG) emissions, and traffic congestion. The current cost of driving for motorists does not necessarily account for the costs associated with these externalities. Policymakers are employing a portfolio of policy instruments, including taxes, subsidies, mandates, restrictions, and transit investment, to transfer the costs of these externalities to motorists and the automotive industry.

Recent research suggests that among the various externalities, congestion causes the maximum negative impact because of the economic cost of unproductive time. However, compared with other externalities such as global GHG emissions, congestion has received less attention from policymakers because of its local nature and relative lack of public support for anti-congestion measures.

A vehicle miles traveled-based charge that varies according to vehicle characteristics, and the time and location of use, would be a way to transfer the costs of automotive travel-related externalities to motorists.

Average externality costs and taxes by location



Source: Alberini, Anna, Davide Cerruti, and Joshua Linn. 2018. “Pricing car externalities: Are UK drivers over-or under-paying?” World Congress of Environmental and Resource Economists.

- Aggressive supply-side policies for fuel economy and vehicle electrification could discourage automakers from continuing to invest in research and development to improve the fuel economy of internal combustion engines.
- Reduced costs for new and replacement batteries, reduced electric vehicle manufacturing costs through economies of scale and reduction in electric vehicle (EV) depreciation rates will be critical if EVs are to achieve unsubsidized cost competitiveness with internal combustion engine vehicle counterparts.

Summary for Policymakers

Air pollution, greenhouse gas (GHG) emissions, and traffic congestion account for some of the major negative externalities associated with personal automotive travel. Current policy measures are insufficient to transfer the costs of these externalities to motorists. Among these externalities, recent research suggests that congestion causes the largest negative impact because of the economic cost of unproductive time. However, other externalities such as global GHG emissions continue to receive more attention from policymakers, due to their global significance and the strong public support to mitigate them.

Taxes, subsidies, mandates, restrictions, and investment are some of the instruments used by policymakers to address automotive travel-related externalities. Economists recommend using market-based instruments, i.e., taxes, as opposed to command and control policies.

Current auto travel taxation policies do not fully transfer the associated external costs to the motorists. Recent research also suggests a mismatch between the externalities caused and taxes paid by different driver segments. Urban consumers produce more auto travel-related damages because of higher congestion and local pollution, whereas rural consumers typically pay more taxes because of their higher fuel use and the higher registration taxes on larger vehicles.

A vehicle miles travelled (VMT)-based charge that varies with vehicle characteristics, time and location of use would be a way to transfer the costs of auto travel-related externalities to motorists. Parking pricing is another tax-based policy instrument that could help to reduce congestion, especially in commuter-heavy cities. The way in which tax revenue is recirculated, and other taxes are compensated for, is important in determining the efficiency of tax-based policy instruments.

Public transit investment has received significant political support for its ‘green’ reputation and contribution to environmental sustainability. It lowers congestion in the short run because of the substitution effect. However, public transport does not have a positive impact on auto congestion in the medium to long run because the latent demand effect it causes dominates the substitution effect.

Together with first-best tax-based policy instruments, several second-best supply-side policies, such as regulatory mandates, are becoming increasingly popular because of their political acceptance. Fuel economy standards for regulating GHG emissions represent one such popular choice. An important consideration when deciding on fuel economy targets is the associated societal cost-benefit analysis, and technology forms a large part of the costs. Vehicle attribute trade-offs, such as acceleration for fuel economy, represent a potential low-cost compliance choice to help automakers meet fuel economy standards. Trade-offs benefit consumers by providing them with more choices. Consumers unwilling to pay for extra fuel saving technologies can opt for cheaper and slower vehicles, while those willing to pay more can choose higher-priced, faster and more fuel-efficient vehicles.

As fuel economy targets become more ambitious, the benefits from incremental fuel savings diminish, resulting in a rebound effect: higher fuel economy reduces per-mile driving costs and may increase VMT. Stricter fuel economy standards also result in used vehicles staying on the road longer because of the increase in the prices of new and used vehicles. Consequently, as fuel economy standards become stricter, the vehicle scrappage effect and vehicle use rebound effect reduce the overall benefits of these standards.

Supply-side fuel economy standards impose constraints on automakers, resulting in implicit subsidies for fuel-efficient vehicles and taxes on fuel-inefficient vehicles. Thus, a vehicle ‘feebate’ policy, i.e., taxing fuel-inefficient vehicles and giving rebates for fuel-efficient vehicles, is the demand-side policy equivalent of fuel economy standards. However, recent research suggests that a vehicle feebate performs better than fuel economy standards in improving new vehicle fleet fuel economy. This is because a feebate policy affects all auto manufacturers, whereas fuel economy standards only affect manufacturers that fall below the standards. Recent research also shows that feebate policies have redistributive effects on consumer surplus. It has a negative impact (in terms of consumer surplus) on high-income consumers who usually purchase high performance fuel-inefficient vehicles, while not impacting low-income consumers who usually purchase fuel-efficient vehicles.

Supply-side mandates- such as the United States’ (U.S.) Zero Emission Vehicle (ZEV) policy and China’s New Energy Vehicle Policy - are prompting electrification disruption in the light-duty vehicle (LDV) sector. Electrification, combined with ride-sharing and automation, could create a multiplier effect that might lead to significant disruption and the displacement of oil as fuel. The expected disruption and risk of stranded assets among oil company shareholders could discourage investment in oil production in favor of alternative energy technologies. This could in turn lead to a shortfall in oil supply, resulting in increased oil prices and speeding up the penetration of electric vehicles (EVs) and alternative energy technologies, although potentially at the expense of economic growth. However, oil companies are likely to continue investing in oil production if they remain skeptical about rates of EV penetration.

Among the two supply-side policies - fuel economy standards and electrification mandates - the impact of fuel economy standards on driving improvements in internal combustion engine vehicle (ICEV) fuel economy could lead to a major decline in oil demand. However, aggressive fuel economy targets, coupled with increasing EV demand and profitability, could discourage automakers from investing in further research and development (R&D) for ICEV fuel economy improvements.

Subsidies for EV purchases represent the most prominent demand-side policy choice globally. However, higher purchase prices and faster depreciation rates of EVs outweigh the fuel savings benefits from a total cost of ownership perspective, particularly in the U.S. where transport fuel taxes are relatively low. However, given the unique and high perceptual reaction to oil price, EV promotional campaigns typically continue to highlight the fuel savings benefits of EVs compared with their ICEV counterparts. Reducing the costs of new and replacement batteries, and reducing EV manufacturing costs through economies of scale remain critical if EVs are to achieve unsubsidized cost competitiveness with ICEVs.

Background to the Workshop

On Nov. 15, 2018, KAPSARC hosted a one-day workshop in Riyadh, Saudi Arabia, that focused on potential policy levers for promoting fuel-efficient transport mobility. The workshop discussion centered on policy instruments for addressing personal auto travel-related externalities, including congestion, pollution, and GHG emissions, and their potential impacts.

The workshop sessions focused on three main themes:

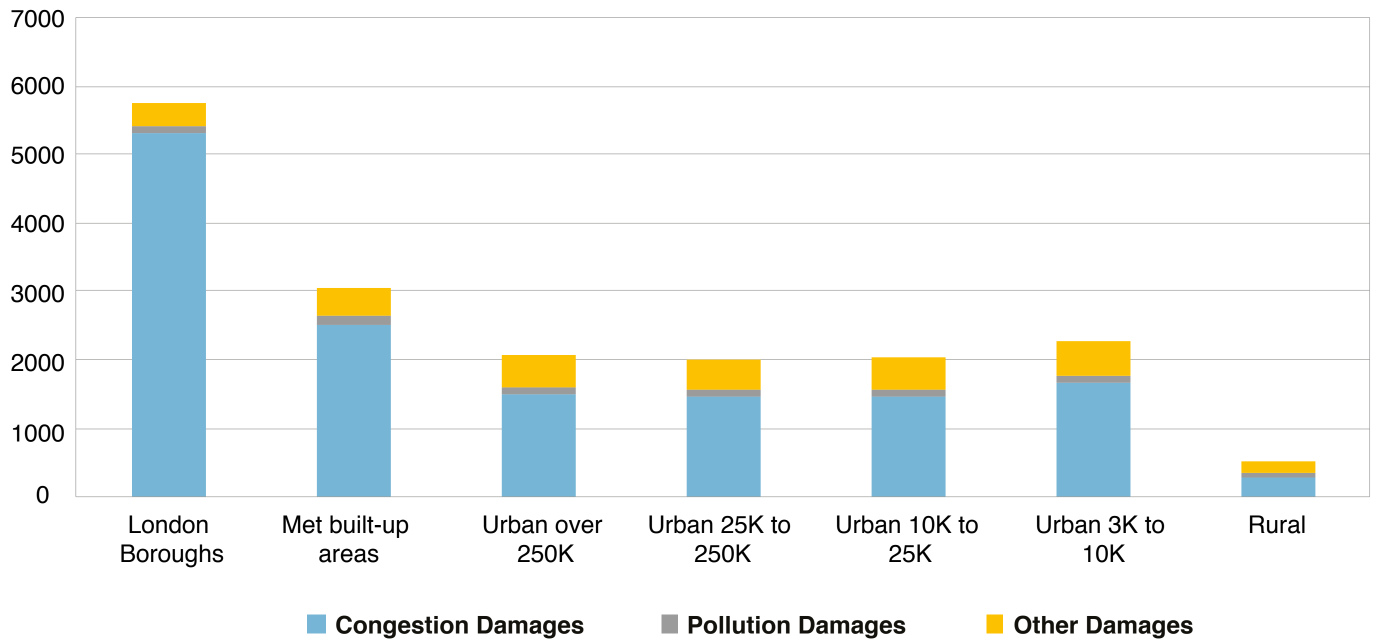
- Addressing personal auto travel-related externalities - policies and impacts
- Fuel economy standards and vehicle feebates
- Light-duty vehicle electrification - potential impacts and policy support.

Addressing personal auto travel-related externalities - policies and impacts

Personal auto travel results in many negative externalities, including air pollution, GHG emissions, and traffic congestion. The current cost of driving for motorists does not necessarily account for the costs associated with these externalities, which are usually difficult to measure. The extent of the effects of these externalities depends on many factors. Traffic congestion depends on when, where and how much people drive, and local air pollution depends to a large extent on which cars people drive. Recent research suggests that among the various externalities, congestion causes the maximum negative impact because of the economic cost of unproductive time. However, compared with other externalities, such as global GHG emissions, congestion has received less attention from policymakers because of its local nature and relative lack of public support for anti-congestion measures.

Policymakers are employing a portfolio of policy instruments, including taxes, subsidies, mandates, restrictions, and investment, to address these auto travel-related externalities. Economists recommend using market based instruments, i.e., taxes, as opposed to command and control policies. Auto travel taxes not only raise revenue but also make drivers accountable for the negative externalities they cause. However, current taxes on auto travel, mainly fuel taxes, do not directly ameliorate the

Figure 1. Average U.K. driver externality costs and taxes by location.



Source: Alberini, Anna, Davide Cerruti, and Joshua Linn. 2018. “Pricing car externalities: Are UK drivers over-or under-paying?” World Congress of Environmental and Resource Economists.

impact of these externalities. Recent research suggests there is a significant mismatch between the externalities caused and taxes paid by different driver segments (see Figure 1). The externality costs are higher in urban areas because of higher congestion and local pollution. Drivers in rural areas typically have higher VMTs and consequently tend to pay more in tax. Those living in rural areas also tend to buy larger, fuel-inefficient, vehicles with higher registration taxes. Overall, rural drivers typically pay taxes in excess of the costs of the externalities they contribute to, while the converse is true for urban drivers. Achieving parity between externality costs and charges paid by motorists would require internalizing the externalities through a VMT-based charge that varies according to vehicle characteristics, time and the location of use.

The possibility of such a system depends on technological capability and public support. For example, the Los Angeles metropolitan area is planning to use cell phone data to price express lanes on freeways. This could also provide an opportunity to introduce congestion pricing that varies according to the time and location of use. The emergence of interconnected and automated vehicles could also help support such a taxation system to control congestion. However, if connectivity and automation significantly displace mass transit, they could contribute to increasing congestion levels.

Another potential tax-based policy instrument that could address congestion is parking pricing, especially in central areas of cities with high levels of private vehicle commuters. The revenue generated from this tax could help provide more public transportation alternatives to and from the city center. The recirculation of tax revenue and how it compensates for other taxes is an important factor in determining the efficiency of tax-based policy instruments.

Driving restriction policies can also help address the externalities associated with auto travel. An example of such policies includes low emissions zones where only vehicles classified as having low emissions can enter a circumscribed area. Other examples of driving restrictions include banning drivers from using their vehicles on given weekdays based on the last digit of their license plate. However, the latter restriction can be circumvented by individuals purchasing additional cars, especially used cars.

Public transit investment is another widely-used policy instrument to encourage auto travel substitution. While public transit investment receives plenty of political support for its ‘green’ reputation and contribution to sustainability, its efficacy in addressing traffic congestion is debatable. Recent research suggests that the effect of increases in public transit supply on auto travel depends on the time horizon. In the short run, when accounting for the substitution effect only, on average a 10% increase in transit capacity leads to a 0.7% reduction in auto travel. However, transit capacity has no effect on the demand for auto travel in the medium run, as latent and induced demand offset the substitution effect. In the long run, when accounting for both substitution and induced demand, on average a 10% increase in transit capacity leads to a 0.4% increase in auto travel.

Fuel economy standards and vehicle feebates

Tax-based policy instruments might be the first best solution to tackle unpriced emissions, but economic and political constraints can sometimes preclude their use. As a result, supply-side policies, such as standards and mandates, are becoming increasingly popular among policymakers.

Consumers typically undervalue lifetime operating costs compared with up-front costs. This undervaluation, known as the energy efficiency gap, is one of the reasons for introducing additional supply-side policy instruments such as fuel economy standards. Nevertheless, supply-side policies remain second-best solutions despite their political acceptance.

Fuel economy standards are the most commonly employed supply-side policies for regulating GHG emissions from light-duty vehicles. Fuel economy standards are set at the maximum feasible levels based on what is technologically practical. Societal cost-benefit analyses are important when considering such policies.

Technology costs depend on the stringency of fuel economy standards. To reduce technology-related compliance costs, automakers could choose to trade-off other vehicle attributes in favor of fuel economy. Recent research suggests that such vehicle attribute trade-offs are a potential low-cost compliance choice to help automakers meet these standards. Consumers unwilling to pay for extra fuel saving technologies can opt to buy cheaper and slower vehicles, while those willing to pay more can choose higher-priced faster and more fuel-efficient vehicles.

Fuel savings are the most prominent benefits of fuel economy standards. However, as fuel economy targets become more ambitious, the benefits from incremental fuel savings diminish. Higher fuel economy reduces per-mile driving costs and may increase VMT, resulting in a rebound effect. Stricter fuel economy standards also result in increased new vehicle prices. Higher new vehicle prices result in lower demand for new vehicles and higher demand for used vehicles. More demand for used vehicles and higher new vehicle prices increase the prices of used vehicles. Higher prices for used vehicles means they stay on the road longer, essentially lowering their scrappage rates. As a result, the vehicle scrappage effect and vehicle use rebound effect reduce the overall benefits of the fuel economy standards.

Aside from supply-side instruments such as fuel economy standards, policymakers also employ demand-side instruments such as vehicle taxes, vehicle rebates and feebates. The constraints imposed on automakers via fuel economy standards result in implicit subsidies for fuel-efficient vehicles and implicit taxes for fuel-inefficient vehicles.

Both fuel economy standards and vehicle feebates result in higher prices for fuel-inefficient vehicles and lower prices for fuel-efficient vehicles. Vehicle feebates have a greater positive impact, however, than fuel economy standards. This is because feebates affect all auto manufacturers directly. Conversely, fuel economy standards only affect manufacturers that fall below the standards.

Feebate policies create winners and losers because they increase the prices of some vehicles and decrease the prices of others. Recent research into the effects of feebate policies on consumer surplus suggests that under a proportional income tax structure a feebate policy has a redistributive effect. It shows that feebate policies have no impact on consumer surplus for low-income consumers and a negative impact on high-income groups.

Light-duty vehicle electrification - potential impacts and policy support

The passenger light-duty vehicle (LDV) sector is the biggest single oil consuming sector worldwide and represents about one-quarter of global oil demand. Demographic changes (rising income and urbanization) and economic growth are likely to drive passenger LDV oil demand even higher. As a result, local and national governments focus on the passenger LDV sector when implementing measures to reduce associated GHG emissions and local air pollution.

Vehicle electrification is expected to disrupt the LDV sector, and commentators and analysts are likening it to the disruption of landlines and digital camera caused by smartphones. This anticipated disruption to the LDV business could discourage investment in oil production and encourage investment in alternative energy technologies, resulting in a shortfall in oil supply. Reduced supply could lead to increased oil prices, speeding up EV penetration and the development of alternative energy technologies, albeit potentially at the cost of economic growth. However, oil companies are likely to continue investing in oil production if they remain skeptical about EV penetration, though concerns from shareholders on the risk of stranded assets could encourage diversification. Electrification, combined with ride-sharing and vehicle automation, could have a multiplier effect that might lead to significant disruption and the displacement of oil.

There is a consensus among forecasters that improvements in ICEV fuel economy would lead to a greater decline in oil demand than EV uptake. However, if fuel economy targets keep getting more ambitious and EV demand and the profitability of EVs for automakers keeps rising, it is unlikely they would continue investing in R&D for ICEV fuel economy improvements.

The consensus forecast among analysts is that the net impact of these counterbalancing forces could result in similar oil demand from the passenger LDV sector in 2040 as in 2015. However, the slowdown in passenger LDV-led oil demand is likely to be offset by an increase in oil demand from the aviation, freight, maritime and petrochemicals sectors. This is because of the lack of low cost substitutes for oil in these sectors.

Such a scenario would undermine the Paris Agreement goal to limit the global average temperature to 2 C above pre-industrial levels. Although the 2 C target might reflect what needs to happen to mitigate climate change, what actually happens could differ. Forecasts for the 2 C carbon scenario are based on conservative estimates for economic and demographic growth compared with the consensus view. They also have aggressive assumptions on cost decline in batteries, as well as policy support for EVs.

Battery costs are largely driven by key metal component costs, mainly nickel, cobalt and lithium. Most forecasts assume a reduction in these raw material costs. However, the cost of cobalt could increase, especially in the short term, given that only a limited number of producers mine and market it. The fact that only a limited number of countries have proven reserves of cobalt, led by the Democratic Republic of Congo, could also pose geopolitical risks. As EVs replace ICEVs, the geopolitical risks associated with oil extraction might be replaced by increased geopolitical risks associated with metals extraction.

Supply-side mandates in China - such as China's New Energy Vehicle Policy and the U.S. Zero Emission Vehicle (ZEV) policy, or ZEV mandate -

dominate policy support for EVs. For China, EV policy is as much a tool to help reduce local air pollution as it is an industrial policy to help China leapfrog other countries in the EV manufacturing space.

Subsidies for EV purchases are the most common demand-side policies globally. The higher purchase price of EVs relative to ICEVs is the biggest part of the total cost of ownership (TCO) of EVs and thus one of the major barriers to EV adoption. Recent research suggests that, apart from the up-front cost, the rapid depreciation rate of EVs is a significant contributing factor to their higher TCO. The combined higher purchase price and rapid depreciation rate outweigh the fuel savings offered by EVs compared to ICEVs, particularly in the U.S. where fuel taxation is low.

Research also highlights the scope for a mismatch between the realized fuel savings from EVs and the potential overemphasis by education and outreach campaigns promoting the fuel savings of EVs. This could result in EV consumers' realized economic benefits not matching their expected benefits.

However, given the wide impact of the price of oil on consumers, it is understandable that EV advertisers might want to highlight the fuel savings from EVs in their promotional campaigns. Governments are developing innovative road tax mechanisms to compensate the public purse for lost fuel tax revenue from consumers switching to EVs. These road taxes include charging by distance or levying fixed annual road use fees on EV owners, further increasing the TCO of EVs.

Electric vehicles will only achieve unsubsidized cost competitiveness with their ICEV counterparts when battery costs for new and replacement batteries, the electric vehicle depreciation rate, and electric vehicle manufacturing costs are reduced. Automakers currently use developments in innovation and scaling to produce EVs with larger batteries rather than lowering their prices. As such, EVs may not become cost competitive with ICEVs any time soon. The desire of automakers to achieve profitability may also discourage them from reducing the prices of EVs in the near term.

About the Workshop

KAPSARC convened a workshop in November 2018 in Riyadh, Saudi Arabia, bringing together more than 35 international experts to explore potential policy levers for promoting fuel-efficient automobile mobility. Specific attention was given to policies addressing the passenger travel-related externalities of congestion, pollution and greenhouse gas (GHG) emissions and evaluating their potential impacts. The workshop was held under a modified version of the Chatham House Rule under which participants consented to be listed below. However, none of the content in this briefing can be attributed to any individual attendee.

List of participants

Patrick Akl – Consultant, Saudi Energy Efficiency Center

Fahad Al Ajlan – Ministry of Energy, Industry and Mineral Resources

Mahmoud Al Tarifi – Researcher, Nissan Middle East (R&D)

Adeeb Alameen – Innovation Committee Project Manager, 2nd Industrial City, Alfarnar City

Samer AlAshgar, Head of Policy and Planning, Ministry of Energy, Industry and Mineral Resources

Mohanad AlDakheel, Saudi Energy Efficiency Center

Naif Alhomaidhi – Scientific researcher, Saudi Energy Efficiency Center

Dr. Dhari Aljutaili – Assistant Professor, Kuwait University

H.E. Dr. Majid Al-Moneef – Kingdom of Saudi Arabia Royal Court

Amar Amarnath – Program Director, KAPSARC

Dr. Amer Amer – Chief Technologist, Aramco Fuel Technology Research & Development

Dr. Anvita Arora – Program Director, KAPSARC

Hassan Babiker – Scientist, Aramco Research & Development Center

Randolph Bell – Managing Director, Global Energy Center, Atlantic Council

Hanna Breetz – Professor, School of Sustainability, Arizona State University

David Brownstone – Professor, University of California, Irvine

David Bunch – Professor, University of California, Davis

Davide Cerruti – Researcher, ETH Zurich

Yuan Chen – Ph.D. Candidate, University of California, Davis

Dr. Kaushik Deb – Research Fellow, KAPSARC

Dr. Rubal Dua – Research Fellow, KAPSARC

Dr. Isis Durrmeyer – Professor, Toulouse School of Economics

Wael El Zanaty – Director, Government Relations & Public Policy, GM Middle East & North Africa

Yaser Faquih – Senior Policy Advisor, G20 Saudi Secretariat

Dr. Akshima Ghate – Principal, Rocky Mountain Institute

Waleed Gowharji – Ph.D. Candidate, Carnegie Melon University

Dr. Antoine Halff – Senior Research Scholar, Columbia University

List of participants

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Dr. Antung Liu – Assistant Professor, School of Public and Environmental, Indiana University

Dr. Alan Meier – Professor, Environmental Science & Policy, Energy Efficiency Center, UC Davis

Dr. James Miller – Deputy Division Director, Energy Systems, Argonne National Laboratory

Jitendra RoyChoudhury – Research Fellow, KAPSARC

Abhishek Saxena – Young Professional, NITI Aayog

Adam Sieminski – President, KAPSARC

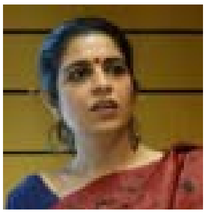
Dr. Mehmet Soytas – Research Fellow, KAPSARC

Dimpy Suneja – The Energy and Resources Institute, India

Cristina Vasquez – Global Outlook Analyst, Saudi Aramco

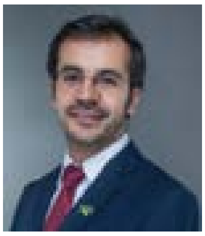
Dr. Elisabeth Windisch, Policy Analyst, International Transport Forum, OECD

About the Team



Anvita Arora

Anvita is the director of KAPSARC's Transport and Urban Infrastructure program. Before joining KAPSARC, she was the CEO of Innovative Transport Solutions. She holds a Ph.D. from the Indian Institute of Technology Delhi, India.



Rubal Dua

Rubal is a research fellow at KAPSARC, working on vehicle regulatory policy and shared mobility research from the consumer perspective. He holds a Ph.D. from KAUST, Saudi Arabia, an M.Sc. from the University of Pennsylvania, U.S. and a B.Tech. from IIT Roorkee, India.

Dimpy Suneja

Dimpy is a visiting researcher at KAPSARC and a research associate at The Energy and Resources Institute (TERI), India. His research interests include sustainable transportation, electric mobility and resource management. He holds an M.Sc. from TERI University, India.

About the Project

The KAPSARC Drivers of Transportation Fuel Demand workshop series provides a forum for discussing key sustainability issues in transportation and current policy strategies to address them. Particular emphasis is placed on the adoption of fuel-efficient and alternative-fuel vehicles for road transportation, innovation in fuel and vehicle technology mixes, and the shift from road to other modes of transportation.

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