

A HIGH SHIFT SCENARIO: ACHIEVING LOW-CARBON URBAN TRANSPORT IN THE MIDDLE EAST AND NORTH AFRICA

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EXECUTIVE SUMMARY

Around the world, within urban and metropolitan areas, transport systems play a key role in economic development and serving the economic and social needs of society by providing mobility and access. But they also contribute to problems. In particular the growth in private automobile use has triggered widespread traffic problems and high levels of pollutant and CO2 emissions in most large cities in the world. In contrast, the use of public transit (bus, rail) and “active” (walking, cycling) transport systems can help mitigate these effects while simultaneously providing equal or even better mobility options across societal groups – if the right investments are made and high quality, safe systems put into place.

In this paper we consider a specific region (Middle East and North Africa – MENA) and explore whether and how much a major expansion in high quality urban public transit and infrastructure for active transport there could reduce urban transport emissions and increase mobility and accessibility. We also look at the costs of building such systems and compare these costs to a “status quo” world of car and roadway domination. The paper builds upon a recent analysis examining a “High Shift” scenario worldwide (ITDP and UC Davis, 2015) and creates a “higher granularity” scenario focused on MENA. This paper also extends the overall analysis of urban population growth beyond the previous study.

We undertake this analysis using an urban transport projection system linked to the IEA Mobility Model. We create two scenarios. In the first, we rely on the IEA baseline urban travel projection to 2050 based on recent trends, including a continued strong rise in car ownership as incomes rise. In a second scenario,

we create a High Shift Scenario exploring the implications of shifting urban passenger transportation investment and travel patterns in a more sustainable direction, with far more transit and active transport use. We then estimate the costs, energy use and CO2 emissions of these scenarios. Supplementary analysis has been added to create a deeper picture for the MENA region. Finally we discuss the types of policies that would be needed to bring about this alternative “High Shift” future.

Among the deeper analysis conducted for the MENA region beyond the original “High Shift” global study were a) the construction of an updated database of kilometers of urban transit systems (Metro, BRT, Rail, Tram/LRT) by city within the region to create a baseline picture, b) the comparison of this data to other indicators such as population by city to assess the level of provision across the region, and compare to other regions, and c) development of targets for provision of future systems and for system lengths. We created targets for rapid transit system growth (measured as system lengths and capacity) in MENA that are roughly in line with cities (mostly in Europe) that have more expansive transit systems today, with regional differences factored in.

Finally, this analysis provides a particular focus on one potential policy: the removal of inefficient fuel subsidies in MENA and redirection of these subsidies to help pay the costs of needed investments in the high shift scenario. This could provide a strong boost to efforts to shift future urban travel towards sustainable transport in the region.

The following main findings were drawn from the analysis:

Travel: We project total passenger travel in the metropolitan areas of MENA countries to rise from about 2,000 billion passenger kilometers in 2015 to 3,700 billion passenger kilometers by 2050, as a function of rising population and income. In the baseline scenario, car travel increases by almost 100% while travel by public transit increases by only 25%. In the high shift scenario, this pattern is dramatically altered: travel on much improved and more extensive transit systems increases by 150%, containing car travel growth to only 15%, a complete reversal from the baseline.

Emissions: We estimate that if the MENA region were to transition to a high shift scenario compared to a baseline scenario, urban transportation CO₂ emissions would be reduced by **2,800** megatons cumulatively, 2010 to 2050, or about a 20% reduction from the transportation sector over this time frame. The reduction relative to the baseline scenario grows over time, and in 2050 reaches 50%. This reflects the much higher share of travel in very low carbon modes by that year, and much lower share in high-carbon personal vehicles (cars in MENA tend to be large and high-emitting and are projected to become only moderately more efficient over the coming decades).

Costs: Total transport related costs (including

investments in infrastructure, capital and operating costs for vehicles, and operating costs for transit systems) between 2010-2050 for the Baseline and High Shift Scenarios, are roughly \$32 trillion and \$28 trillion respectively, meaning a cumulative savings of **\$4 Trillion** in the High Shift scenario. Savings rise over time and in 2050 alone are roughly **\$500 Billion dollars**. A major reason for the net cost savings is the avoided costs of roads, parking and other car-related infrastructure, fuel cost savings, and the large savings associated with the need for fewer personal vehicles within society. Much of this savings is offset by higher investment costs for transit and active transport infrastructure, and system operating costs, but there remains significant net savings. The implication is that there are net cost savings to society along with large reductions in CO₂, and likely more liveable cities with better mobility especially for those who don't own cars even in the Baseline scenario.

Subsidies:

A key challenge for achieving the High Shift scenario is the large public investment cost to fund new infrastructure and systems. The region already spends an estimated 40 billion dollars per year on motor fuel subsidies. Depending on the particular MENA country, the revenue created from eliminating fuel subsidies could cover a significant portion or even all of the public investment costs of developing the High Shift scenario.

INTRODUCTION

As transportation demand increases around the world, it creates enormous pressure on cities to provide transportation infrastructure and services. The “side effects” of this growth include traffic congestion, road injuries and fatalities, air pollutant emissions and CO₂ emissions. In the climate context, transportation is being asked to “do its part” to drastically reduce CO₂ over the coming decades to help limit global temperature changes to 2 degrees or below. This will be very challenging, as it means that transport CO₂ emissions must eventually drop sharply, rather than the on-going increase they have experienced in recent years, especially in developing regions such as the Middle East and North Africa (MENA).

This study provides a “deep dive” analysis of this MENA region, focused on urban transportation, and builds off of the UC Davis/ITDP study of “High Shifts” that was conducted as a worldwide study and published in 2015. Here we investigate the current urban situation in MENA, recent trends related to transport, and look at future scenarios and relate these scenarios to both CO₂ emissions and costs. In particular, we compare a baseline (business as usual type) scenario with a “High Shift Scenario” for MENA cities whereby high quality, high capacity transit systems are built that can handle much of the future growth in urban travel, with car growth much more limited than in the Baseline.

This analysis uses the same modeling system as was used in the global study, but adds some features, notably a higher resolution snapshot of MENA urban travel and transit infrastructure, as well as consideration of policies not included in the global study –notably a dramatic reduction in fuel subsidies that could be used to help pay for advanced transit systems.

The paper is organized as follows: first the background and context of cities and urban travel in MENA are presented, including some comparison to other world regions. The study’s methodology is then presented, along with data analysis that underpins the projections. Then the two main scenarios are presented and explained in terms of their scope and assumptions. Next the results are presented in terms of indicators such as total travel by mode, energy use, CO₂ emissions, and system (public and private costs). Finally, an analysis of policies is presented, including the subsidies analysis, and policy recommendations and conclusions are provided.

MENA Urban Background and Context

According to the United Nations *World Urbanization Prospects* population projections, urbanites are projected to represent about two thirds of the world’s population in 2050. Using the most recent UN’s urban population forecasts (WUP, 2014), and UC Davis’s 2050 extensions (Fulton et al, 2014), Figure 1a is a global look at the UN urban population projections at the growth in each city class size. Figure 1b zooms in on just the Middle East and North Africa’s growth. In

2015, MENA has roughly 20 million people who live in cities with a population of 10 million or more (Tehran and Cairo).

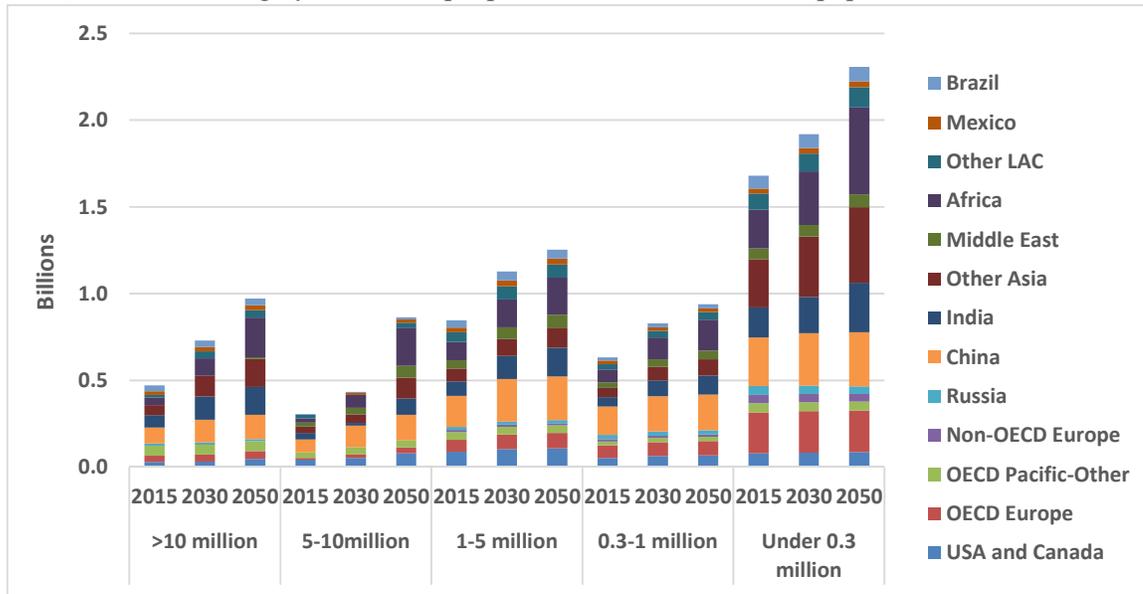


Figure 1a: UN urban population projections (2014 revisions) to 2035, with UC Davis extensions to 2050 broken into 5 city classes (Fulton et al. 2014)

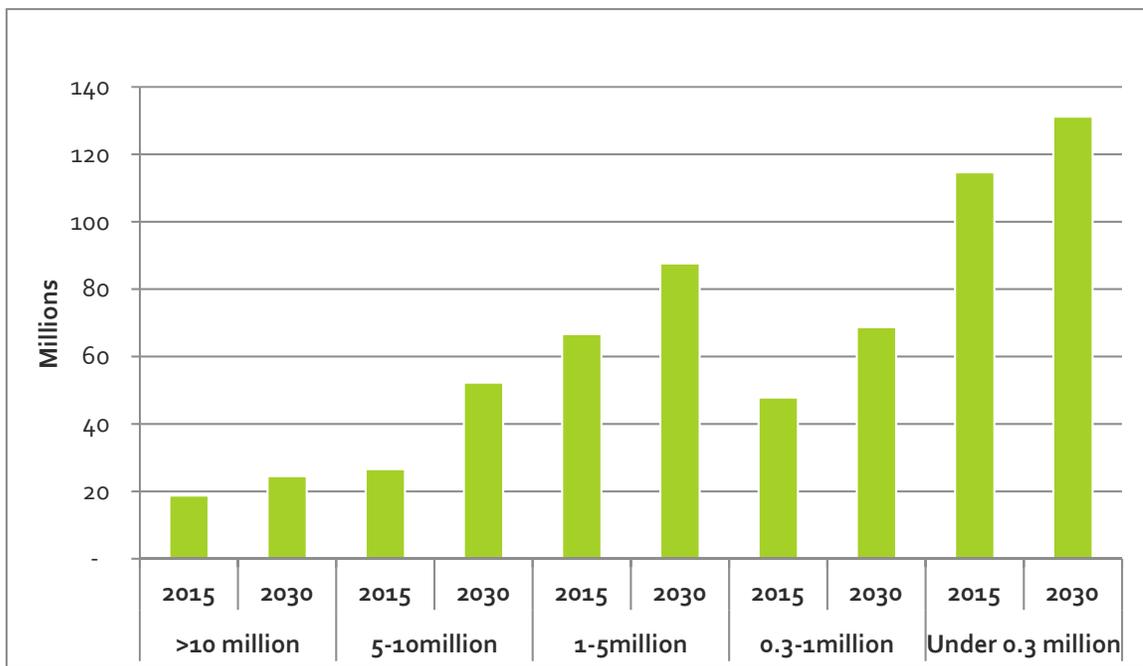


Figure 1b Middle East and North Africa Urban Population Projections (Fulton et al. 2014)

The Middle East and North Africa both are experiencing rapid growth of major cities and large regional centers, with concurrent rapid development of small and medium sized cities. There is also significant growth in the five to ten million-city class sizes. Africa and Asia in general are urbanizing faster than other regions, as they hold 90 percent of the world’s rural population (WUP, 2014). The Middle East and North Africa are relative latecomers in the global urban transition, but are now rapidly catching up (UNHABITAT, 2003).

Table 1 shows the percent urban population in the Middle East and North Africa in 1950 and 2010.

Country	Total population (millions)		Percentage urban		
	1950	2010	1950	1980	2010
Algeria	8.75	35.5	22.2	43.5	72
Bahrain	0.116	1.26	64.4	86.1	88.6
Egypt	21.5	81.1	31.9	43.9	43.4
Iran	17.414	74	27.5	49.7	68.9
Iraq	5.72	31.7	35.1	65.5	66.5
Israel	1.26	7.42	71	88.6	91.8
Jordan	0.449	6.19	37	59.9	82.5
Kuwait	0.152	2.74	61.5	94.8	98.2
Lebanon	1.44	4.23	32	73.7	87.1
Libya	1.03	6.36	19.5	70.1	77.6
Morocco	8.95	32	26.2	41.2	56.7
Oman	0.456	2.8	8.6	47.6	73.2
Qatar	0.025	1.76	79.2	89.4	98.7
Saudi Arabia	3.12	27.5	21	65.9	82.1
Syria	3.54	20.4	30.6	46.7	55.7
Tunisia	3.53	10.5	32.3	50.6	66.1
Turkey	21.5	72.8	24.8	43.8	70.5
United Arab Emirates	.07	7.51	54.5	80.7	84
West Bank and Gaza	.932	4.04	37.3	62.4	74.1
Yemen	4.32	24	5.8	16.5	31.7

Source: "World Urbanization Prospects, 2011 Revision," United Nations.

Table 1: Urbanization rates in Middle East and North Africa, (WUP, 2014)

According to Table 1, as of 2010 Egypt and Yemen were the only MENA nations that are less than 50 percent urbanized. Approximately thirteen MENA countries were more than 70 percent urban: Bahrain (88.6 percent), Kuwait (98.2 percent), Lebanon (87.1 percent), Libya (77.6 percent), Oman (73.2 percent), Qatar (98.7 percent), Saudi Arabia (82.1 percent) and the United Arab Emirates (84 percent). With almost 60 percent of its population living in cities, the MENA region is far more urbanized than East Asia or South Asia (World Bank). Even though Egypt and Iran are only 43.6 percent and 68.9 percent urban respectively (WUP, 2014) their major cities like Cairo and Tehran have populations of over 10 million. Furthermore, according to UN projections the MENA population will reach 430 million by 2020, of which 280 million are expected to be urban (Bejerde, 2008). All MENA nations face the challenges of rapid urbanization along with challenges associate with urbanization levels of the past (WUP, 2014). Problems in urban areas could be exacerbated without proper urban transport services.

Income differences across the countries in the region exist, specifically income. Although there are similarities and common trends among countries in MENA, the region is relatively heterogenous. National income differs a great deal in the region. The quality of infrastructure also varies amongst the different economies. Expectedly the more developed oil producing countries in the Gulf Cooperation Council (such as Saudi Arabia, Bahrain and the United Arab Emirates UAE) generally have a higher income and GDP per capita as nations. Gulf Cooperation Council (GCC) countries generally have greater public investment in infrastructure. For example the paved road network in km per 1000km of arable land in GCC is 27 times greater than that of the developing oil exporting countries and 5 times more than that of developing oil importing countries (Estache et al. 2013, p.7). Although urban transport investment in the region is limited, some countries do view certain urban transport projects positively. Countries like the UAE experiencing higher levels of economic development, have introduced capital-intensive rapid transit projects such as the Dubai metro (El-Geneidy 2013).

Transportation Systems in MENA Cities

Despite relatively high levels of urbanization in MENA countries and the large size of some cities, the development of public transit systems has lagged behind most other regions, and car travel dominates many cities. Investments in mass transit infrastructure as well as for “active transport” (walking/cycling) infrastructure have been comparatively low. In general most countries in MENA have extensive road networks in comparison to other developing nations (Ianchovichina et al., 2013). The quality of urban transport is poor especially in supporting growing modern economies. A large young population also adds more pressure to urban infrastructure and services in the region. Population growth and rapid urbanization have altered the work force. Past urbanization rates means that a bulge is working its way through the population pyramid of the region adding pressure to the work force and schooling (Rodenbeck, 2000). The growing population will only increase demand for urban services. In most countries, the population has changed from one engaged mostly in rural and agrarian areas to one involved in different types of urban industrial and service-oriented economic activities. (Moghadam 2010, p.87). This shift is important to the context of urban infrastructure in the region. The figure below shows the lack of urban transport infrastructure in MENA as compared to other world regions.

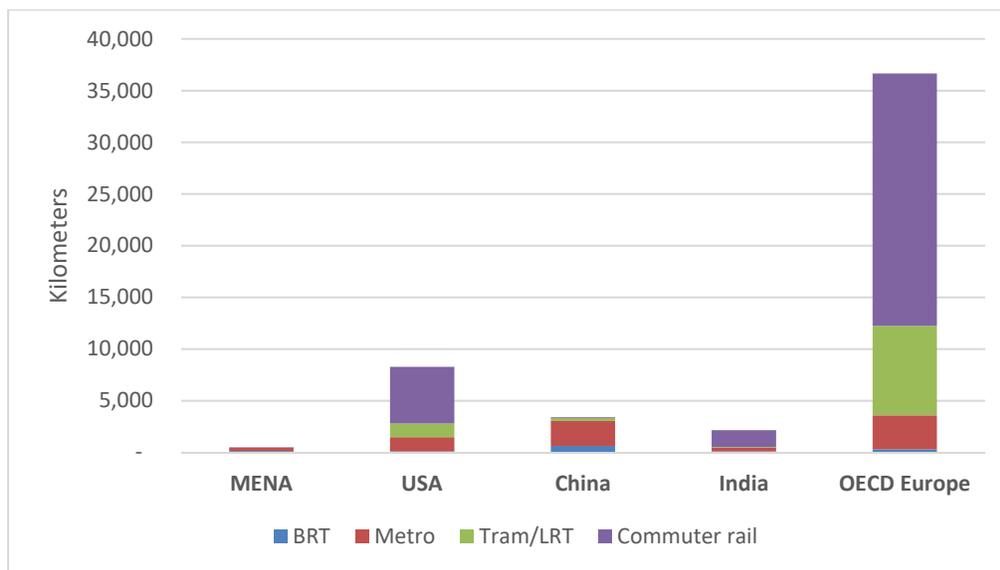


Figure 2: Length of Rapid Transit by Region, 2015 Infrastructure Extent

A general look at the region shows a common trend of growing private vehicle use. Figure 3a illustrates with 2010 MENA region data that the majority of urban passenger kilometer miles per capita are traveled using light duty vehicles. Slowing the growth of private vehicles is important to the mobility of the region as urban areas of the region grow. Many of the region’s large urban areas, where the bulk of GDP is produced, face increasingly difficult transport problems with a high degree of traffic congestion, reduced mobility, and deteriorating air quality (World Bank, 2010). Although levels of private motorization in MENA are, in general, relatively lower compared to other regions in the world, the inability to adequately satisfy the ever-increasing demand for public transport services has encouraged users to seek alternative modes, particularly private vehicles for those who can afford them (El Geneidy, 2013). Although automobile kilometers traveled per capita in countries like the US and Canada are far greater than in the MENA region, this region relies much more heavily on car travel than developing countries like India.

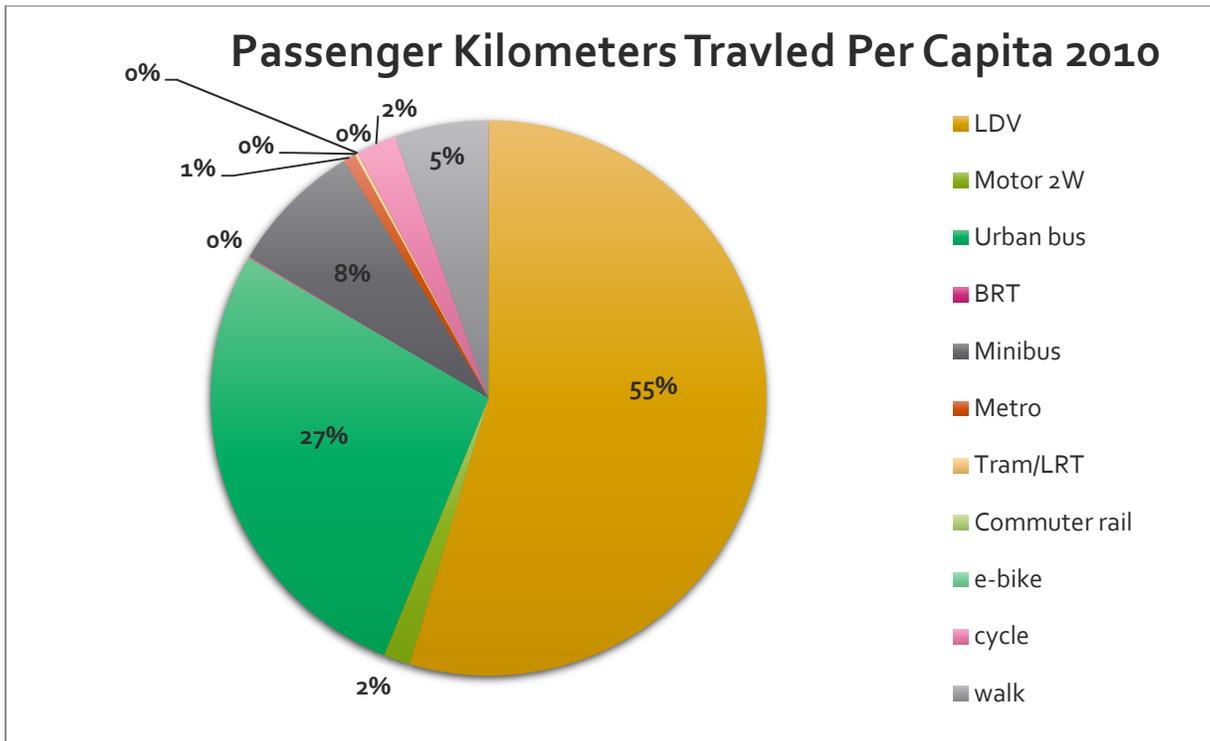
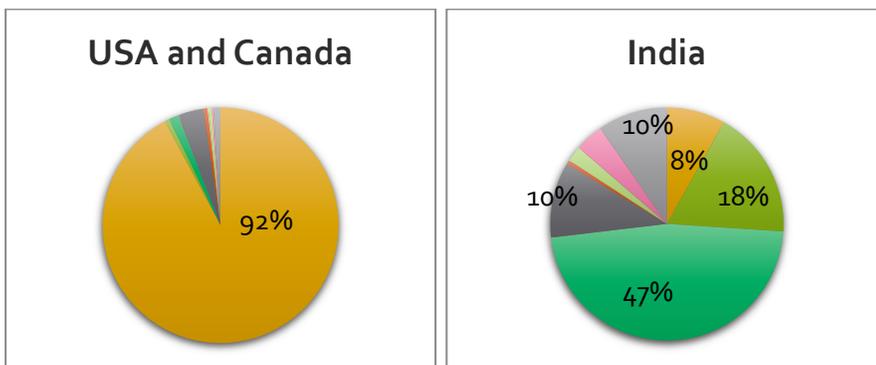


Figure 3a: Passenger Kilometers Traveled per capita 2010 in MENA using Baseline Data (Fulton et al. 2014)



Figures 3b and 3c: Comparative Passenger Kilometers Traveled per Capita, Baseline Data for USA and Canada, India

Sustainable Transport in MENA

Implementing sustainable transport policies in the MENA region is essential to not only maintain the quality of life but to enhance it. Rapid unplanned growth and urbanization threaten sustainable development when important infrastructure is not developed or when policies are not implemented to ensure that the benefits of city life are collective (WUP, 2014). For example, since only those with sufficient financial means can purchase a private vehicle, motorists benefit most from investments in road infrastructure through increased access to destinations, creating an impediment to upward mobility for the poor (El Geneidy, 2013). For developing nations the continued encouragement and laxness on growing private vehicle use at the expense of other modes can be detrimental in other ways. Transport related greenhouse-gas emissions are increasing, with rapid growth projection in low-income and middle-income countries (Woodcock, 2009). The projections shown later through the Baseline scenario of the model in MENA also show an increase in greenhouse-gas emissions. With rising traffic congestion in MENA (El Geneidy, 2013), a “High Shift” transport future could improve mobility (such as average speed) for many, reduce carbon emissions, and assist economic growth of each country within the region. In

terms of access to services, population growth and reductions in government social spending are straining the quality and quantity of urban services in MENA, specifically in poorer areas of urban cities (Moghadam 2010, p.92). In order to keep up with economic development, major investments in sustainable transportation infrastructure, like public transport, need to be considered. Improving mobility options for all people in the region is integral to improving the quality of life and subsequently reducing the effects of income inequality (El Geneidy, 2013).

Methodology

The approach to creating the two scenarios presented in this paper comes from an existing mobility modeling system (MoMo) from the International Energy Agency. MoMo is a technical-economic model aimed at tracking energy needs and emissions from worldwide mobility, taking into account the cost of materials and resources. The model includes detail consistent representations of populations, travel level, mode choices, vehicle sales/stock/travel/efficiency, and resulting energy use, emissions, costs and other outputs for all parts of the world broken into over 30 countries/regions (Fulton et al. 2014). The model does not optimize or contain extensive behavioral representation. It rather focuses on creating “what if” scenarios; for example if mode shares change in certain ways in the future, what will this mean for energy use and CO₂ emissions. This type of tracking is accomplished with direct relationships between vehicle numbers, vehicle characteristics, travel extent in those vehicles, and other variables linked in clear “accounting system” ways. The IEA Mobility Model’s projection system and reference case projection are linked to the IEA WEO 4 degree scenario, which is consistent with a 4 degree global average temperature rise by 2050. The current research uses an adjusted and expanded “Urban” version of the model, including detailed analysis of transit system infrastructure and use in MENA as well as other world regions.

The approach for this study was to update the Urban Model to create a new urban “Baseline” scenario that is consistent with the IEA 4 Degree Scenario, but with national data replaced by urban data on populations, vehicle stocks, travel and other indicators for all modes. The “High Shift” scenario was developed specifically for this study, using the urban model. The two scenarios can be summarized as follows.

BASELINE: The analysis presents two main future scenarios projected to 2050. The baseline scenario builds upon current trends in travel and transportation investments whereas the High Shift scenario explores a hypothesized future scenario where travel trends and investments are shifted in a much more sustainable direction. In the urban context, car and motorcycle travel mode share rise rapidly in the Baseline Scenario, with travel by mass transit, walking and cycling slow growing or stagnant in most regions. Fuel efficiency improvements occur rapidly for a while where fuel economy standards are in place but stagnate after 2030; alternative fuels do not gain much traction and petroleum fuels still dominate in 2050.

HIGH SHIFT: The High Shift scenario projects far greater urban passenger travel by clean public transport, non-motorized modes, and less single occupant cars than the Baseline. Urban public transport modes like buses and urban rail systems, as well as non-motorized travel like walking and biking are increased. It projects a decrease in the rates of road construction, parking garages and other ways in which car ownership is encouraged. The goal and outcome of the High Shift scenario would be to cut carbon dioxide emissions associated with urban passenger transport as well as a reduction in infrastructure costs associated with private vehicles.

A key part of the High Shift scenario is to re-allocate passenger kilometers across modes in a given year so as to preserve total travel. The urban model allows this since it is simply adding up travel by mode to derive total travel; if modal travel is increased in one mode it can be reduced in another mode to offset and preserve an overall total. The approach here is to gauge the extent to which urban travel via public transit and active transport modes might plausibly be increased, taking into account the current situation, the investments required to improve systems and increase capacity, the numbers of people the improved systems could then carry, and how much this would allow reductions in travel by other modes, particularly automobiles. No attempt is made here to relate the types of trips that might be made by the different modes, but over the long term, as these cities develop, it is assumed that mobility growth that is accommodated by transit and

active modes will allow commensurately lower growth by private vehicles, in part based on investments, urban planning, and other policies that help shift the direction of travel growth.

A particular goal in this modal shift exercise is to see if it is possible to cut the 2050 level of car travel in half via increased use of the public/active modes. Figures 4a and 4b “cut to the chase” and show the mode share projections in both scenarios, and among other things show that car travel is cut by nearly half in 2050 in the HS scenario compared to the baseline scenario, with all of the travel picked up by other modes. The more challenging question becomes – how can cities make shifts like this happen? Much of our analysis involves estimating the potential – and cost – of improving transit systems within these countries to accommodate the rapid growth in such travel that occurs in the High Shift scenario. This is the “backstory” to Figure 4b, and is laid out in the following section.

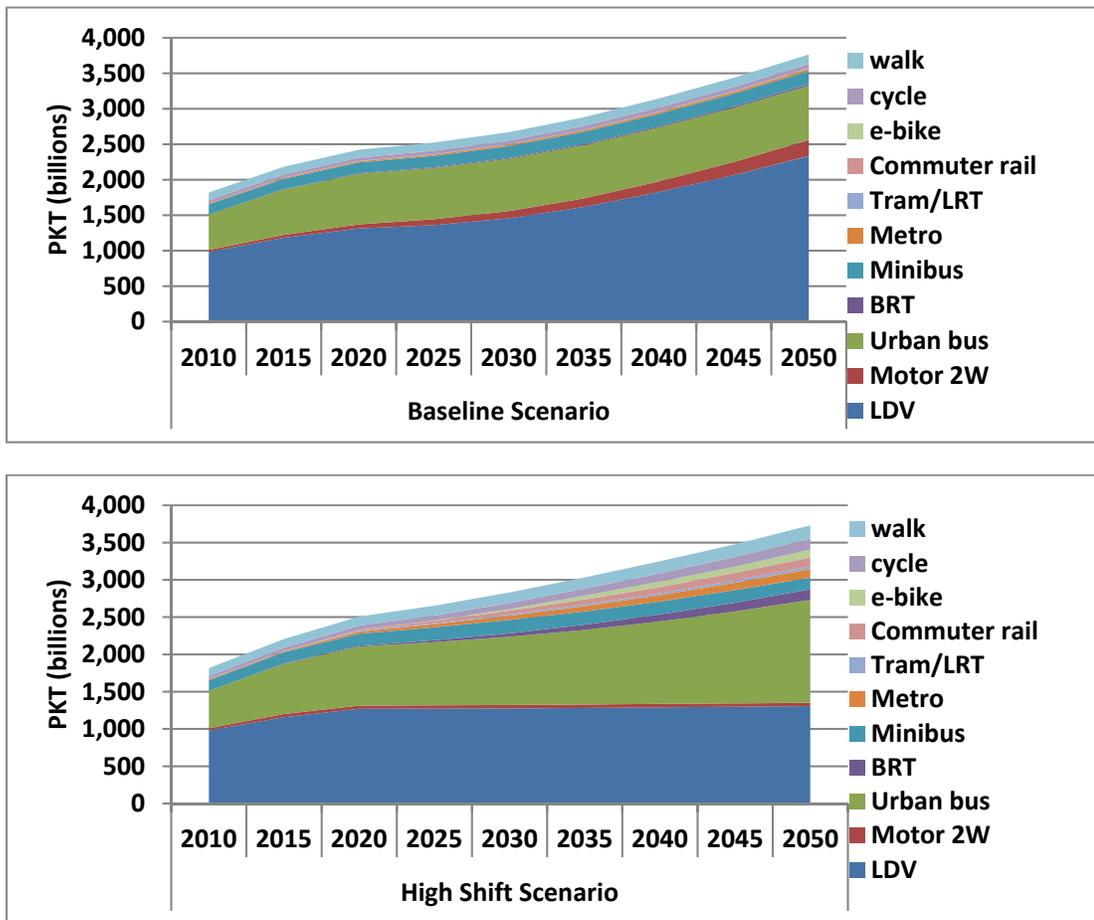


Figure 4a (top) and Figure 4b (bottom)

KEY FINDINGS

Urban Rapid Transit Projections

To become a successful, efficient, transit-oriented city, an urban area needs to supply a sufficiently high level of rapid transit services. A key aspect of the projections in the High Shift scenario is growth in urban rapid transit systems, particularly rapid transit such as metro, tram/light-rail (LRT), commuter rail and bus rapid transit (BRT) systems. The High Shift scenario focuses in part on increasing the ratio of rapid transit kilometers per million urban residents (the “Rapid Transit per Resident” or RTR) in emerging economies like those in the MENA region, closer to the levels found

today in advanced developed economies. To project the extent of these systems, the analysis estimates their extent in cities around the world today, and developed targets for their expansion and new construction in cities out to 2050.

As discussed, this research has included a newly created global database of rapid transit systems and their lengths along with other attributes like population, GDP and density. This included an analysis of transit systems in the Middle East and North Africa. The regression analysis used the data shown in Table 2 along with the global database of system length and attributes. Detailed data analysis, including multivariate regression, was conducted on all cities of the world with urban transit systems to attempt to tease out factors that account for strong transit system presence. A statistical analysis of system lengths versus city attributes like size, GDP, and density was undertaken to see if correlations are strong enough to justify projections of future system investments based on projections of these other attributes. Perhaps surprisingly, few strong correlations were found. Table 2 provides an example of the correlation coefficients with Metro system lengths versus city population, density, and national GDP (sample size of systems, N=151).

	System Length	System Length Per Capita	Population	National GDP Per Capita	Population Density	OECD vs NON-OECD
System Length	1.00					
System Length Per Capita	0.11	1.00				
Population	0.62	-0.20	1.00			
National GDP Per Capita	0.10	0.20	-0.11	1.00		
Population Density	0.08	-0.13	0.24	-0.43	1.00	
OECD vs NON-OECD	0.06	0.12	-0.16	0.74	-0.33	1.00

Table 2: Correlation Matrix of Metro Lengths: gray is weak correlation, yellow moderate correlation, and green green stronger correlation (refer to the appendix for detailed regression analysis and logistic regression of each system type)

The regressions were run separately for the four types of systems (Metro, Bus Rapid Transit, Tram/LRT and Commuter rail). The darker green shaded correlation coefficients above show stronger positive correlations between the extent (length) of metro system length and several potentially important factors affecting these. However, for all the different systems, population data and system length gave the only strong correlation. System length (km of metro in a city) and population resulted in the highest correlation with an R coefficient of 0.62. Intuitively, as the population of a city grows the system length of metros grow. And while city size matters, factors like wealth and density appear relatively unimportant. It may be the case that the most important factor apart from size is simply each city’s commitment to building transit systems. Some “poor” cities have extensive transit systems while some richer ones do not. The same goes for low and high density cities.

As a result, to develop the targets of system length for the future, the model ultimately used relatively basic “rules”, based mainly on city size. In the “High Shift”, future cities have rapid transit system lengths roughly in line with those in the world’s better cities of that size today, with regional differences factored in. For example, European (and especially Eastern European and Russian) average tram system sizes per capita are so much bigger than most other parts of the world, that it was not expected that any other regions could reach these levels even by 2050. MENA’s targets were set to balance ambitious investment and growth while being realistic about how fast and how much investment is possible on a decade-by-decade basis. Targets reflect an effort to have the average cities in MENA by 2050 achieve transit per capita already achieved by the more transit-oriented cities. Using projections of cities of similar sizes, our resulting targets set for 2050 are loosely based on current average city and top city data in MENA.

As shown in Figure 5 a-d, the growth of systems (km) in MENA are set towards a 2050 target for each for the four types of transit system. They support the passenger kilometers traveled targets set to increase urban rapid transit travel. Since cities in the Middle East and North Africa have fewer systems than other regions, the targets were set much lower than

other regions. Targets were set much higher for regions that have a history of building the specific type of system. BRT targets are much higher for developing countries. Further explanation of BRT assumptions and targets are described alongside urban buses and minibuses in the motorized vehicle projections section below. The above targets for MENA are ambitious and would require coordinated planning and increased infrastructure investment towards urban rapid transportation

SYSTEM TARGETS:

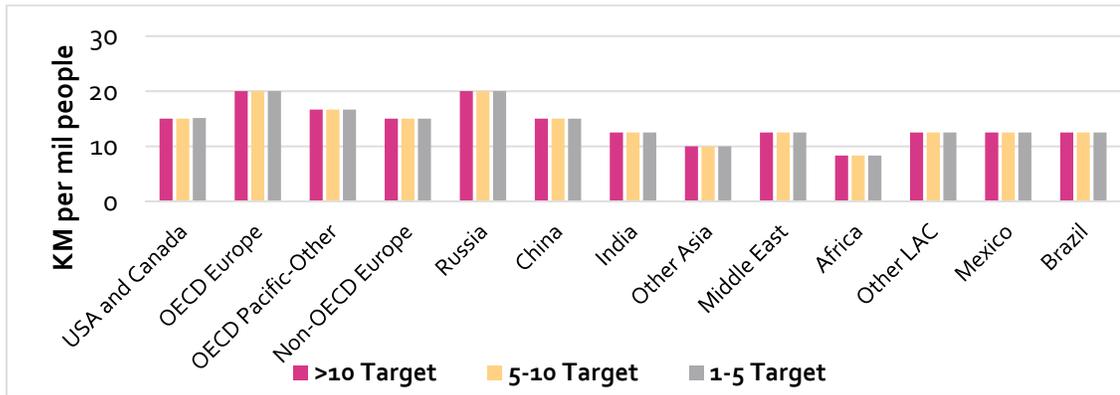


Figure 5a: Resulting targets set for Metro, 2050

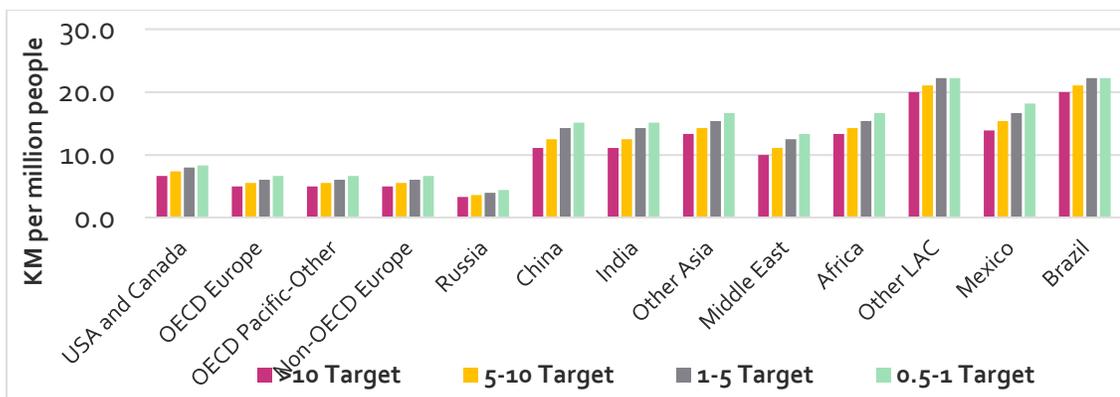


Figure 5b: Resulting targets set for BRT, 2050

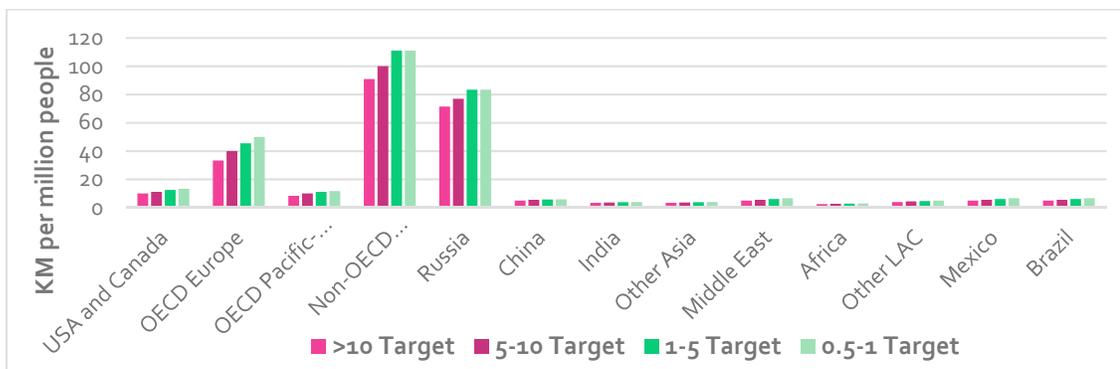


Figure 5c: Resulting targets set for Tram/LRT, 2050

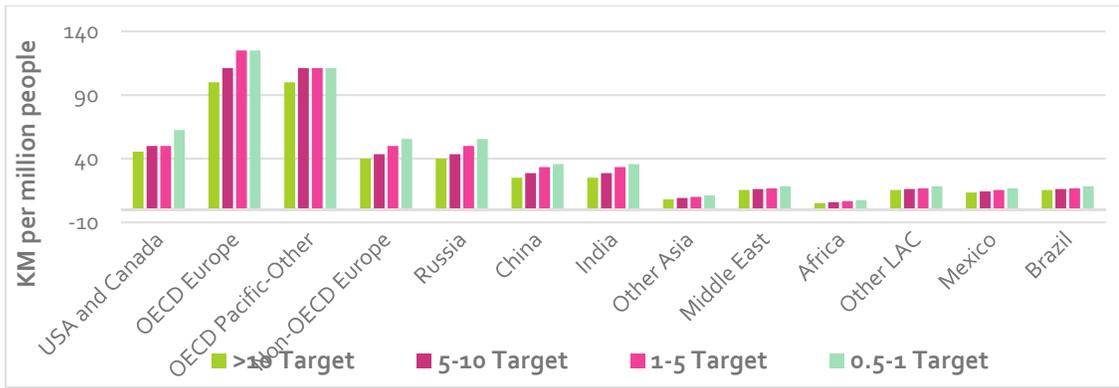


Figure 5d: Resulting targets set for commuter rail, 2050

Motorized Vehicle Projections

In order to achieve a significant reduction in projected private vehicle use, policies discouraging private vehicle growth are assumed in the High Shift scenario. For private motorized modes, the ownership rates projected in the baseline that are related to income growth are reduced along with lower travel per vehicle, roughly in amounts that offset increased transit and active travel modes, leaving overall passenger travel levels unchanged for a given year's projection. As shown in Figure 6, across all MENA urban areas, car travel is cut roughly in half in 2050 in the High Shift case relative to the BAU. All of these changes would need to be achieved through policy and pricing initiatives, since independent changes in lifestyle that might affect car ownership are already included in the baseline.

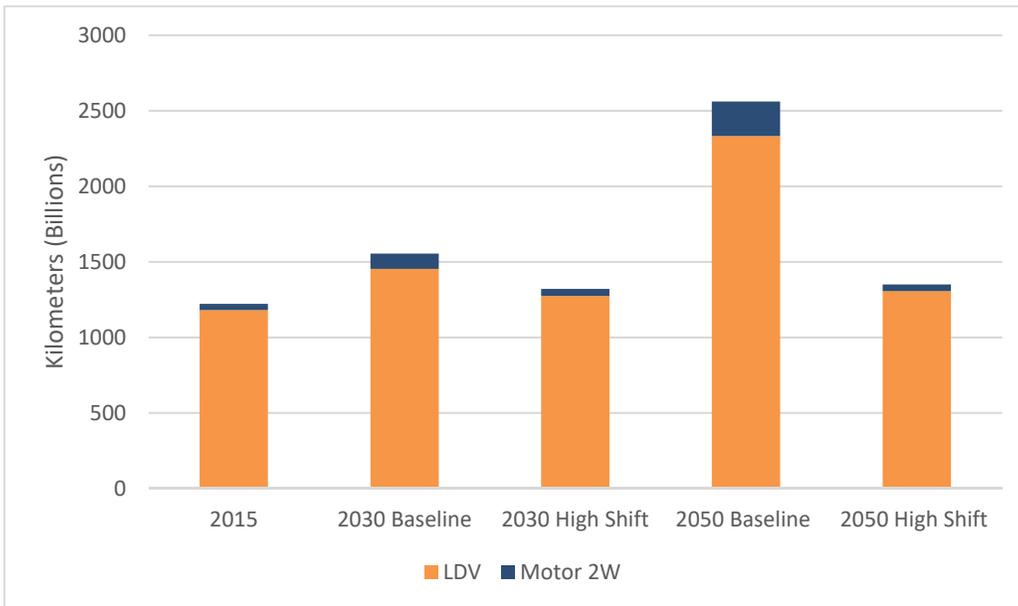


Figure 6: Total Motorized Passenger kilometers travelled, projections for both cases

Another form of motorized travel not included in the detailed “rapid transit” urban transit projections described above is urban bus, which consists of buses and minibuses. Rather than the fairly flat level (very slow) growth of buses in the BAU, in the High Shift scenario there is steady growth in the number of buses around the world, particularly in non-OECD regions like MENA. Ridership per bus also increases except where load factors reach a saturation point (comfort on buses is desirable so a limit is placed on load factors (Fulton et al. 2014)). Bus Rapid Transit starts from a very low level in all countries but rises rapidly. This is based on the number of cities that appear amenable to developing BRT and through assumptions about the percentage of people living in proximity to a BRT system (Fulton et al. 2014).

Key assumptions:

- “For conventional urban buses, data from MoMo is used for 2010, and growth rates are based on reaching certain targets for bus stocks and pkm per capita, with higher ridership assumed in the developing nations like MENA
- For Minibuses, existing MoMo data for 2010 was used to establish the base year. In the existing baseline projection, minibus numbers and ridership grow slowly around the world, based on historical trends. For the High Shift scenario, these actually decline, particularly after 2030, as riders shift to larger buses and (in particular) BRT systems where available.
- For BRT systems, the 2010 and 2015 situation was established using the ITDP BRT database (ITDP, 2014), which tracks systems and system characteristics, and to some extent World Resources Institute/IEA database (IEA, 2014) (for time series of BRT system growth around the world).
- The growth in BRT systems was based on the preceding discussion of BRT system targets, assuming future construction of BRT in appropriate sized cities, using ratios of the world’s population expected to live in such cities. Ridership on those BRT systems is loosely based on the ITDP rating system and ridership levels in the best systems of today.
- For the general High Shift scenario, it was assumed that the BRT ridership worldwide was similar to that of the TransMilenio system in Bogota, Colombia while at the same time making sure that the worldwide system infrastructure construction did not unrealistically increase.
- In terms of modal shift, BRT ridership is not only assumed to pull riders from light-duty vehicles (private cars) but minibus and regular bus riders as well” (Fulton et al. 2014).

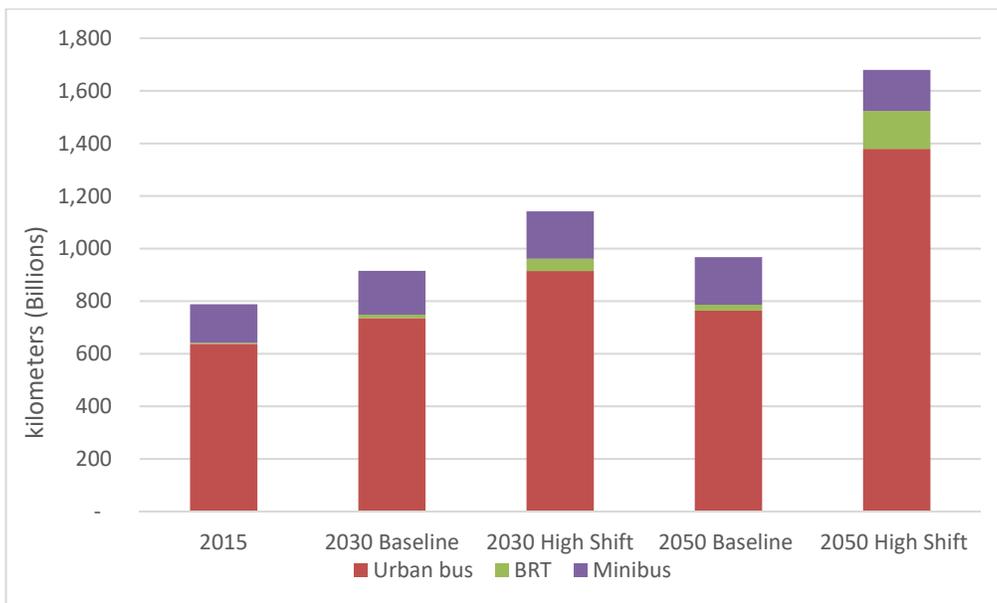


Figure 7: Total Bus Passenger Kilometers in each scenario

In the High Shift scenario as shown in figure 7, MENA experiences significant increase in Urban Bus travel to keep up with growth and mobility needs. BRT also experiences significant growth in comparison to previous years.

Non-Motorized Vehicle Projections (Bikes, E-Bikes, Walking)

Initial non-motorized transport 2010 numbers in MENA are based on rough guides. For this analysis MENA numbers are based on a general ideal of what non-motorized travel is like, because of lack of reliable data on walking and cycling trips in the region. This has an impact on the accuracy of non-motorized transport projections for MENA. Targets for 2050 were selected based on current bike use levels and plausible future use levels. Essentially non-motorized travel in MENA is assumed to be the same as the general assumptions made for the Non-OECD countries by the High Shift scenario.

A part of the High Shift scenario is an increase in the use of e-bikes and bicycles in countries that do not already have high levels of use, and use of walking for short trips in all urbanized areas of the world. While in the reference case there are high levels of walking in most countries and high levels of biking in a few countries such as the Netherlands, in HS the walking and biking trips would increase among people with motorized options such as access to cars (Fulton et al. 2014). Electric bicycles and low-powered electric scooters (here collectively called “e-bikes”) are currently only in widespread use in China, but in HS would increase around the world (Fulton et al. 2014). These are different from higher-powered scooters and motorcycles because they could contribute to slower traffic speeds and safer conditions in areas where they become prevalent.

Although bikes are already widely prevalent around the world, e-bikes are less common. The basic approach for e-bikes was to hypothesize future ownership levels that appear possible. The average use per day and per year would generate travel projections.

Key assumptions:

- “Regular bike ownership is explicitly modeled, but based on weak data, and follows use patterns that appear consistent with existing literature. Average ownership per capita and use (annual kms) per bicycle are compared to total travel per capita by bicycle where such data is available.
- It is simply hypothesized that bike use will rise over time in HS as investments are made into bike lanes, safety features, and other relevant infrastructure in metropolitan areas around the world. If such investments were focused on the 2015-2030 time frame, an increase in bike share would increase to 2035 then level off.
- For e-bikes, it is assumed that ownership is currently near zero. Growth in ownership would not conflict with bike ownership (many people could own both) and often it would be bike owners who adopt e-bikes. (Though a model of joint/separate ownership could be developed.)
- In HS, rapid uptake of e-bikes would begin in most countries in the world by 2020, with rapid ownership and use growth through 2040 before saturating at some level” (Fulton et al. 2014).

The resulting projections are shown in the various figures below. The total Non-motorized travel PKMs rise for all three modes over time, but with stancher increases for e-bikes and much slower increases for walking and biking. The average number of trips per capita (per day) in 2050 for the three modes range from; 1.6 trips per day in OECD regions to 2.2 trips per day in non-OECD regions. The Middle East and North Africa would fall under the Non-OECD region.

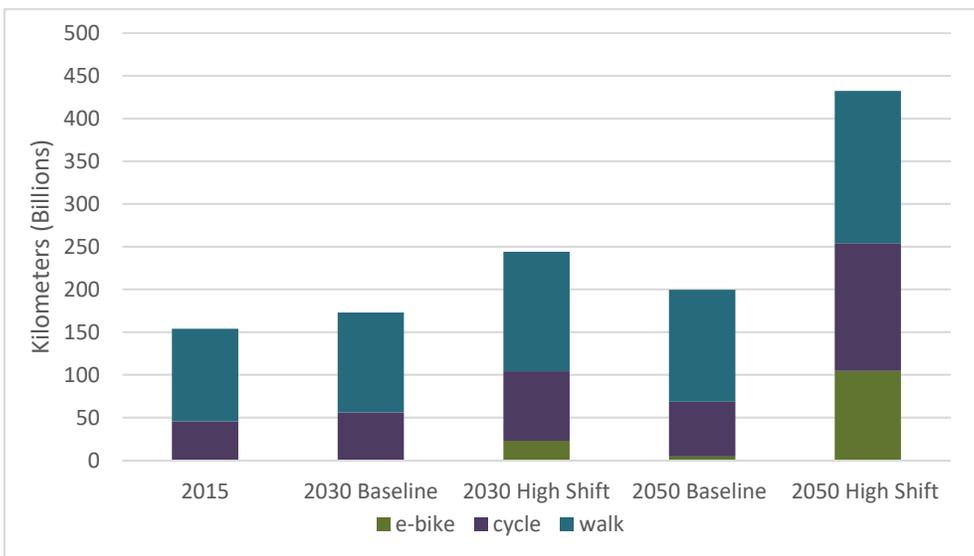


Figure 8: Total Non-Motorized (Walking, Biking and E-Bike) Pkm

Figure 8 is the resulting projections for MENA of non-motorized travel. The figure includes walking, cycling and electric bikes. Walking, Biking, and E-Bike passenger kilometer miles are roughly doubled in the 2050 High Shift Scenario. Essentially electric bikes and electric scooters could replace inefficient motorcycles that use internal combustion engines. Policies promoting pedestrian and bike infrastructure will be important for the growth of Non-Motorized travel in the High Shift scenario

Combined modes: total passenger kilometer projections

The figure below shows passenger kilometers traveled by mode, taking into account the changes in passenger travel described for the various modes in the previous sections. This figure demonstrates how passenger kilometers of private vehicles are reduced by 50% compared to the projected 2050 baseline. At the same time the 2050 High Shift projection would result in some increase of car travel over current levels, but the vast majority of growth is eliminated, given the growth in transit and active modes. Passenger kilometers in total stay relatively the same across both scenarios in a given year.

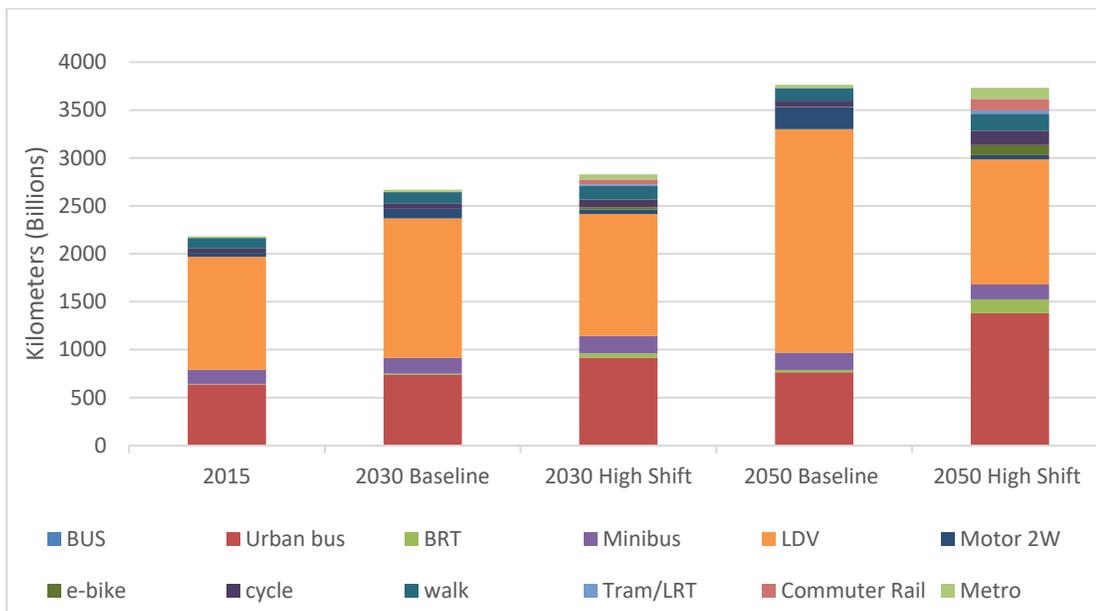


Figure 9: Total Passenger Km by mode

Carbon Dioxide Reduction

Car-dominated transport systems create other costs related to air quality, safety, and climate impacts. Within MENA the transport sector is responsible for 22 percent of carbon dioxide emissions in the region (El-Geneidy, 2013). The High Shift scenario involves a shift to lower carbon modes of transportation, including an increase in non-motorized transport infrastructure and urban rapid transit.

The projected high shift scenario results in a significant reduction of carbon dioxide emissions for the MENA region. If the MENA region were to transition to a high shift scenario compared to a baseline scenario, carbon dioxide savings are projected to be approximately **2,800** megatons cumulatively, 2010 to 2050. This is about a 20% reduction in carbon dioxide emissions. The savings in 2050 alone compared to the 2050 baseline is nearly 50%.

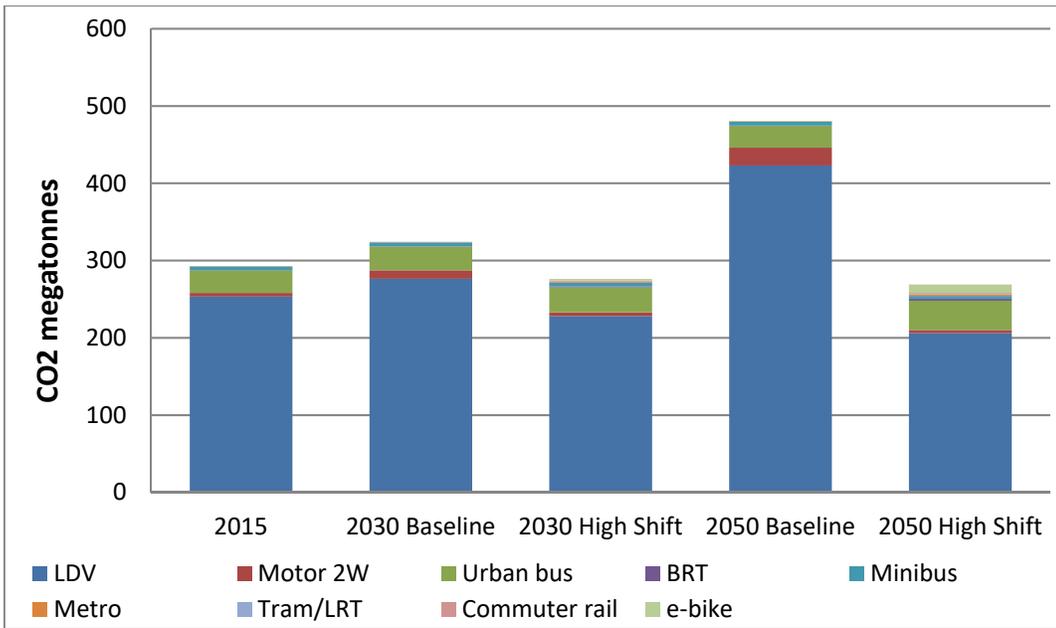


Figure 10: Projected Carbon Emissions in MENA by mode of travel, compared by scenario and year

The main reason for the large reductions in CO2 that result from the modal shifts in the High Shift scenario are the large differences in passenger energy efficiency (and carbon intensity) of each of the modes being used. As shown in figure 10, personal light duty vehicles in 2015 (and into the future) are expected to produce far more CO2 per passenger kilometer of travel than any form of transit. This is a function of average occupancy and the average occupancy of public transit modes around MENA is high and is expected to remain high. Some improvements in vehicle efficiency occur over time and are reflected in the figure, as are some increases in average load factors in the high shift (even for LDVs due to some increased use of carpooling and ride sharing), but these do not change the basic story.

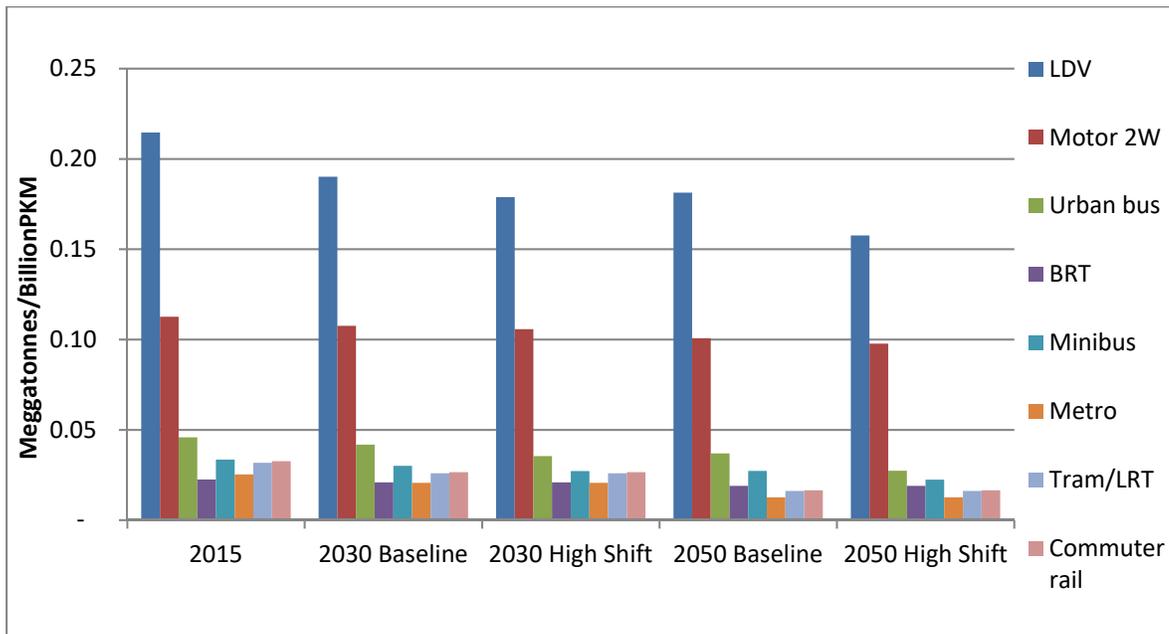


Figure 11 Carbon Intensity of Modes in MENA

Costs and Funding the High shift Scenario

The total costs associated with owning and operating vehicles, vehicle systems, and infrastructure, have been estimated for all years in each of the two scenarios. These costs are high, not surprising since transportation (including energy and infrastructure related costs) take up a significant share of GDP, often 10% or more.

Over the 2010-2050 time frame, total costs for the Baseline and High Shift Scenarios are roughly \$32 trillion and \$28 trillion respectively or a savings of \$4T from the High Shift scenario over the time frame. As shown in Figure 12, in 2050 alone (when savings are greatest), costs saved by the High Shift scenario are roughly **\$500 Billion dollars**. Cost savings rise over time since travel grows, and avoided costs such as future road infrastructure and energy costs become larger as the system grows.

Costs considered in this analysis include capital and operating costs for bus and rail rapid transit systems, rail infrastructure, road and parking infrastructure, all major types of vehicles. This takes into account the full direct cost per kilometer to build new roads (a function of projected car travel), parking lots (a function of projected car stocks), sidewalks along urban non-highway roads, and cycle lanes and paths to handle much of the projected cycling travel. A separate documentation report from the larger project is available that details many of the assumptions behind the cost estimates (Fulton et al. 2014). To summarize some key elements here:

- BRT and rail system costs are based on current average capital/operating costs per kilometer in a range of countries.
- Vehicle capital and operating costs are based on current average prices in different world regions.
- Infrastructure costs are based on a review of available reports and are considered a very rough average as the data is generally quite variable.

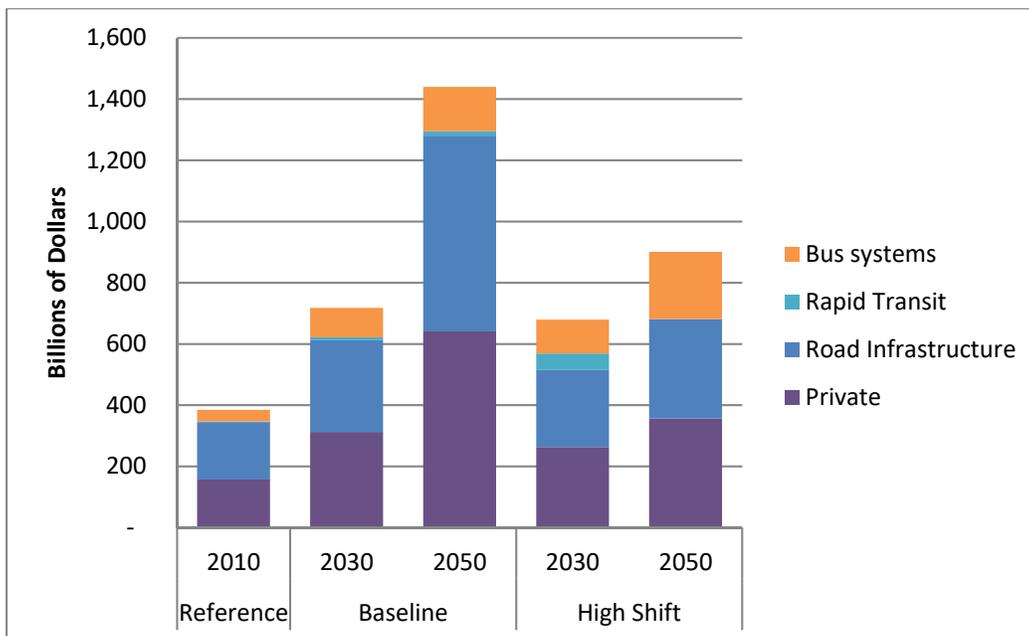


Figure 12 : Total Projected MENA Costs each year alone by scenario (costs broken down by category of year)

Other considerations include:

- We have not attempted to separate private from public expenditures but this could be an important factor in affecting the viability of certain policies. In general, in the High Shift scenario, public expenditures rise (such as from operating more and larger transit systems) but private costs decline (since fewer private vehicles are needed).
- The analysis has not included taxes (and has attempted to exclude them where possible), has used 2010 data where possible, and are reported in US Dollars.
- Future costs are not discounted. Costs are intended to be societal costs, and only direct costs to consumers and producers are included
- Costs are often approximate and often based on very little available data, so the costs results must be interpreted as approximations.

It is important to note that certain costs are not included in this analysis. For example, costs related to travel time, convenience and other “hedonic” factors are beyond the scope of the analysis, but could be important (Fulton et al. 2014). A key assumption is that the quality of transit and transport options increases in High Shift. If hedonic factors were counted they may have added more net benefit to the HS scenario. Furthermore, if policies are used that increase the price of driving, and people shift due to these prices (rather than because new, better travel options appear), this would result in hedonic costs, which should be kept in mind when developing policies to support the High Shift Scenario.

Costs by Country:

The Urban Mobility Model gives output for the MENA region as a whole. The cumulative costs of implementing the High Shift and Baseline scenarios were calculated by country to better understand the individual needs of each country. Costs for each MENA country were calculated by weighting the MENA output for the Baseline and High Shift Scenarios, by each respective countries population.

Each bar in Figure 13a includes all projected purchasing costs, fuel costs, operation and maintenance costs, and infrastructure costs for each country. This is a cumulative calculation for the 2010-2050 projections of the baseline and High Shift scenarios.

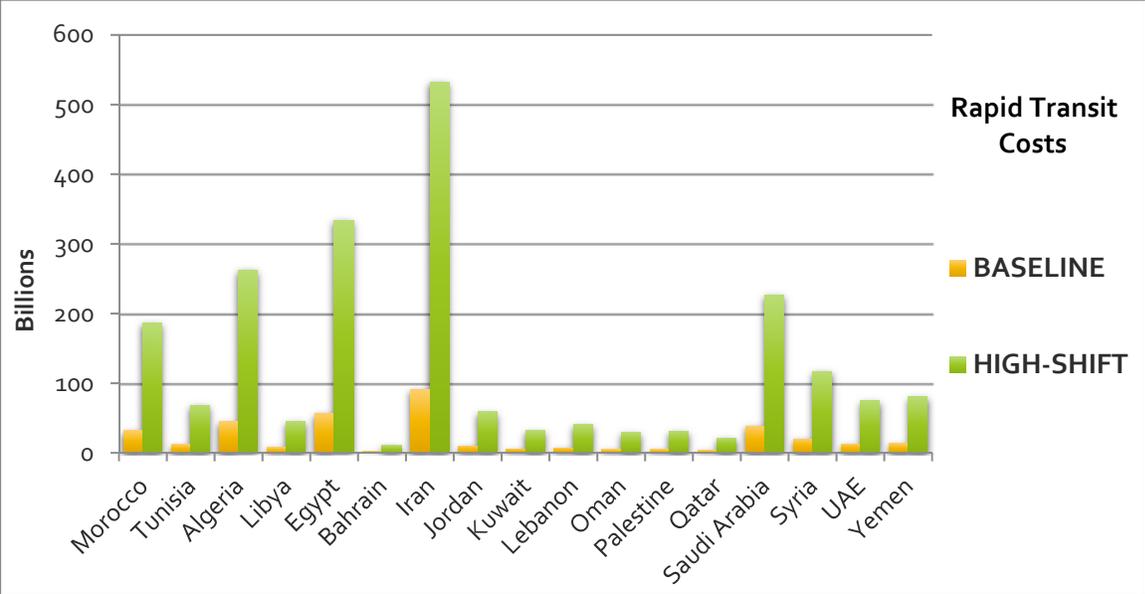
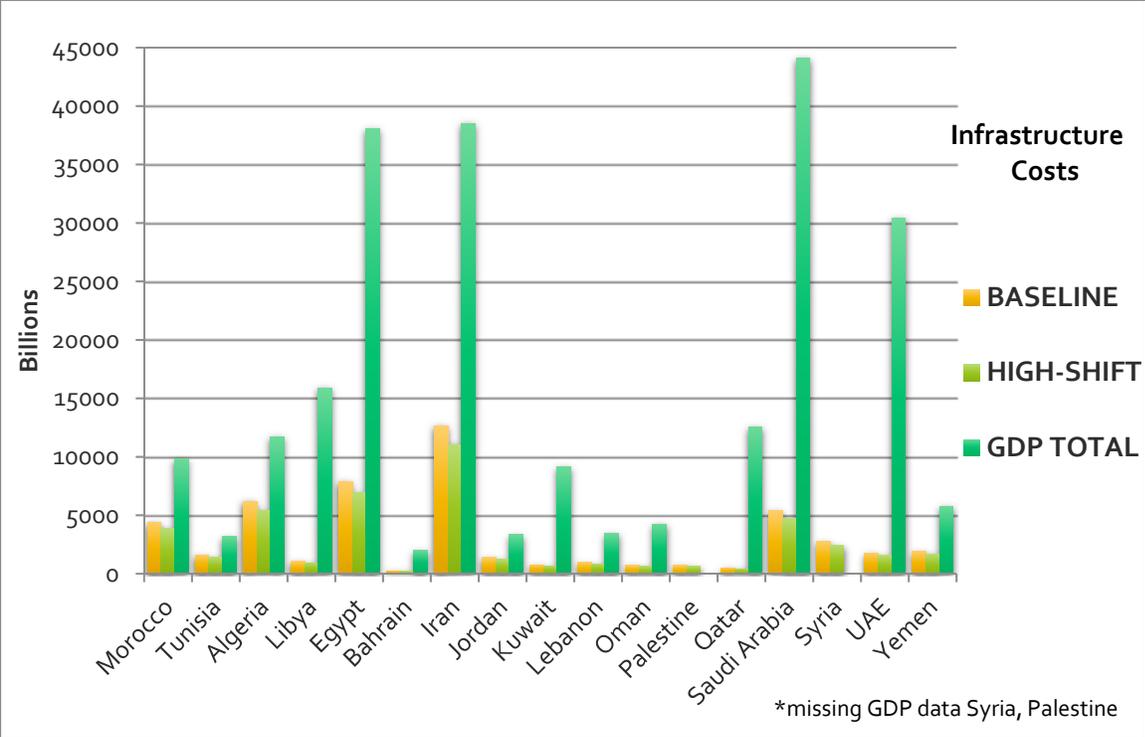


Figure 13a (top): Total Infrastructure Costs by Country with GDP comparison; Figure 13b (bottom): Total Costs of Rapid Transit Infrastructure by Country *GDP Data (Knoema, 2017)

Total costs decrease in the High Shift scenario versus the Baseline Scenario for each country. Although the High Shift Scenario reduces overall costs in the long run, it requires significant investment in urban rapid transit. Figure 13b shows that costs for rapid transit alone increase in the High Shift scenario versus the Baseline scenario. Since rapid transportation in the High Shift scenario requires significant

infrastructure investment, getting a High Shift scenario implemented in the region will require some change in the designation of funds.

Subsidy Reform

In MENA energy subsidies take a significant portion of each country’s GDP. Some see fuel subsidies as a means to alleviate poverty, but fuel subsidies are not appropriate for the objective. The richest 20 percent of households in low and middle-income countries use six times more subsidized fuel than the poorest 20 percent (IMF, 2013). Those who own and use private vehicles tend to already have higher incomes. Although fuel subsidies make fuel more affordable for the residents of each respective country, it ultimately ends up costing countries while only benefiting a segment of the population. Furthermore, implementing higher fuel prices raises the cost of driving and therefore indirectly reduces the amount of car travel (Parry, 2005). Appropriately, subsidy reform in the MENA region will be a key contributor to a transition to a High Shift scenario.

The countries of MENA are among the world’s largest producers of petroleum based energy sources; the levels of CO2 emissions are steadily rising (El-Geneidy, 2013). Partly in consequence to fuel availability, every country in the MENA region enacts some sort of fuel subsidy excluding Lebanon, Morocco, Palestine and Jordan where fuel is priced at about the cost covering retail price or slightly taxed.

The potential revenue from the elimination of fuel subsidies in MENA countries was calculated by pricing gasoline and diesel at the cost covering retail price. The cost covering retail price for gasoline in 2013 was 97 cents and 1.07 dollars for diesel (GIZ). Figure 14 shows the cost of fuel subsidies for each country in 2015. This was calculated based on the Baseline fuel consumption data from the IEA and GIZ (German International Cooperation) International fuel prices.

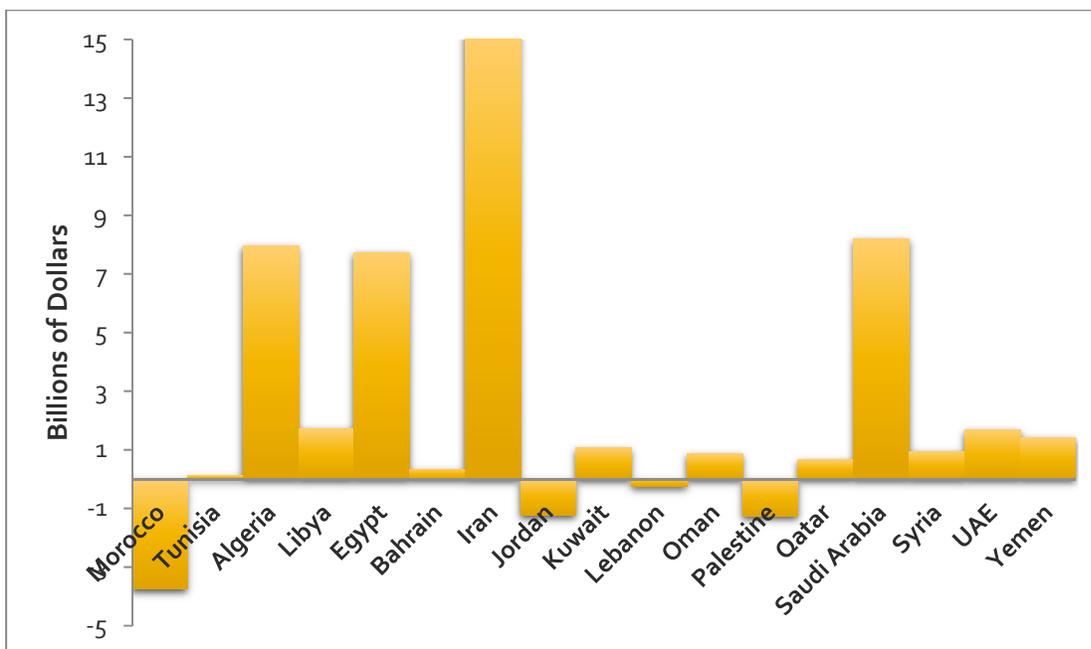


Figure 14 MENA Costs of Fuel Subsidies, 2015 (IEA, GIZ 2013)

**Update: In 2014 Egypt raised its fuel prices by 40 percent and continues to rise (James, 2015)*

Each country in MENA subsidizes fuel differently. The costs were calculated separately for each country, in order to clearly compute the range of subsidized gasoline in the region. This was done by multiplying the amount of fuel consumption throughout time, based on HS and Baseline projections, and the price of fuel in each MENA country. Currently fuel prices are subsidized in many of the countries. Figures 15a and 15b display the projected Baseline and HS total costs of fuel for consumers in each country and the region as whole if fuel is continued to be subsidized in the 2010-2050 projected time frame. As a result of less future car travel the High Shift scenario projects lower fuel costs.

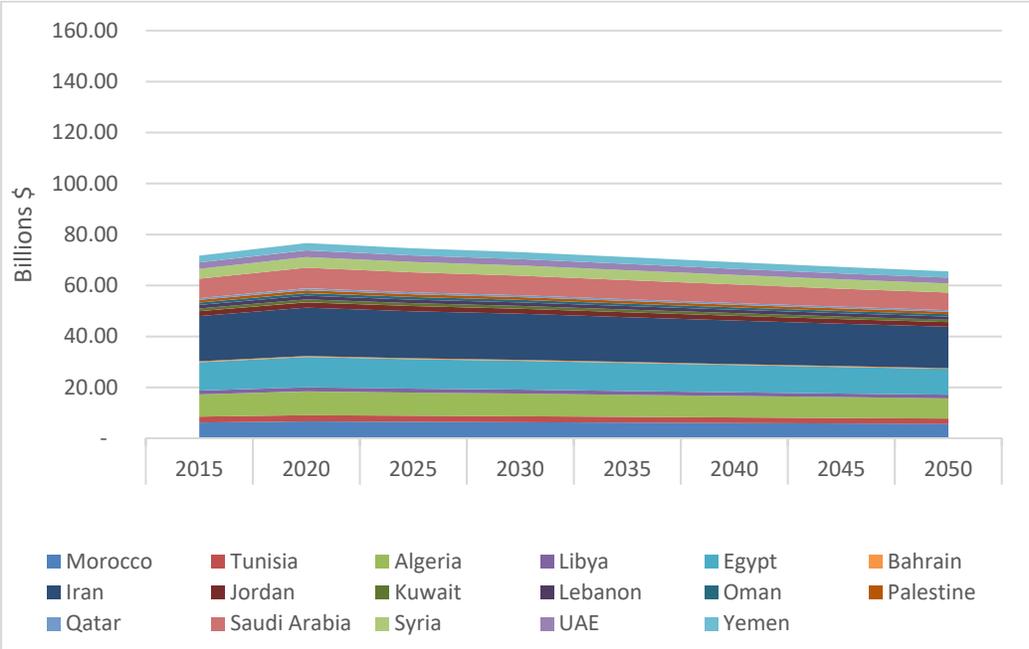
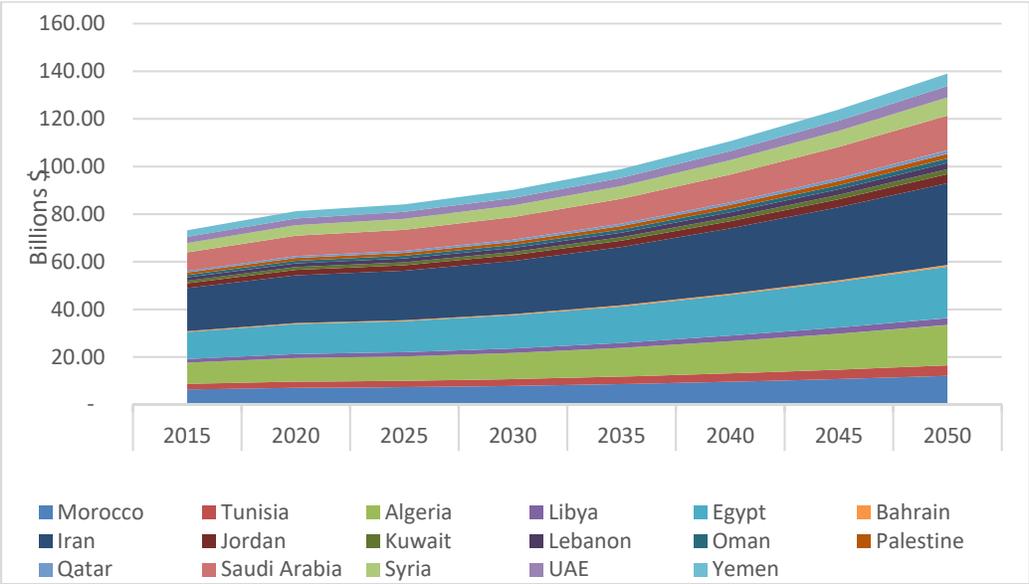


Figure 15a: Baseline Subsidized fuel (Cost to consumers); 15b: High Shift Subsidized fuel (Cost to Consumers)

Pricing fuel at the cost covering retail price for each of these countries would subsequently mean that fuel costs for the citizens of each respective MENA country would increase in both the High Shift and baseline scenarios. In the baseline scenario subsidizing fuels projects roughly 140 billion dollar costs to consumers cumulatively in 2050 for the region. Not shown in the figure above, not subsidizing those fuels would mean a 180 billion cumulative costs to consumers in the baseline.

For the High Shift scenario subsidizing fuels projects roughly 65 billion dollars costs to consumers cumulatively in 2050 for the region. Not shown in the figure above, not subsidizing those fuels would mean an 85 billion cumulative costs to consumers in the baseline.

It is important to note that regardless of whether fuel subsidies are removed or not, the High Shift scenario compared to the baseline scenario results in cost savings.

How Eliminating Subsidies could cover High Shift Transit Costs

The money saved through subsidy reform could be redirected towards other needs of the region. For example, their reduction could free resources for much needed infrastructure development. Expanding mobility options beyond private vehicles provides a more equitable benefit to the region, and reducing fuel subsidies could help support the modal shift in question.

In 2010 gasoline fuel subsidies cost the MENA region almost 40 billion dollars. The costs are projected in the baseline scenario to increase to 70 billion by 2050 along with growth in the rate of fuel consumption.

Because less fuel is used in the High Shift scenario, at the same subsidy rate there is less projected cost from the subsidized fuels. This is already a significant savings, on the order of 35 billion dollars in 2050. In the High Shift scenario, regardless of whether fuel is unsubsidized or not, consumers will save on fuel costs, and governments will save on subsidies, because of a reduction in private vehicle use. It is important to note that fuel numbers are for travel as a whole and the High Shift scenario projects only urban travel.

Reduction of fuel subsidies is one way of supporting a high shift scenario in the long run future of the region. Although the High Shift scenario greatly reduces both private and public transportation costs, successfully implementing the projected high shift scenario requires significant funds put into rapid transit infrastructure. Figures 16a and 16b compare total urban transport costs including infrastructure for each country in MENA in the High Shift and Baseline scenarios, to potential cumulative revenue of fuel subsidy removal over the 2010-2050 time span.

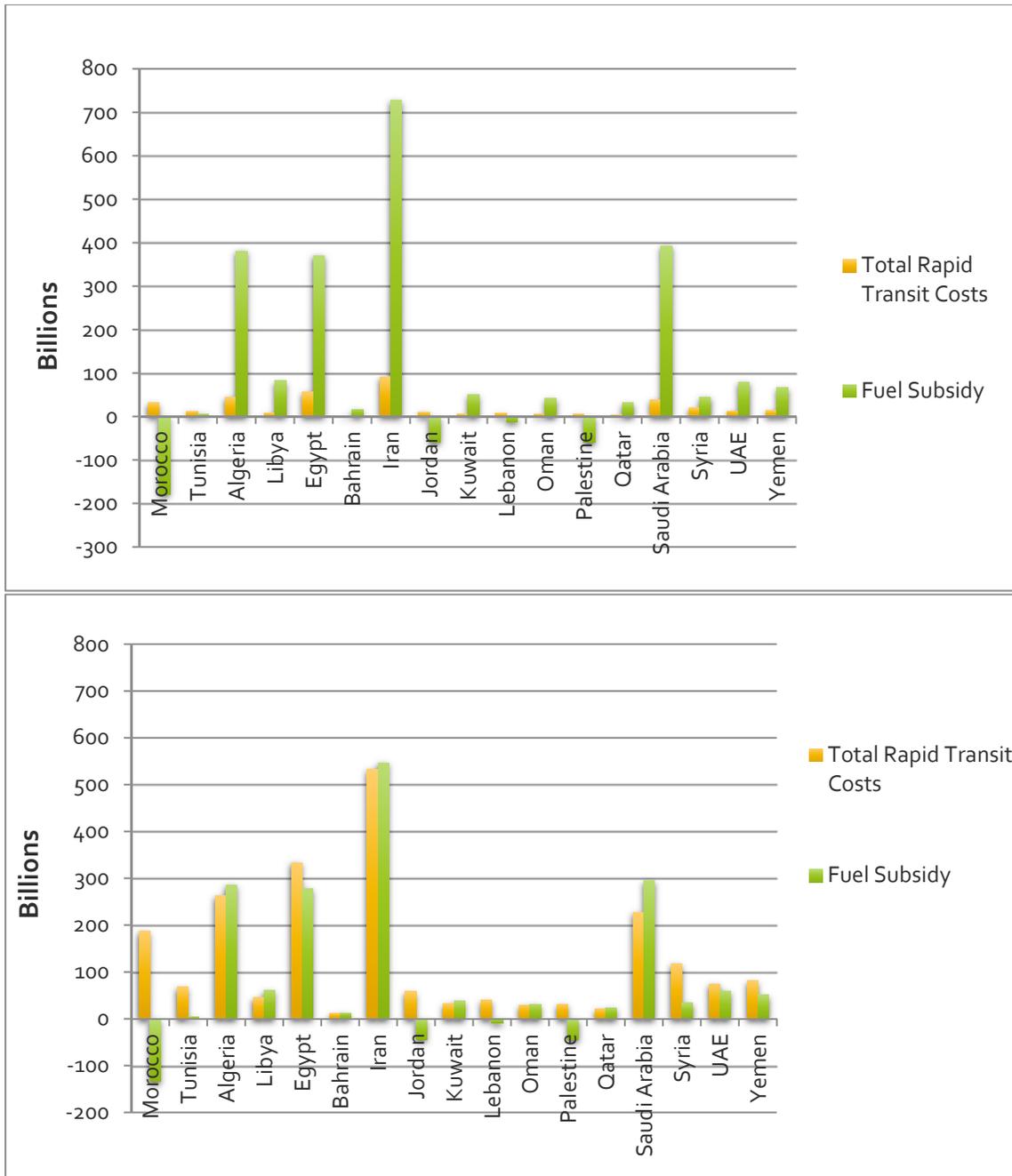


Figure 16a (top): Baseline; Figure 16b (bottom): High Shift

As mentioned before, fuel use would decrease in the High Shift scenario as a result of reduced car travel. The High Shift numbers on fuel use are factored into the calculation of the revenues gained from subsidy reform. Although with the High Shift Scenario revenue would decrease as a result of reduced light duty vehicle use, the government revenue gained from subsidy reform could still be enough to significantly invest in rapid transit systems. Countries like Syria, UAE, and Yemen could consider taxing fuel above the cost covering retail price to fully pay for Rapid Transit costs in the High Shift Scenario. These suggestions combined provide a path for MENA to move towards a sustainable urban transport future.

POLICY RECOMMENDATIONS

Finally, country specific solutions are important. Policy makers will have to recognize that there are large differences in initial conditions, as no broad urban transit trend exists in the MENA region. Weak institutional and legal frameworks as a product of long overdue structural problems in some countries need to be addressed. In order to successfully implement such an ambitious scenario, many national governments in the region would likely need to be more stable, transparent, and in tune with the unique needs of each city. Transparency and communication with the public is especially critical to the removal of fuel subsidies in the region, through an understanding of how the revenues could help to build a far stronger transportation system in cities.

Challenges and Suggestions:

- ***Proper investments in urban transportation are needed to make public transportation comparable to other modal options.***

Regardless of lacking urban transport, one challenge facing cities in the region is inefficient urban transport services. In many countries a stigma is already attached to the use of public transportation. Moreover the ineffective existing systems lead to the development of informal transit services (El-Geneidy, 2013). For example, “Bus service in both Kuwait and Egypt is subject to a lack of funding, resulting in aging bus fleets, overcrowding, and declining service frequencies” (El-Geneidy, 2013). The flexibility that informal transportation services and private motorized vehicles provide is difficult to compete with. In Egypt new urban areas are heavily reliant on the informal sector (UNDP, 2010 pg. 7). In order for public transportation services to be viable options for those in the region policy makers, transportation authorities and planners in the region need to prioritize transit services. Policies to support public transportation development are important for each country’s potential transitions to a High Shift scenario.

The most common way of supporting public transportation in the region is through subsidizing its pricing and improving access and frequency of public transport service (El-Geneidy, 2013). Encouragingly, the relatively new metro in Dubai is among the cities in the world where commuters spent the least on public transportation as percentage of GDP (RTA, 2014). Making public transportation affordable in the region at least in its initial stages of implementation will allow for an easier transition to High Shift scenario. Finally, subsidies making public transport like metros more affordable need to be applied carefully. To prevent subsidies from being mismanaged or appropriated by employers any support in the form of a capital or operating subsidy should be based on a contract specifying clear standard of performance and effective penalties (World Bank, 1996). Proper management through a stable overarching policy structure ensures systems are running smoothly and efficiently. Achieving transit systems comparable to the level of service of European nations is impossible without expanding coordination, collaboration and capacity.

- ***Without secure, continuous, and quality infrastructure, people will often refrain from walking and bicycle travel.***

Walking is already an important mode in many of these countries. The demand for the infrastructure already exists. For example, walking represents 54 percent of urban trips in Casablanca Morocco (World

bank, 2008). In Egypt, non-motorized travel consists of 6.6 million trips per day of a total of 24 million trips (El Araby, 2013). Cycling groups also exist in some of these countries. One example is the group “Cycle Egypt” which includes more than 6,000 members (El-Geneidy, 2013). The problem lies in lack of infrastructure and emphasis on the importance of non-motorized travel to the public. Even with the prevalence of biking and walking in the mode share of the region, interests of non-motorized travelers tend to be neglected in investment, network management and infrastructure maintenance (El-Geneidy, 2013).

- ***Increasing the cost of car ownership through taxation and implementing stricter import laws is one way to ease congestion and direct the public to more sustainable transport modes.***

As mentioned, low fuel prices not only cost the region significantly but also encourage sprawl and dependence on private vehicles. The suggestion of increasing the price of fuel through the elimination of fuel subsidies could encourage less vehicle travel. “High rates of private automobile use in the MENA region are strongly associated with the low price of fuel, due to government subsidies” (El-Geneidy, 2013). Increased preference for private vehicles come from a multitude of factors, like growing incomes and vehicles being more readily available to residents of the region (Hillstrom 2003, pg. 192) Other related reasons include the region’s generally low cost of car ownership, insurance, and maintenance relative to other areas in the world (El-Geneidy, 2013). Lax import laws leaves many of these countries with low quality vehicle fleets. For example Algeria, reported an excessive number of private cars registered before 1997 (Algeria National Statistics Office, 2009). Older vehicles also tend to consume more fuel and produce more emissions.

More relatedly, to effectively divert growing use of the private vehicles, providing a viable alternative in public urban transit services is important. Combining these strategies with the removal of vehicle fuel subsidies as this analysis suggests will be integral to encouraging an overall more efficient transport picture for the region.

- ***Eliminating inefficient fuel subsidies is an important strategy to consider for a sustainable transport future.***

Often times, subsidy reform is difficult to sell to a public that is already accustomed to low fuel prices. More specifically resistance may exist with instability in the region and a lack of government credibility and administrative capacity. Even if the downsides of fuel subsidies are known, the public may resist because of little confidence that the government will use savings from subsidy reform wisely (IMF, 2014). Essentially subsidy reform will not be successful unless governments in the region build trust with the people of their respective countries.

Some countries in the region have already attempted subsidy reform. For example Iran conducted a broad public relations campaign before the reforms took effect to explain their purpose. The government described how people would be compensated for higher energy prices and the benefits to the country as a whole (Coleman 2014). Although a public relations campaign was a step in the right direction, implementation has not been sufficient. Part of the plan was to use cash transfers to the poor to phase out subsidy reform, though this did not work as planned. Instead of redistributing the funds to the poor, the government provided payments to everyone (The Economist, 2014). Governments need to monitor and plan the use of these funds with transparency. A productive option could have been to use these funds towards the infrastructure needs of the country. Those who consume the most fuel have a greater benefit

from low fuel prices. Therefore when considering the elimination of fuel subsidies more equitable benefits should be applied.

Egypt has raised its fuel prices since 2014 as a part of general austerity measures. The country has a larger goal of reducing the government's budget deficit (James, 2015). There was little public opposition due to the government's public relations campaign connecting subsidy reform to limiting costly power cuts and outages (James, 2015). No consumption data is available to show long term impacts of the fuel subsidy cuts. It is too early to tell if any of these funds will be going towards much needed infrastructure improvements. Though there are reports that overall, people have adjusted to the fuel price increases rather than protesting them: car-pooling and bus-pooling are reported to be on the rise (James, 2015). The High Shift scenario would encourage this trend by investing in transit infrastructure.

Raising the price of fuel offers an opportunity to remove the region's heavy energy subsidies both in oil-importing and oil-exporting countries alike. Their removal could not only support the implementation of the High Shift scenario through higher fuel prices but could introduce a new source of funds for investment in rapid urban transit infrastructure. Raising the price of fuel could also prevent the prevalence of fuel smuggling in the region, and the forgone costs associated with smugglers taking cheaper fuel and making a profit elsewhere. The High Shift scenario along with the elimination of fuel subsidies provides a framework for governments in the Middle East and North Africa.

CONCLUSIONS AND FUTURE RESEARCH

Many challenges face the Middle East and North Africa in moving towards a more sustainable transport future. Decisions made now about transport infrastructure will have powerful implications for the future. Unmanaged growth in private vehicles use could exasperate income inequalities (including inequality in terms of access to transit), along with environmental problems such as CO₂ emissions and pollutant emissions in the urban areas of MENA. Encouraging the use and expansion of urban rapid transit can provide a lower societal cost, and more equitable transport system to MENA residents. The strategies presented face challenges without an overarching transport policy structure, as no simple solution exists. The initial investments in public transportation infrastructure can be aided through the elimination of fuel subsidies but a long-term strategy is imperative. Comprehensive and holistic strategy will provide a durable plan for a sustainable well-functioning transport future.

Additional work can be done to make this analysis more robust. Results for the region, and particularly for individual countries, would benefit from more comprehensive and precise estimates. More effort in improving data and assumptions regarding current transportation situations, such as mode shares (including viewed across different demographic and income groups) would help. Specific cost estimates suitable for cities around MENA would also result in a more precise analysis, and could strengthen the argument that the High Shift scenario represents a cost effective transport future in MENA.

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