مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center

Policy Levers for Promoting Sustainable Mobility

February 2018

doi.org/10.30573/KS--2018-WB13

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

An effective transport policy framework would take into account the costs of rising local pollution, congestion, accidents and global greenhouse gas emissions. The various supply- and demand-side transformations happening in personal mobility provide policymakers with opportunities and challenges for addressing these externalities.

Balancing current consumer preferences with short- and long-term costs for achieving the 2 degrees climate change target means choosing between two pathways: (1) a much higher rate of electrification of the passenger transport sector than proposed in the Paris Agreement's nationally determined contributions, or (2) coupling the proposed rates of electrification with significant improvement in fuel economy of conventional internal combustion engine vehicles (ICEVs) through more ambitious fuel economy standards.

Either transition pathway could reduce oil demand, putting downward pressure on oil prices and thus slow the pace of transition unless offset by a fiscal disincentive such as a carbon tax. However, the carbon tax – by some estimates, \$350/tonne of CO_2 – needed to sustain such a transition may not be politically palatable in many countries.

Policies that encourage ride-sharing are crucial for addressing all the externalities, as they accrue per vehicle mile rather than per passenger mile traveled.

On-demand mobility may facilitate ride-sharing. However, automation could reduce the incentive to rideshare by making personal mobility cheap and convenient. If not offset by policy intervention, on-going technological advancements might fail to deliver a sustainable and equitable mobility future for the poorest in society.

Summary for Policymakers

Traditionally, international efforts addressing transportation issues have focused on pollution, congestion and accidents. The issue of climate change was only recently added to the agenda following the 21st Conference of Parties (COP-21) in Paris. The signatories to the Paris Agreement placed much emphasis on 'improve' measures, as opposed to 'avoid' and 'shift', in their nationally determined contributions (NDCs). These included raising fleet fuel economy and vehicle electrification.

New vehicle fleet fuel economy has been steadily rising in most countries. However, the average global annual rate of improvement over the last decade, around 1.5 percent, is well below the 2.8 percent needed to meet the 2-degree target. Furthermore, recently the annual rate of improvement has been declining, driven by lower oil prices and growing consumer purchasing power leading to a shift toward heavier and bigger vehicles.

The rate of vehicle electrification specified in the NDCs does not seem sufficient to meet the 2-degree pathway agreed, even if powered by 100 percent zero carbon energy. Getting on track would require either (1) higher rates of electrification or (2) simultaneous improvement in fuel economy of conventional internal combustion engine vehicles (ICEVs) to complement the NDCs' specified rates of electrification. The automotive industry's choice between these two pathways would be based on balancing current consumer preferences with short- and long-term costs. Incremental improvements in easier-to-sell ICEVs appear to provide the short-term cost optimal solution. Yet, this might prove to be a dead-end in the long run if it cannot be part of the zero emissions solution. However, given the capital-intensive nature of the automotive industry, profits from near-term ICEV sales are essential for development, production and perhaps subsidization of zero emission vehicles in the future.

Employment of low-carbon fuels, especially biofuels for decarbonizing freight, aviation and shipping, represents another strategy for achieving the 2-degree target. However, biofuels will experience price competition versus future costs of fossil fuels and sustainability challenges – to the extent they are based on crops such as sugar cane, corn, rapeseed and whether there is enough arable land for sustainable cultivation. There is a chance that next generation biofuels may not require conventionally arable land or may have a small areal footprint for production plants/facilities.

Reduced oil demand from passenger transport because of vehicle electrification, improvement in ICEVs fuel economy and low-carbon biofuels, would put a downward pressure on oil prices. Lower oil prices would intensify the competition with electrification and low-carbon biofuel strategies. Some agencies estimate that to offset the impact of lower oil prices, a carbon tax of around $350 per metric tonne of CO_2 would be needed.

Along with reducing greenhouse gas (GHG) emissions, an effective transport policy framework would also address the externalities of congestion, pollution and accidents. Policies that encourage shared mobility or discourage driving, such as a vehicle miles traveled (VMT) tax or gasoline tax, are aligned with the impacts that generate these externalities. However, the economic and efficiency gains arising from such taxation policies would have to be balanced against concerns about social inequity; depriving the poorest in society of access to affordable mobility services. The model used in some parts of Europe – reinvesting the revenues raised from taxes and congestion charges to promote shared mobility, including public transit – is likely to generate higher levels of public acceptance.

Despite its potential societal benefit, the level of VMT or gasoline taxation needed to change consumer habits may not be politically palatable in several countries. Low-levels of taxation, on the other hand, provide a weak signal to the consumers as to how all the costs add up. That is why, traditionally, fuel economy standards have been the globally preferred policy of choice. An alternative policy that front-loads the tax/rebate instrument at the point when a consumer makes the choice might induce a stronger response, as illustrated by the successful application of 'feebates' in raising the new vehicle fleet fuel economy in France. Equally innovative policies that encourage shared mobility or discourage driving can play a crucial role in addressing the externalities of congestion, pollution and accidents.

Smart mobility – comprising of shared on-demand use of automated high fuel economy vehicles – has the potential to become a sustainable transport solution. However, without policy intervention, smart mobility, like most other technology revolutions, is likely to make mobility more convenient and cheap. Consequently, it is likely to precipitate additional travel demand. The inconvenience of a slightly longer shared ride with a stranger, and the insignificant cost advantage of a shared automated taxi ride, would make solo automated taxi trips preferable.

The high upfront-cost of electric vehicles (EVs), diminishing operating cost advantage as oil prices fall, and implementation of road use fees on EVs to offset the loss of revenue from gasoline tax, represent potential barriers to electrification. Automation will probably lead to increased driving because of lower 'time cost,' as the driver can focus on activities other than driving. Higher cleaning costs for shared vehicles and the potential for renting out one's own personal automated vehicle while not in use could keep personal vehicle ownership attractive even in an automated future.

The vision offered by smart mobility may not arrive organically, but require policy intervention to ensure that it revolutionizes the transport sector to achieve the intended outcome of lower energy use, GHG emissions, pollution and congestion.

Background to the Workshop

On December 13, 2017, KAPSARC hosted a one-day workshop in Riyadh, focused on research aimed at understanding potential policy levers for promoting sustainable mobility. The workshop discussion centered on policies for addressing the externalities of congestion, pollution, accidents and GHG emissions related to passenger transportation, and evaluating their potential impacts. The workshop sessions addressed four main themes, covered in the following sections:

- Strategies for complying with GHG emissions reduction targets.
- Offsetting unintended consequences of new vehicle policies.
- Internalizing externalities beyond GHG emissions.
- Policy-led smart mobility – a means to sustainable transport.

Strategies for Complying With GHG Emissions Reduction Targets

The Paris COP-21 agreement seeks to limit global temperature rise to below 2 degrees Celsius from pre-industrial levels. The majority of the signatories have filed NDCs for cutting their respective GHG emissions. Emissions reductions from transport is a major part of most NDCs, as it is the one of the largest and fastest growing contributors to GHG emissions. However, current NDCs fall substantially short of the trajectory needed to meet the below 2-degree target. The agreement includes provision for revising and tightening of the NDCs on a regular basis.

The NDCs place greater emphasis on passenger transport than on freight, aviation and shipping. Within passenger transport, developed countries are focusing more on 'improve' measures such as fuel economy improvement and vehicle electrification. In developing countries, there is some emphasis on 'avoid' and 'shift' measures too, driven by the desire and need for equitable and sustainable mobility while achieving GHG emissions reduction as a collateral benefit.

According to recent estimates, achieving the 2-degree scenario would require a 50 percent reduction in sales-weighted fuel consumption of all new cars sold globally by 2030. Sales-weighted new vehicle fuel consumption has been declining in most countries since 2005, due to technological improvements in response to implementation of fuel economy standards. The global annual rate of improvement has been 1.5 percent since 2005. However, studies estimate that reaching the 2-degree target requires around 2.8 percent annual improvement for 2005-2030, so the current rate of improvement has been well below the target rate. Moreover, the rate has been declining over this period due to a global shift toward heavier and bigger vehicles, a likely function of consumer preferences combined with lower oil prices. The growing share of vehicle sales in traditionally less fuel-efficient countries is also contributing to the decline.

There is a large variation in new light duty vehicle (LDV) fleet fuel economy across countries, arising from differences in consumer demographics, preferences and policy contexts, for both developing and non-developing countries. Among the Organization for Economic Cooperation and Development (OECD) and European Union (EU) countries, the U.S., Australia and Canada are the least efficient, while France is the most efficient. Among non-OECD countries, China and India represent the two extremes with India having a higher new LDV fleet fuel economy. The average fuel economy in 2015 for OECD/EU and non-OECD was roughly comparable. However, there is wider variation in OECD/EU countries, and although the average rate of improvement from 2005-2015 is around 1.8 percent, the improvement has slowed from 2.3 percent (2005) to 0.5 percent (2015). In non-OECD countries, on the other hand, while the average rate of improvement over the same period was 0.8 percent, it has increased from 0.1 percent (2005) to 1.6 percent (2015).

Comparing the trends for new LDV fleet fuel economy improvements across different countries highlights the significant impact of policy choices. In France, strict fuel economy standards, coupled with 'feebates' (fees on low fuel economy vehicles and rebates for high fuel economy vehicles) and high fuel taxes have resulted in substantial fleet fuel economy improvement. Under this combination of policies, the average curb weight and footprint have largely stayed constant. Indonesia, in marked contrast, has no fuel economy regulations and subsidizes fuel prices. Consequently, new vehicles have seen an increase in average curb weight and footprint and no improvement in fleet fuel economy. A third case is Brazil, which does not have fuel economy regulations but uses monetary tax incentives for automakers to meet fleet fuel economy goals instead. Its impact appears to be similar to other countries that use fuel economy regulations.

Despite the focus on vehicle electrification in the NDCs, the committed or expected rate of electrification does not seem enough to meet the requirement for getting on the 2-degree pathway, even if powered by 100 percent zero-carbon energy. Getting on the path would require either a higher rate of electrification or simultaneous improvement in the fuel economy of conventional ICEVs with a committed rate of electrification. Automakers choice among the two pathways would be based on balancing current consumer preferences with short- and long-term costs. In the short term, incremental improvements in ICEVs might appear as the cost optimal solution, especially given its alignment with consumer choices. However, ICEVs may not end up being part of the long-term zero-emission solution. Thus, the incremental improvement in ICEVs may prove to be a dead end in the long run and the associated investments might prove to be sunk costs. However, given the capital-intensive nature of the automotive industry, profits generated from easier-to-sell ICEVs are essential for the development, production and perhaps even subsidization of zero-emission vehicles in the near term.

Low-carbon fuels are another potential strategy for achieving the 2-degree target according to a majority of the global integrated assessment models (IAMs). However, for low-carbon fuels, especially biofuels, it is important to consider whether there is enough land area to produce these biofuels sustainably.

The majority of these global IAMs also project that passenger cars will continue to be the dominant source of energy use and GHG emissions. In addition, the demand for liquid fuels would continue to grow even under policy scenarios with freight, aviation and shipping as the fastest growing modes.

It is important to consider that modeling such pathways includes many assumptions and leads to various uncertainties. The IAMs involve understanding and projecting major global trends in terms of gross domestic product growth, demand growth, changes in policy, changes in technology, geopolitics, supply availability, prices and so on. Furthermore, many parts of IAMs rely on expert opinion for their specification and parameterization. Therefore, one has to take their findings with a grain of salt. Also, such models may not be best suited for cost-benefit analysis of environmental policies. However, they can be useful tools for understanding emissions reduction potential of different pathways.

Lower oil demand from passenger transport because of vehicle electrification, improvement in ICEVs fuel economy and low-carbon biofuels could put downward pressure on oil prices. Lower oil prices in turn can reduce the rate of electrification by reducing the operating cost advantage of EVs. A drop in oil prices would also further intensify the competition with low-carbon biofuels, especially biofuels for decarbonizing freight, aviation and shipping. Besides, reduced oil prices can further shift consumers to faster modes of transportation such as aviation, especially for intercity travel, resulting in potentially higher GHG emissions. To offset the impact of lower oil prices, carbon tax might represent a potential policy lever. However, according to some agencies estimates, the carbon tax needed, around $350 per metric tonne of CO_2, may not be politically palatable in various parts of the world.

Adding further uncertainties are the emerging smart mobility services, including mobility-on-demand services and automated vehicles. Whether these new mobility services support electrification remains to be seen, especially if oil prices start falling because of reduced demand. Although automation improves vehicle efficiency and thereby the range for EVs, current levels of energy demand from sensors and graphics processing unit (GPU) computing have a severe limiting effect on EV range. This can limit the potential use of electric powertrain for automated vehicles, pending drastic improvement in the energy density of batteries.

Offsetting Unintended Consequences of New Vehicle Policies

New vehicle policies of various types, such as taxes, fuel economy standards and feebates, also affect the demand and price of used vehicles. If new vehicles become expensive because of these policies, then demand for used vehicles increases; since new vehicles are expensive, over time their value as used vehicles also increases. Thus, after an accident, the owner might be better off getting the vehicle repaired instead of buying a replacement. This is especially true in developing countries where the labor and repair cost is low, especially in the rural areas. This results in used cars, which are less fuel efficient, staying on the road for a long time. However, new car policies tend to ignore this effect.

Recent simulation studies suggest that changes in vehicle scrappage, both rate and composition, can cause 10 to 15 percent lower gasoline savings than expected assuming no effect from new vehicle fuel economy standards. The impact is bigger than or equal to the rebound effect, arising from an increase in driving by consumers buying higher fuel economy vehicles.

Beyond this CO_2 emissions or gasoline savings leakage effect, new car policies also impact local air pollution caused by used vehicle fleet. Recent studies suggest that the older half of the used vehicle fleet emits more than 95 percent of smog-forming pollutants. What makes matters worse is that a majority of the contribution comes from low fuel economy, large vehicles that stay on the road longer because of new vehicle policies. This highlights the need for a countervailing policy for used cars to undo the damage to local air quality from new car policies. Potential solutions could involve either scaling up the fuel tax or used car registration tax based on the car's local air pollution potential. Encouraging vehicle scrappage through subsidy programs, such as cash-for-clunkers type programs, may not represent a cost-effective solution because even owners who would have scrapped their car anyway will also obtain these subsidies.

Internalizing Externalities Beyond GHG Emissions

Besides GHG emissions reduction, transport policies should also consider the full set of vehicle-related externalities, such as congestion, pollution and vehicle collision, to maximize net benefits to society. Since these externalities accrue per vehicle mile, any tax that discourages driving or vehicle miles traveled (VMT) would help reduce them. Fuel economy standards by themselves do not account for such externalities.

Recent research suggests that a VMT tax together with fuel economy standards could address externalities related to driving. Such a combined policy could also produce a larger net economic benefit than a gasoline tax, especially if the VMT tax is fine-tuned to account for differences in urban and rural geographies and time of day.

Recent research findings also suggest that commuters purchase large cars in response to traffic as they feel safer and more comfortable in a large car during their tense and congested commute. Thus, congestion pricing could not only reduce traffic but also result in people buying smaller cars, further raising fleet fuel economy and reducing accident severity. However, there is need for more research to separate conflating factors causing congestion such as road capacity and accidents. Consumers' choice to buy larger vehicles could be due to safety concerns from accidents, which in turn causes congestion. Findings from new vehicle buyer surveys confirm that safety and road visibility are among the topmost reasons for people buying SUVs rather than congestion per se.

An interesting case study to confirm the simulated impact of congestion pricing on vehicle size choice would be to look at European cities that have had congestion pricing for a while now.

The economic and efficiency benefits arising from VMT or gasoline taxes would have to be balanced against inequity concerns. The high revenue generation potential of such tax instruments, especially congestion pricing, also raises the question of where the money should be reinvested. In Europe, cities reinvesting the raised money into public transport have seen higher levels of public acceptance for congestion pricing.

The level of VMT or gas taxes needed to achieve the intended targets may not be politically palatable in some countries such as the U.S., especially as gasoline prices fall as a result of the intended reduction in demand. A low level of tax instruments provides a weak signal to the consumers regarding how all the costs add up. That is why, historically, even for GHG emissions reduction, it has proven hard to find actionable policies that are as cost-effective as fairly strong fuel economy standards that apply to the manufacturers. Innovative policies, similar to feebates for reducing GHG emissions from LDVs, would be needed to address the externalities of congestion, pollution and accidents. This is because feebate type of policies front-load the tax/rebate instrument at the point when the consumer makes the choice. Such policies could potentially induce a strong response from the consumers.

Policy-led Smart Mobility – a Means to Sustainable Transport

The transportation system is vast and continues to evolve. Changing demographics and societal trends, including prioritizing personal conveyance over shared mobility such as public transit, have had an enormous negative impact on the transportation system efficiency. Moreover, a systematic shift toward faster modes of transport has also had a deep impact on GHG emissions.

From the supply-side, given the capital-intensive nature of the transportation system and long timescales, industry is usually more inclined toward incremental improvements rather than radical change. However, things are in motion on the supply-side as well, led mainly by the rise of smart mobility, including electrification, automation and shared mobility-on-demand.

The synergistic interaction among the different elements of the smart mobility system holds the key to ensuring sustainable transport. Among them, shared mobility-on-demand is of prime importance. It holds potential for: (i) lowering the societal cost of electrification, (ii) improving the transport system efficiency and (iii) addressing associated externalities such as congestion, pollution and accidents. All these benefits arise from the promise of fewer vehicles on the road offered by shared mobility-on-demand.

Cost and convenience are the two major deciding factors for consumers on whether to opt for shared mobility or not. Studies suggest that given the lower cost of automated taxis, the additional savings from sharing an automated taxi would be low. Furthermore, solo trips would be preferred given the disutility of ride-sharing due to longer trips and sitting with a stranger. Thus, without suitable policy intervention, shared mobility may not be able to realize its true potential.

According to recent findings, electrification, the second major pillar of smart mobility, may not be able to edge out the incumbent internal combustion engine technology, at least in the near- to mid-term. This is mainly because of EVs high upfront-cost. Furthermore, the diminishing operating cost advantage due to reduced oil prices, which could arise from declining oil demand from the corresponding shift to EVs, would make transition tougher. The implementation of road use fees on EVs to offset the loss of revenue from gasoline tax would also act as a barrier.

Automation is also likely to lead to a rebound effect, with larger VMT, because of lower time cost. A lot of factors suggest that personal vehicle ownership might still be attractive in an automated future. These include lower time cost, convenience and pride of owning a car, potential for better hygiene (especially for families with children), higher cleaning costs of shared vehicles and potential for renting out your personal automated vehicle while not in use. Additionally, the driver market, especially for truck drivers, is a non-trivial labor market that has historically been quite active. Thus, the transition to automation may not be as seamless as desired.

Without suitable policy intervention, advances in the smart mobility field may not be able to revolutionize the transport sector in terms of reduced energy use, lower GHG emissions and less congestion. In fact, current signs suggest that if left unchecked, smart mobility, like most other technology revolutions, will probably make mobility convenient and cheap, thereby reducing the incentive for sharing as well as incurring extra travel demand. Policy would continue to play a key role in realizing the benefits of emerging changes in demand and supply.

About the Workshop

KAPSARC convened a workshop in December 2017 in Riyadh with more than 35 international experts to understand potential policy levers for promoting sustainable mobility. Specific attention was given to policies for addressing the externalities of congestion, pollution, accidents and greenhouse gas emissions related to passenger transportation, and evaluating their potential impacts. The workshop was held under a modified version of the Chatham House Rule in 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

Abdulhadi Alotaibi – Technical Regulations Manager, Toyota - ALJ Motors

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Dan Malik, Director – ALG/TrueCar

Alan Meier – Professor, Energy Efficiency Center, UC Davis

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Majid Al-Moneef – Secretary General, Kingdom of Saudi Arabia Supreme Economic Council

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Kurt Van Dender – Head of the Tax and Environment Unit, OECD

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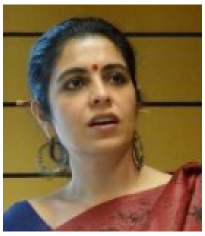
About the Team



Anvita Arora

Anvita is program director for Transport and Urban Infrastructure at KAPSARC. Previously, she was the CEO of Innovative Transport Solutions. Anvita holds a Ph.D. from the Indian Institute of Technology Delhi, India.

Marcello Contestabile

Marcello was formerly a research fellow at KAPSARC specializing in energy transitions and innovation policy. Previously, he worked at Imperial College London.

Rubal Dua

Rubal is a senior research associate at KAPSARC, working on vehicle regulatory policy and shared mobility research using the consumer perspective. He holds a Ph.D. from KAUST, Saudi Arabia and an MS degree from the University of Pennsylvania, USA.

Tamara Sheldon

Tamara is a visiting researcher at KAPSARC and an assistant professor of economics in the Darla Moore School of Business at the University of South Carolina. Her research interests include environmental and energy economics and how these fields interact with public policy. Tamara holds a Ph.D. in Economics from the University of California, San Diego.

David Bunch

David is a professor in the Graduate School of Management and the Institute for Transportation Studies at the University of California, Davis. He has consulted on transportation policy issues for state and federal agencies, public utilities and the airline industry. David holds a Ph.D. in Mathematical Sciences from Rice University, Texas.

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Anthony is an assistant professor of economics in the School of Public and Environmental Affairs at Indiana University. His research interests include environment-economy interactions in China. Anthony holds a Ph.D. in Economics from the University of California, San Diego.

About the Project

The workshop series Drivers of Transportation Fuel Demand provides a forum for discussing key sustainability issues in transportation and current policy strategies to address them. In particular, much 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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