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

Mobility-on-Demand: Understanding Energy Impacts and Adoption Potential

October 2016 / KS-1658-WB052A

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.

Legal Notice

Key Points

Major transformations are taking place in the mobility sector; where a transportation system comprising of shared, fully electric, connected and driverless cars available on demand may be on the cusp of emergence. Technological developments and preferences of the next generation toward pay-per-use mobility instead of owning a vehicle is leading this innovation.

- Mobility-on-demand could critically alter key aspects of travel behavior such as vehicle ownership, miles traveled and use of mass transit; potentially causing major changes in the automotive and energy sector.

- Enhanced personal mobility and economic gains from mobility-on-demand are expected to affect societal welfare — impacting energy demand, greenhouse gas emission, alternative fuel vehicle adoption and congestion. The outcome depends on whether it replaces mass transit or personal driving, which will decide if there is an increase or decrease in vehicle miles traveled.

- Satisfying consumer needs and delivering financial and social value would lead the future evolution, underlining the importance of understanding mobility from a consumer's perspective.

Summary for Policymakers

The mobility sector is undergoing significant shifts including the rise of shared, automated, multi-modal and electric mobility options based on the concept of mobility as a service model. The shared vehicle ecosystem has expanded from station-based car sharing to app-based ride-sourcing, with shared autonomous mobility holding promise for the next phase of the evolution. Shortcomings of the current mobility model, namely high upfront cost of personal vehicle ownership, coupled with new consumer preferences and technological developments are contributing to this evolution.

App-based ride-sourcing, also known as mobility-on-demand, has the ability to influence key aspects of travel behavior, such as vehicle ownership, vehicle miles traveled (VMT) and mass transit use. In developed countries, mobility-on-demand could displace the need for a second vehicle in many households. It could also affect the demand for alternative fuel vehicles (AFVs), such as battery electric vehicles (BEVs), which generally tend to be acquired as a second vehicle. Fuel-efficient AFVs hold promise for adoption by mobility-on-demand drivers and fleet providers because of the higher mileage per vehicle expected. In developing countries with low per capita income, mobility-on-demand could potentially make vehicle ownership redundant.

Mobility-on-demand could complement other shared-use modes such as mass transit (trains, subways and buses) by helping to resolve the "last-mile" problem. Increased mass transit usage and shared mobility-on-demand could reduce overall VMT.

On the other hand, if a significant number of consumers start using mobility-on-demand in place of mass transit that could increase VMT. Higher VMT may also occur by demand from sections of the population that previously were unable to drive such as children, the infirm, elderly and disabled.

Enhanced personal mobility and economic gains from mobility-on-demand could result in either societal benefits or costs depending on its utilization. By using fuel-efficient vehicles, getting the right-sized vehicle to match customers' needs and higher vehicle occupancy through shared ride-sourcing, greenhouse gas (GHG) emissions could be reduced. Shared mobility-on-demand in place of driving a personal vehicle could also contribute to lower congestion.

Continued growth of mobility-on-demand will depend on the satisfaction of consumer needs and the value they derive. Personal vehicle ownership offers intangibles other than just mobility, which providers of the mobility service have to understand in order to succeed. At the same time, if consumers get benefits from the mobility-on-demand model that is not currently offered by vehicle ownership, such as using the time during the journey for practical functions, or enhanced social interaction during shared mobility-on-demand, growth may become exponential. Understanding the needs and motivations of current and potential users holds the key to gaining insights into this evolution of mobility.

Background to the Workshop

In March 2016, KAPSARC hosted a workshop in San Francisco, California to explore opportunities to enhance the energy-efficiency of mobility-on-demand. The session also included discussion on factors that could encourage the adoption of such energy efficient mobility options.

The workshop discussion centered on understanding the energy impacts and adoption potential of mobility-on-demand.

Mobility-on-Demand: Energy Impact

Shifts in mobility sector

The mobility sector is undergoing major transformations. Shifts not witnessed until recently include shared, automated, multi-modal and electric mobility options, based on the concept of mobility as a service. A connected system comprised of vehicle-grid-internet integration may be on the cusp of emergence, providing more mobility options than ever before.

The shared vehicle ecosystem has grown from shared use vehicle services such as station-based car sharing (Zipcar and City CarShare) to shared mobility-on-demand (uberPOOL, Lyft Line, Lyft Carpool). Within shared use vehicle services, mobility-on-demand has experienced exponential growth. While car sharing attracted only 1.7 million users globally in the last 15 years, Uber alone has at least 8 million users globally within its first five years.

Shared autonomous vehicles may be the future of mobility-on-demand. Such vehicles can take mobility-on-demand to the next level. Driverless vehicles could further reduce the cost per mile and make mobility-on-demand very competitive versus personal vehicle ownership.

Shortcomings of the current mobility model have been influential in the creation of mobility as a service model. Personal vehicle ownership requires a high upfront expense and yet is used for only 2-10 percent of its available time. However, other intangibles beyond mobility go into the decision to buy a personal vehicle, which must be met for the mobility as a service model to succeed. Mass transit – one of the earliest forms of mobility as a service – represents an inexpensive, but often inconvenient option because of issues such as availability, timing and the “last-mile” problem.

Impact of mobility-on-demand on travel behavior

Mobility-on-demand has the potential to influence travel behavior by affecting the three important travel considerations: availability, reliability and trust. By offering technology-enabled, easily accessible options, it can influence different aspects of travel behavior as discussed below:

Personal vehicle ownership

The great promise of mobility-on-demand is that it offers many of the flexible mobility benefits of vehicle ownership without the high up-front and operating costs of owning a car. Preliminary research suggests that frequent mobility-on-demand users tend to either postpone or decide against personal vehicle ownership when considering a second vehicle. For them, mobility-on-demand becomes an extension, rather than a replacement for primary vehicle ownership.

The “last-mile” problem is common to transportation, utilities, telecommunication and other supply chain networks. It refers to the difficulties faced in the movement of goods and people from a central hub to their final destination. In the case of passenger mobility, the last-mile problem could deter mass transit usage altogether, even when high quality transit services may be available for a majority of the trip. For mass mobility providers, ensuring the last connection often presents challenges of inefficiency and high costs, as the service may not be shared by a high number of riders.

Recent survey studies also suggest that one station-based car sharing could take 9-13 personal vehicles off the road. Similarly, recent simulation studies suggest that one shared autonomous vehicle could replace 10 personal vehicles. However, such survey-based findings could suffer from self-selection bias issues, i.e., selection of enthusiastic early adopters of such programs/technologies, which need to be accounted for when extrapolating their effects for mainstream adopters.

In developing countries with low vehicle ownership, mobility-on-demand could make vehicle ownership redundant. For example, many such countries adopted cell phones directly in place of land lines. Developing countries' populations have a lower per capita income and personal vehicle ownership is still considered a luxury. Shared mobility-on-demand could offer affordable transportation and reduce congestion on typically choked and underfunded roads.

Adoption of alternative fuel vehicles (AFVs)

Higher mileage of mobility-on-demand vehicles favors use of low operating cost, fuel efficient vehicles such as BEVs. However, frequent charging and higher mileage might degrade batteries more quickly, necessitating frequent battery replacement. Such expense might reduce the BEV appeal as internal combustion engine powertrains become more fuel efficient.

On the other hand, mobility-on-demand could negatively impact adoption of AFVs as personal vehicles. Both of these adopters are innovators who like to try new experiences. AFVs, like the BEVs, tend to be adopted as a second vehicle in the household, while mobility-on-demand tends to displace the need for a second vehicle. Also, both usually serve intracity, or short range, transportation and thus mobility-on-demand may reduce BEV demand as personal vehicles.

Vehicle miles traveled (VMT)

Mobility-on-demand may result in an overall reduction in VMT through increased ride-sharing but if it displaces mass transit usage then it may lead to an increase. Moreover, for sections of the population who are unable to drive (such as the infirm, elderly or children) or can't afford a vehicle (such as in developing economies), mobility-on-demand could provide mobility options, and its use may result in an increase in overall VMT.

Use of mass transit

Shared mobility could complement or substitute mass transit. Cities with a widely dispersed user base see shared mobility, such as mobility-on-demand, as an opportunity to fill in mobility gaps such as the "last mile" problem. Development of public and private collaboration such as fare integration for mass transit and mobility-on-demand could also help resolve "last mile" issues.

Societal impacts of mobility-on-demand

One of the most straightforward societal impacts of mobility-on-demand is that it offers more mobility options and thus greater access to economic opportunities by bringing together people, goods and services. The economic benefits from enhanced personal mobility options offered by mobility-on-demand can carry other social benefits or costs, depending upon how they are utilized, as discussed below:

GHG emissions

Mobility-on-demand could offer potential GHG emissions reduction through: (i) use of fuel efficient vehicles encouraged by their lower operating costs; (ii) the scope for BEV adoption powered by clean renewable energy; (iii) higher fleet turnover utilizing newer fuel efficient technologies; (iv) potential for right-sizing, i.e., matching a vehicle to number of passengers; and (v) higher vehicle occupancy through ride-sharing. Mobility-on-demand could also result in GHG emission increase, however, through: (i) rising energy use if it replaces high capacity transit; (ii) low ride share; (iii) inefficient energy utilization, e.g., higher idle time, driving to pick up riders or searching for parking; (iv) creation of additional VMT due to ease of access.

Congestion

Shared mobility-on-demand, if increasingly utilized in place of personal vehicles, could reduce the number of vehicles on the road at a given time, thus reducing traffic congestion. If mobility-on-demand replaces mass transit, however, it could increase congestion levels. Congestion-related concerns were raised in New York City, where currently there are more mobility-on-demand drivers than cab drivers. However, such concerns did not find support in research findings from the New York City mayor's office. Their findings suggested that increased freight movement, construction activity and population growth are the major reasons for the rise in congestion. Mobility-on-demand only partially contributed to the congestion, but did not drive the recent increase. However, the mobility-on-demand industry is yet to mature and it may be too early to tell.

Socially responsible mobility options

Mobility-on-demand could reduce isolation and enhance social interaction and health care accessibility for the elderly and infirm. Society could provide better care for their aging population with para-sharing. Para-transit non-emergency medical transportation costs for the elderly have been steadily rising. As an alternative, funding from public transit services could support mobility-on-demand for seniors. It is imperative that ride requesters are able to track vehicles providing such services, ensuring trust and safety.

Mobility-on-Demand: The Consumer's Perspective

Mobility-on-demand usage

Mobility-on-demand provides more accessibility to consumers than ever before, just at the push of a button. Mobility-on-demand tends to be used more frequently during the night for social trips, when mass transit is either unavailable or sporadic. Common uses during the day include for leisure, business in downtown areas or trips to the airport — all of which means fewer taxi cab rides. This developing pattern implies mobility-on-demand is replacing more automobile trips than mass transit rides. Survey data on transportation mode substitution suggests that mobility-on-demand users would revert back to either driving alone or car sharing, if it was not available. Mobility-on-demand usage has increased during the day, but still represents a minority mobility choice for most commuters.

Mobility-on-demand users

Mobility-on-demand users tend to be young, educated, upwardly mobile people living in urban centers. They are more likely to use mass transit, spend less on transportation and own fewer personal vehicles. They are curious about new experiences. They think like innovators and generally have higher incomes. Their needs are inherently different from those with families and living in the suburbs. Although suburban residents working in the city may choose shared mobility options in place of driving their personal vehicles because of gridlock traffic, too little parking and operating expenses. Some new vehicle buyers also tend to use mobility-on-demand frequently, not necessarily as a replacement, but as an extension of driving their personal vehicle. Presently, mobility-on-demand is still not reliable and inexpensive enough to replace personal vehicle commuting.

Importance of consumer's perspective

The revolution around mobility-on-demand currently has very little information about the repercussions on what will happen if it becomes mainstream. It is presently used as a peer-to-peer service, but consumers might use the service very differently from what its creators' envisaged. Cell phones, for example were not invented to send texts or pictures. Its inventors did not foresee the immense popularity of such a messaging service. The cellphone platform morphed through user preference changes. Such platforms can become useful in very different ways than originally conceived.

The recent emergence of rental services allowing drivers to hire vehicles, driving for Uber and Lyft, shows an extension of the original peer-to-peer service concept. Lyft itself originated as a service of Zimride, a long distance ride share program. In its current form, it represents an on-demand, city based ride-sourcing application. The consumers' needs play a big role in deciding what models become viable in the future.

Although consumers represent a very important part of the equation, their behavior and decision-making is inherently difficult to understand and quantify. There is a certain heterogeneity among consumers that is hard to generalize for research. Their preferences and inclinations also tend to be malleable. For example, shared autonomous vehicles may not be under consideration for many users, but successful pilot demonstrations might change that perception. It is important to look at mobility as a service model via the consumers' lens. In particular, it is worth considering mobility-on-demand as it has demonstrated its viability and ability to induce radical shifts in the mobility market.

Several essential questions arise while viewing mobility-on-demand through the consumers' lens, including: (i) who uses the service and for what purpose; (ii) how users see the service utility in their future needs and which factors currently prevent or discourage such usage; (iii) what other demographic might use the service; and (iv) how the other demographics may be encouraged to use the service?

Consumer survey data could help reveal certain insights about the motivations of early adopters. Understanding the innovators and early adopters provides the learning opportunity needed to encourage further adoption. This knowledge will help meet the needs and demands of consumers at different stages of the adoption curve, which in turn would drive evolution of some of the more disruptive business models.

Next Steps

Currently there is limited information on whether the impact of the present mobility-on-demand system is going to be positive or negative in terms of number of vehicles on the road, energy usage, extent of adoption, and how people decide to use them versus how their creators imagined they would be used. It might be worthwhile to develop a resilient policy framework that could incorporate the wide range of uncertainties and which is also able to adapt as more discoveries are made in years to come.

KAPSARC and Strategic Vision are launching a survey study on the interactions of mobility-on-demand services, human behavior and energy. The research aims to combine psychographic and demographic data with mobility data to understand the motivations of mobility-on-demand drivers and users and how this will shape the future of energy in both developed and developing economies.

About the Workshop

KAPSARC convened a workshop in March 2016 in San Francisco with around 30 international experts to explore possible ways to enhance the energy-efficiency and adoption of mobility-on-demand. The workshop was held under a modified version of the Chatham House Rule — participants consented to be listed below. However, none of the content in this briefing can be attributed to any individual attendee.

List of Participants:

Mohammed Alajaji – Research Analyst, KAPSARC

Rob Bailey – Research Director, Energy, Environment & Resources, Chatham House

Tom Baloga – Senior Director, Government Affairs, Audi of America, Inc.

John Boesel – President and CEO at CALSTART Inc., CALSTART

David Bunch – Professor of Management, UC Davis

Chris Chaney – Vice President, Strategic Vision

Nicholas Chase – Research Fellow, KAPSARC

William Chernicoff – Manager, Energy & Environmental Research Group, Toyota Motor North America

Regina Clewlow – Director of Transportation Research and Policy, RideScout & Research Scholar, Future Mobility Center, UC Davis

Steve Douglas – Senior Director, Environmental Affairs, Alliance of Automobile Manufacturers

Rubal Dua – Senior Research Associate, KAPSARC

Alexander Edwards – President, Strategic Vision

Peter Gigante – Policy Research Manager, Lyft

Jeffery Greenblatt – Staff Scientist, Lawrence Berkeley National Laboratory

Tiffany Groode – Senior Director, IHS

Jamie Hall – Manager, Advanced Vehicle and Infrastructure Policy, General Motors

David Hobbs – Head of Research, KAPSARC

Rebecca Levinson – Systems Analyst, Sandia National Laboratories

Zhenhong Lin – Senior Researcher, ORNL Center for Transportation Analysis, J.F. Assoc. Professor, University of Tennessee, Industrial and Systems Eng., Oak Ridge National Laboratory

Rebecca Lindland – Senior Director, Commercial Insights, KellyBlueBook

Dan Malik – Director, ALG/TrueCar

Michael Nicholas – Post-doc, UC Davis

Creighton Randall – Program and Development Director, Shared-Use Mobility Center

Aymeric Rousseau – Systems Modelling and Control Group Manager, Argonne National Laboratory

Adam Stocker – Research Associate, UC Berkeley

Gil Tal – Assistant Professional Researcher, UC Davis

Margaret Taylor – Engineering Research Associate, Stanford University's Precourt Energy Efficiency Center

Jake Ward – Program Manager, Analysis, Vehicle Technologies Office, Energy Efficiency and Renewable Energy, U.S. Department of Energy

Kenny White – Senior Research Analyst, KAPSARC

About the Team

Rubal Dua

Rubal is a senior research associate analyzing mobility and vehicle regulatory policy programs using the consumer perspective. He holds a PhD degree from KAUST and a MS degree from the University of Pennsylvania.

Kenneth White

Kenneth is a former senior research analyst analyzing transportation and Chinese energy policy. He has an MPP from Stanford University.

Nicholas Chase

Nicholas is a research fellow focusing on the future of transportation energy demand in China and India. He holds an MA from John Hopkins University and a BA from the University of Michigan-Ann Arbor.

Marcello Contestabile

Marcello is a research fellow specializing in energy transitions and innovation policy. He has a PhD in Energy Policy and Technology from Imperial College London.

Mohammed J. Alajaji

Mohammed is a research analyst. He holds a bachelor's degree in industrial engineering and a bachelor's degree in economics and mathematics with honors from Northeastern University.

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 mobility-on-demand.

Notes

Notes

www.kapsarc.org