



Drivers of Transportation: Measuring the Impact of Policy on Adoption of Alternative Fuel Vehicles



About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is an independent, non-profit research institution dedicated to researching 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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Summary for policymakers

The effects of fuel economy and greenhouse gas (GHG) emission standards continue to reverberate through the automotive industry as governments attempt to reduce tailpipe emissions. Manufacturers are developing alternative fuel powertrains and more efficient internal combustion engines in order to meet these tightening regulations. However, customers do not seem to have as much appetite for these alternatives as policymakers anticipate. Understanding what consumers want and what policy approaches work best to drive adoption of more efficient vehicles is the subject of KAPSARC's automotive research project "Transportation Policy Effectiveness and Alignment with Consumer Demand." The project's initial focus is on the United States (US), as this has the most complete data set with which to demonstrate the framework.

KAPSARC is developing an Alternative Fuel Vehicle (AFV) Policy Database for the US, detailing hundreds of different Transportation Rebates, Initiatives, Incentives, and Policies (TRIIPs) designed and implemented by federal, state and local governments to encourage AFV adoption. Examples range from local free in-town parking for hybrids to a federal tax credit for the purchase of a battery-electric vehicle. These TRIIPs are geo-coded and will populate an open-source, interactive policy map, providing guidance and insight for decision makers to evaluate and select the most effective policies for specific state and local situations.

The combination of new automotive innovations, a complex policy structure, and a poor understanding of the value consumers place on fuel efficiency,

results in a market environment with a very high level of uncertainty. As a result, despite myriad initiatives, sales of AFV persistently account for less than 5% of annual US light vehicle sales. Understanding how to achieve a breakthrough in penetration rates of AFVs is critical for policymakers and the auto industry to meet many of the US's stated fuel efficiency goals.

The success of policy depends on overcoming several inherent contradictions, including:

- **Policy push versus consumer pull:** TRIIPs successfully led to the availability of a wide range of AFV technologies and models, but low consumer demand continues to undermine profitability.
- **Investments in new technologies:** Early government support facilitated AFVs but at the same time fuel efficiency standards drove increased competitiveness of internal combustion engines.
- **Paradigm shift in analytical understanding of consumer behavior:** New tools allow manufacturers to understand market segmentation but analysis based on historical data doesn't predict potentially disruptive change from innovations in mobility.

The benefits of better targeted and more successful TRIIPs depend upon an improved understanding of the role of consumers in shaping demand for more fuel efficient vehicles in general and AFVs in particular.



Background to the workshop

KAPSARC organized a two-day workshop in Washington D.C., and a one-day event in Paris to discuss the role of policy in the adoption of alternative fuel vehicles (AFVs) in the United States (US). Alternative fuels and advanced technology include vehicles using electricity, biodiesel, hybrids, hydrogen, compressed natural gas, and clean diesel but the discussions excluded flex fuel/E85 vehicles.

KAPSARC is blending qualitative and quantitative analysis in a non-traditional approach with the goal of delivering broader, micro-level insight into the issue of consumer acceptance of more fuel efficient vehicles, and AFVs in particular. Methodologies under development include:

- Integrating detailed registration and consumer survey data, creating a multi-dimensional data environment with granular geo-temporal specificity and enabling a range of quantitative, “big data” approaches paired with qualitative sentiments.
- Employing structural equation models to analyze customer satisfaction and loyalty by demographic segment.
- State-of-the-art methods based on topological network visualization allows for unique and granular segmentation of the market and identification of new potential AFV buyers.

One of the central hypotheses is that local context is a key influencer in vehicle purchases, and policies are more effective when tailored for the local buyer. KAPSARC does not advocate a particular technology or type of vehicle. Instead, it explores size and scope of the potential market for more fuel efficient vehicles to aid understanding of the impact of existing TRIIPs. Auto manufacturers already produce low-emission and zero-emission vehicles to meet federal fuel economy standards and mandates, but AFV demand is consistently below forecast and

less than 5% nationally, although penetration rates vary greatly by state. KAPSARC’s research seeks to understand these geographical differences, the extent of consumer demand for fuel efficient technology, and the role policy plays in adoption rates.

The current focus of the project is on the US. KAPSARC intends to extend the framework for understanding consumer choice to other countries, particularly China, where location already plays a major role in policymaking. These plans, and expansion into the Middle East and appropriate European markets, will depend on availability of data — a critical barrier to full implementation.

Data key to the project — such as vehicle registration data, detailed sales data, cost of ownership, demographics, and consumer survey data — are all readily available in the US but not as readily available in many other countries. Issues of data quality, availability, and consistency are obstacles to adopting this framework in other regions.

Regulatory push versus consumer pull

Policies and some elements of consumer demand are leading to new advanced efficiency technologies. There are a total of 58 different AFV models commercially available in the US for model year 2014, compared with just 38 in 2012. Sales have risen in tandem with greater model availability. Sales in 2013 were 768,500 vehicles and 745,000 in 2014 according to Autodata Green Vehicle Report.

The Technology Adoption Lifecycle Model shown in Figure 1 illustrates the general stages of consumer adoption of new technologies. Sales of hybrid vehicles, more than ten years after introduction and requiring no special infrastructure, are 3.5% of the market and the Toyota Prius, a vehicle currently in its third iteration, continues to dominate, accounting for 40-50% of monthly hybrid sales. Four years after introduction, electric vehicles are about 1%.

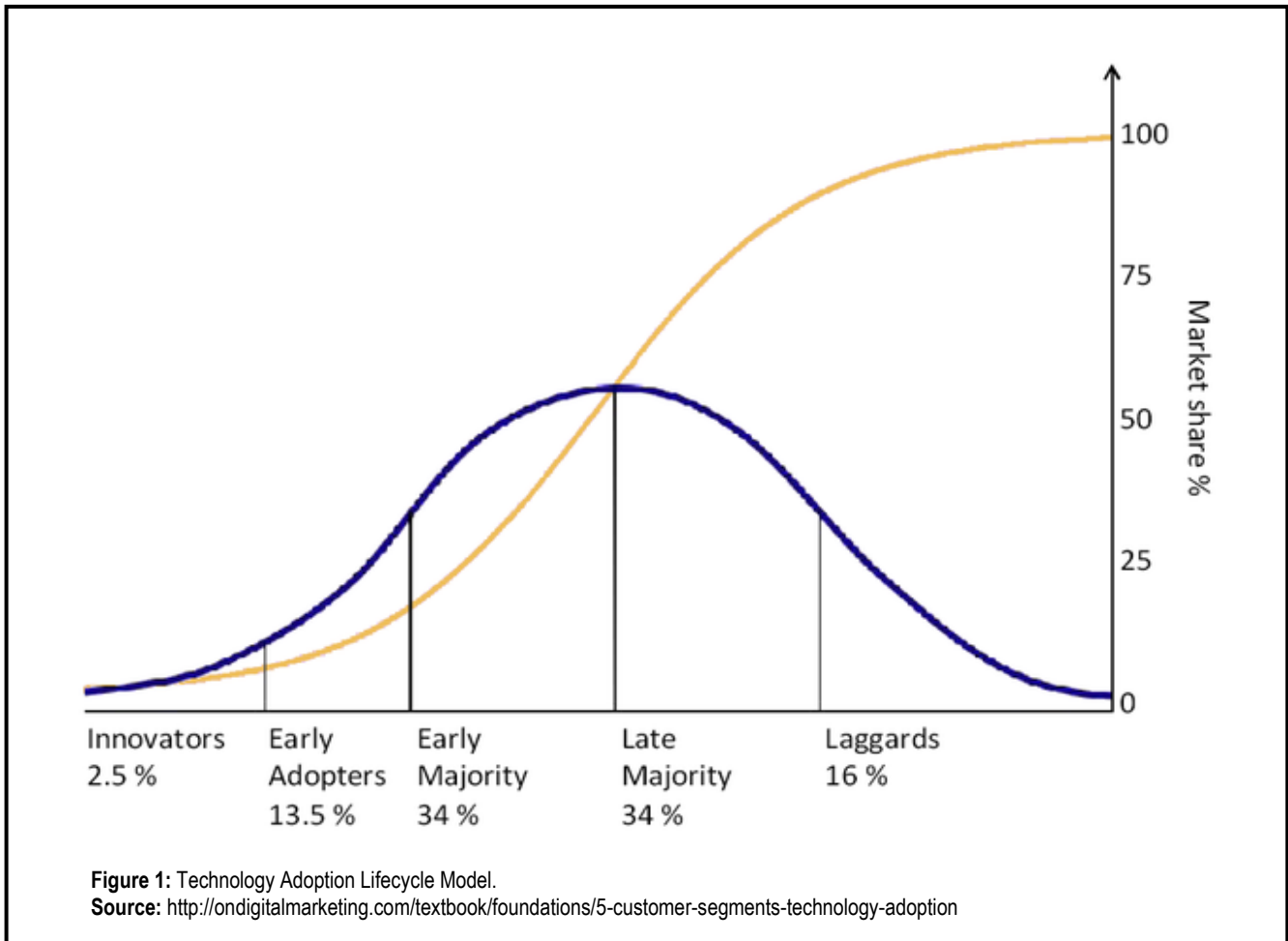


Although more AFV models are available for purchase, consumer demand accounts for less than 5% of the new car market, effectively appealing to the “innovator” mindset and yet to crack the “early adopter” segment.

Part of the challenge to expanding adoption of AFVs is that longer term fuel savings come at the expense of higher upfront costs and, for electric vehicles, the need for fast charging infrastructure to support long distance travel. Higher upfront cost can be off-putting to the consumer, especially when gas prices are low, keeping even a well-established technology such as hybridization in the “innovator” range. Indeed, in many cases consumers could achieve better returns from alternative purchase decisions (such as a more fuel efficient conventional powertrain).

The conundrum for consumer AFV demand is that low volume keeps prices high, but development and manufacturing costs will not come down until volumes increase. With enough demand, economies of scale can help to lower prices, creating a more compelling total cost of ownership proposition for consumers. Similarly, it is difficult to make a business case for investment in charging/alternative fuel stations until more AFVs are on the road, but as lack of infrastructure is identified as a significant barrier to increased adoption rates, it is also difficult to generate momentum.

“Low volume keeps prices high, but R & D costs won’t decline until volume increases.”





While TRIIPs help increase adoption rates, KAPSARC research seeks to understand if there are specific examples where TRIIPs have been more, or less, effectively deployed in specific local contexts. For example, two buyers who are demographically indistinguishable likely apply different cultural values to their vehicle choices depending on whether they live in California or Mississippi. Penetration rates of AFVs vary greatly by geography, and municipalities encourage TRIIPs which suit the local setting. For instance, access to carpool lanes is very appealing in congested urban settings, while higher tax credits or free parking may work better in other areas of the country. The KAPSARC interactive policy map visualizes TRIIPs within the context of potentially key cultural influencers, providing insight for decision makers evaluating and selecting the most effective policies for specific situations.

Investments in technology may have unpredictable results

Government support of new technologies can help increase adoption rates, although this may be hindered by AFV misconceptions and low levels of consumer incentive awareness. Within the seven year period from 2012 to 2019, the Congressional Budget Office estimates the US government will spend about \$7.5 billion on federal policies to promote plug-in hybrid electric vehicles and battery-electric vehicles, with about 25% going towards tax credits. At the same time, the general understanding is – and indeed executives have explicitly stated – most manufacturers lose thousands of dollars on every AFV they sell, stymying profitability and leading some automakers to limit production runs and develop low-volume “compliance cars” solely to meet fuel economy standards.

In any case, the impact of more stringent fuel economy and greenhouse gas emissions standards

has unpredictable consequences. This legislation is pushing car companies to increase conventional automobile fuel efficiency and investments in internal combustion engines, thus eroding the net economic benefits that AFVs can offer to consumers through lower operational (fuel) costs. With these fuel efficiency gains, it is harder for consumers to justify paying the incremental AFV purchase costs when set against the now reduced net fuel cost savings.

Paradigm shift in analytical understanding of consumer behavior

Consumer research and behavioral analysis implies that many of the current TRIIPs reward buyers who would have purchased the vehicle anyway. This is analogous to distributing Apple product discount vouchers to people standing in line to acquire a new model of iPhone. Manufacturers are launching new AFV models nearly every quarter to comply with current and future regulations but penetration rates are stable or declining. There is value in better understanding the market size of potential buyers – who *could* buy an AFV and yet choose not to. The availability of a wide range of data sources may lead to additional insights for increasing adoption rates, improving profitability for manufacturers, and possibly lowering the price of AFVs for consumers or reducing the cost of policy support.

“There is value in better understanding potential buyers — who could buy AFV yet choose not to.”

At the same time TRIIPs are shaping vehicle development, demographic forces are at work among US car buyers. Baby Boomers are retiring, Generation X are just entering their 50s, and Millennials/Generation Y are becoming the major influencers in the marketplace. Initial trends of



behavior in the youngest buyers include later acquisition of a driver's license, delayed marriage and family formation, and managing significant student debt. Attitudes towards vehicle ownership and mobility in general are evolving, as car sharing, urbanization, and connectivity all influence vehicle purchase behavior. The challenge is in integrating this developing shift in consumer behavior into existing models which often rely on historical data as a basis for making future estimates.

“Attitudes towards vehicle ownership and mobility are evolving.”

Conclusions and future efforts

KAPSARC's automotive transportation research concentrates on AFV adoption today, but acceptance of zero emission and fuel efficient vehicles is a long-term challenge facing the US and other markets. Regulatory strategies to reduce emissions call for the adoption of a range of new efficiency technologies, but reducing greenhouse gas emissions from transportation seems to be uniquely difficult.

As consumers of mobility upgrade from two-wheel to four-wheel modes of transport, GHG intensity is actually increasing in the transportation sector unlike other sectors of the global economy. The cost of driving is decreasing due to the very vehicle efficiency demanded by regulators. As GDP grows, consumers shift to faster modes of travel such as vehicles, and vehicle ownership is increasing in most non-OECD countries. Different countries are exploring different strategies for encouraging adoption of fuel efficient technologies including feebates, bonus/malus programs, and taxes.

“GHG intensity is increasing in transportation, unlike other global economic sectors.”

Penetration rates of alternative fuel vehicles are low in many parts of the world, and there is an “automotive revolution” still to come with changes in connectivity, movement to digital, and the shift from vehicle ownership to mobility. Capturing the nuances, implications, and ramifications of these changes is key to understanding consumer demand for highly fuel efficient vehicles and accurately estimating the potential reductions in energy use and GHG emissions from the transportation sector.



About the workshop

The workshops were held in June and September 2014 with over 50 international experts and was conducted under the Chatham House Rule of capturing discussion in a non-attribution basis. Participants included:

Hisham Akhonbay, KAPSARC

Naif Alabbadi, Saudi Energy Efficiency Center

Musaad Almosaind, College of Architecture & Planning, King Saud University

Robert Armstrong, MIT

Samer AlAshgar, KAPSARC

Jonn Axsen, Simon Fraser University

Amy Bason, Saudi Aramco

Julie Becker, Alliance of Automobile Manufacturers

Jean-Marie Bussiere, Hyundai Motor Europe

Nicholas Chase, EIA

Belinda Chen, U.C. Davis; California Air Resources Board

William Chernicoff, Toyota Motor North America

Adam Christensen, Johns Hopkins

Mike Cully, Car2Go

David Daniels, EIA

Alexander Edwards, Strategic Vision

Andre Faaij, University of Groningen

Eric Floss, ESRI

Kenneth Gillingham, Yale University

Min Gong, Altisource Labs

Britta Gross, General Motors

Alex Hare, Strategic Vision

John Hitzeman, University of New Haven

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Ken Katz, U.S. Department of Energy

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Carole Merry, Experian Automotive

Tamara Mlynarczyk, Mazda North American Operations

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

Jack Moore, Saudi Aramco

Dennis Morgan, DOT – U.K.

Nick Nigro, Center for Climate and Energy Solutions

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Andreas Schafer, UCL Energy Institute

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Adnan Shihab-Eldin, Kuwait Foundation for the Advancement of Sciences (KFAS)

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Daniel Sperling, U.C. Davis

Christoph Stuermer, PwC Autofacts

Elizabeth Tate, Alliance to Save Energy

Tim Titus, Experian Automotive

John Voelcker, GreenCarReports.com



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About the transportation team



Rubal Dua is a Research Associate analyzing the alternative fuel vehicles market. He holds a PhD degree from KAUST and a MS degree from University of Pennsylvania.



Daniel Mabrey PhD is a Research Fellow in the Policy and Decision Sciences program. He is project lead on research efforts in East Africa and analytical strategy for the transportation team.



Rebecca Lindland is a Senior Research Fellow in the Policy and Decision Sciences program. She is the project lead on the Drivers of Transportation project.



Kenny White is a Senior Research Analyst focusing on transportation and Chinese energy policy. He has an MPP from Stanford University.

About the Research Project

Improving road transport fuel efficiency and transitioning to low-emission vehicles have become key elements of policy development in several countries. How will regulatory instruments (policies, incentives, rebates, perks) impact the consumer behavior of new vehicle buyers (vehicle choices, acceptance of alternative fuel vehicle technologies, stated and revealed preferences)? A policy designer must understand how the policy can be aligned with consumer preferences in order to achieve the societal goals but with minimal societal burden, and to effectively increase the adoption rates of alternative fuel vehicles.