Policy Brief

Mainstreaming Electric Mobility in Egypt
Seeing the bigger picture of sustainable cities

CEDARE

FRIEDRICH EBERT STIFTUNG

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POLICY BRIEF

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In March 2017, a new Additional Protocol was signed in Berlin by both, the Egyptian and the German governments, amending the Cultural Agreement of 1959. This protocol was ratified by the Egyptian parliament in July 2017 and entered effect in November by Presidential Decree 267/2017.

The FES cooperates with Egyptian partners in the fields of:
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About CEDARE

Center for Environment and Development for the Arab Region and Europe (CEDARE) is an international not-for-profit diplomatic organization based in Egypt. It was established in response to the convention adopted by the Council of Arab Ministers Responsible For the Environment (CAMRE) in 1991, and upon the initiative of the Arab Republic of Egypt, the United Nations Development Programme (UNDP) and the Arab Fund for Economic and Social Development (AFESD).
The mission of CEDARE is to provide leadership and advocate sound governance for sustainable development, through building human resources and institutional capacity, advancing applied research and environmentally friendly technologies and acting as a catalyst to enhance collaborative action between the Arab World, Europe and the International Community.

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EXECUTIVE SUMMARY

- This policy brief aims to consolidate the understanding of the current state of electric mobility in Egypt, focusing on on-road electric vehicles and associated infrastructure. Relevant developments in Egypt to date have been assessed and discussed with stakeholders to provide recommendations for the way forward for the sake of mitigating air pollution and addressing climate change impact of the transport sector. In this 2019 update, focus is in associating e-mobility with the larger context of sustainable cities, in order to ensure policy coherence. This includes the wider scope, which includes walkability and improved accessibility, as well as preservation of cultural heritage for its association with walkability and for the city's economy. A cross-cutting concern as well is that enforcement of existing regulations is essential before discussing future regulations, such as implementation of Environmental (and Social) Impact Assessments (EIAs) for road transport projects, which has been an issue raised repeatedly by stakeholders interviewed throughout the research process for this policy brief.
- Addressing transport sector fuel consumption and emissions is a priority among planners and policy makers in Egypt, especially given the fiscal burden of fuel subsidies: EGP 53 bn had been allocated to subsidize petroleum products in FY 2018/2019, with most burden attributed to the largely imported diesel fuel. With 11 million vehicles in Egypt, half of which are private cars, there is an urgency for planning alternative solutions within the Avoid-Shift-Improve framework of sustainable mobility. Introducing electric vehicles (EVs) is recognized as a promising contributor to the broad mix of solutions, but building local competences to develop plans, policies and action plans remains a key challenge.
- Safe air quality is a fundamental attribute of a sustainable city. In Egypt Diesel fuel is of hazardously low quality, with critically high Sulfur levels, and represents a public health hazard, and it is coincidentally also a burden on the state budget as it is largely imported. It is a priority topic, and EVs are seen as a promising solution. However, with the abundance of natural gas in Egypt, and the already available experience in rolling out Compressed Natural Gas (CNG) vehicles, the move toward CNG is seen by public authorities as the more immediate viable alternative to diesel fuel, but considering the increase in demand, the CNG alternative will not have a significant impact, and diesel standards will remain the most effective solution.
- Numerous indicators note that there is substantial commitment from public and private stakeholders in initiating the deployment of EVs in Egypt, whether in planned or ad hoc initiatives: Custom duty exemption for electric cars in place since 2013 (and maintained in 2018 provisions), public procurement of full electric buses in Alexandria, and charging stations being rolled out starting with demonstrational stations in Cairo, in the New Administrative Capital, and elsewhere, as well as planning for assembling/manufacturing EVs and charging stations by public and private sector players. A further incentive of allowing import of used electric cars has been initiated by a decision by the Ministry of Trade and Industry, although the policy impact must still be investigated (e.g. to assess and mitigate the risks related to introducing used batteries, etc), and the licensing of electric vehicles has been partly formalized within 2019 (yet pending further regulatory development).
- Egypt's grid emission factor shall continue to decrease (i.e. cleaner electricity in terms of CO_2) due to planned efficient Combined Cycle Gas Turbines (CCGT) power plants, and expansions in new and renewable energy in the pipeline, which further magnifies the benefit of EV deployment when compared to conventional vehicles.
- With regards to EVs promotion, high-usage, high-occupancy vehicles should be prioritized in order to maximize relative benefits (taxis, buses, microbuses, tuktuks, ride-share and car-share fleets, company fleets, etc), due to the improvement of the relative Total Cost of Ownership (TCO) (i.e. the comparison with gasoline/diesel vehicles generally improves when the EV is being used more throughout its lifetime), rather than private cars. Such an approach should be reflected in available incentives (e.g. custom duties remain high for electric buses, 40%, while electric cars receive full exemption, despite being destined to private use).
- There is a significant loss of public space in Egypt due to increasing vehicle ownership and insufficient scrapping (and insufficient underground parking space), which represents a significant additional impact on the sustainability of cities in Egypt. An approach of vehicle

scrapping and replacement rather than merely market penetration of EVs is recommended. Micromobility options and combining with connectivity (shared-use) solutions is also a promising area for urban mobility that is gaining recognition in many advanced cities for similar motives.

- A threat to prospects for electric three-wheelers is the current plans in Egypt to ban conventional tuktuks. Plans are underway to replace tuktuks with mini-vans (9-seat buses), with the intention to improve management and monitoring, which can be better enforced on minivans. The foreseen social impact is substantial and represents a large risk in implementation. However, there are demonstrational projects in Egypt that showcase models where tuktuk fleets are properly managed and monitored with suitable technologies, including tracking and electrification of the fleet used. Such models can inform policy makers about alternative solutions with less social impact.

KEY RECOMMENDATIONS TO POLICY MAKERS ARE AS FOLLOWS:

- Diesel fuel standards before EVs and CNG if we plan to address air pollution. If air pollution is the primary concern, then, before EVs and natural gas alternatives, it is imperative to immediately set and enforce safe Diesel fuel specifications as it is more important in terms of ensuring a quick-win in addressing local air pollution in Egypt, and it remains a critical issue. It overshadows any promise for cleaner air that EVs or CNG can offer in the coming decade, especially in consideration of the increased energy demand in the transport sector with respect to heavy duty vehicles. Sulfur levels in diesel fuel remain more than 100 hundred times acceptable levels, and shall remain so through 2030 and beyond.
- Plan for people, not for technology. This moto means that focus should not be on EVs as a "silver bullet" for sustainable cities, but rather a wide mix of interventions is necessary to cater to people's quality of life as the goal. EVs are only a contributor. Future cities must be primarily walkable, cycling friendly, characterized by mixed use and compact development, and equitably distributing public space, before introducing elements of emerging technologies in the city such as EVs and the emerging micromobility options.
- Public space conservation means alternative solutions accompanying EV introduction are necessary, i.e. shared mobility, micromobility, and NMT, along with rationalizing ownership and parking regulations and enforcement. EVs partly address air pollution challenges, but for sustainable cities, the loss of public space must also be addressed.
- Shared services and public transport must be the context of EV mainstreaming rather than private ownership. Combine public transport policies with private-car restriction policies and support to limit the loss in public space and reduce emissions from aging vehicles, while promoting the culture of sharing and public transport use and integration with sustainable last-mile solutions.
- Introduce fuel economy labeling schemes to inform consumers about energy savings and emission reductions, and to enable eventual introduction of Low Emission Zones (LEZs) schemes, whether in the Central Business District or in other historical and cultural heritage sites or areas of sensitive ecosystems.
- Scrap and replace. Targeting vehicle scrapping and replacement approaches is necessary rather than merely market penetration of EVs in order to accelerate the improvement of the average fuel economy and emissions of the overall vehicle stock, curb congestion, and stimulate the automotive sector.
- Develop strategy through a wider participatory approach. For longer term plans, develop national and/or city-wide masterplans as a fundamental prerequisite prior to further interventions, building on existing studies developed or under development and through sharing and disseminating results to coordinate efforts.
- Life cycle management of batteries must receive more attention over the coming year. It is suggested to strengthen channels for experience exchange with neighboring countries at similar stages, such as Jordan. A new challenge in Jordan is the 22,000 EVs in use, soon having large numbers of end-of-life batteries that need adequate management and disposal, and similarly so in Egypt. For environmental authorities, this is highlighted as an important sub-topic for future studies for mainstreaming e-mobility in countries like Egypt and Jordan. Development of centers for certification of the State-Of-Health (SOH) of batteries of imported used vehicles has been also noted by experts as a necessary measure.
- Monitoring and evaluation is imperative for a faster learning curve. In promoting EVs, continue focus on collective transport, but equally important is the need to formalize monitoring and evaluation of EVs and CNG vehicles used in public transport to improve local capacity in conducting feasibility studies, conducting public procurement, and incorporating Total-Cost-of-Ownership analysis in the planning process.
- Prioritize introduction of electric vehicles and non-motorized transport in historical and cultural heritage sites, or areas of sensitive ecosystems strictly in combination with restriction measures for conventional vehicles within the same programs (e.g. Low Emission Zones).

- For longer term plans, develop national and city-wide masterplans as a fundamental prerequisite and through participatory planning. This would include planning for standards for EV charging infrastructure, charging stations and relevant licensing, introducing EV-ready building codes, development of a tariff scheme for vehicle charging, assessment and planning for grid-impact, identifying capacity building needs, etc. This is needed in parallel to the currently ongoing quick-wins and experimental initiatives pursued by various public and private stakeholders today. Substantial research is already under development by the European Bank for Reconstruction and Development (EBRD) and the German-Egyptian Joint Committee for Renewable Energy, Energy Efficiency, and Environmental Protection (JCEEE) that offer substantial support to inform national strategy development. Ensuring participatory planning as per global best practices and national law (e.g. Environment and Social Impact Assessment legal obligations requirements) is prerequisite.
- Expand on provision of high-quality peer-reviewed Arabic content and video content for training, awareness-raising and dissemination of sustainable mobility education amongst both professionals and the general public. This is in recognition of the gap in Arabic content and in Arabization of fundamental concepts in the various evolving sup-topics of e-mobility or sustainable mobility in general, and sustainable cities at large.

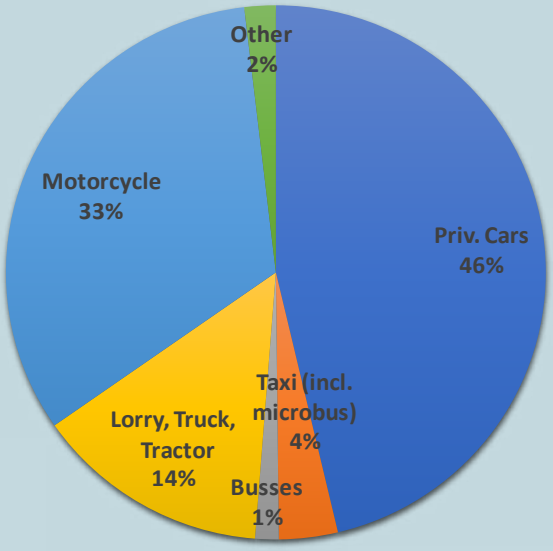
Content

1 Background

The Friedrich-Ebert-Stiftung in Egypt (FES) has been actively fostering environmental awareness and the dissemination of knowledge on sustainable development models with the objective to achieve an ecologically sustainable and innovative green economy. By understanding the importance of reducing CO_2 and other GHG emissions and the urgency of combatting climate change, FES aims to showcase innovative and sustainable solutions to mobility problems in MENA megacities, such as mapping public transportation in Amman, Beirut and Cairo, supporting policy development in the field of electric mobility, among other such activities in the fields of sustainable development.
The objective of this collaboration between FES Egypt and Center for Environment and Development for the Arab Region and Europe (CEDARE), is to work together with the Ministry of Environment of Egypt to assist the public and the decision makers in accessing relevant information that would ultimately result in groundbreaking environmental policies.

One of the key findings in studies on vehicle efficiency in Egypt throughout CEDARE's past decade of activity in the field is the limitation of this approach (of efficiency) in improving pollutant emissions and fuel consumption on a global level. This is because car ownership (as with other types of vehicles) continue to rise rapidly along with fuel consumption, overshadowing the improvement in efficiency of new vehicles.

A paradigm shift is therefore needed, and the most promising alternative to date, from the technology perspective, is Electric Mobility, while further promise is found in various innovations in operational models and shifts towards shared-economy principles along with the broader mix of solutions within the Avoid-Shift-Improve framework of sustainable mobility.
A frequent reminder is repeated however throughout this policy brief that addressing diesel fuel quality to mitigate air pollution is acknowledged as a primary priority in the case of Egypt to ensure policy-coherence with any electric mobility roadmap aiming to improve air quality.



HIGHLIGHTS: EGYPT'S FUELS AND VEHICLES IN BRIEF

There are 11 million licensed vehicles in Egypt, almost half of which are private cars and a third are motorcycles (exceeding 3.5 million)[1]. Congestion, air pollution, and severe lack of public space in its cities are among the main challenges of sustainability. EGP 59 bn had been allocated to subsidize petroleum products in FY 2019/2020, highlighting the substantial fiscal burden of fuel consumption that still remain[2]. Subsidy rationalization is however underway as part of Egypt's reform policies and is felt in the steady increases in fuel prices. This is implemented in tandem with scaling up other more effective social protection programs. Diesel fuel ("Soular") in specific is a higher burden than gasoline as it remains largely imported. Programs to move from diesel to natural gas fueld vehicles are in process. However, the rate of increase in overall fuel consumption may overshadow such measures of reducing dependance on diesel fuel.
With regards to quality, gasoline is approaching European standards for fuels, while diesel is yet far from such targets, having a hazardous sulfur content of 2,600 ppm rather than the common level of 50 ppm[3]. In the meantime, air quality has been estimated by the World Bank to cost Egypt EGP 3.3-9.6 bn (up to 3.2% of GDP) in environmental and health damage[4]. Consequent impact on tourism is also substantial.

Movement towards increased use of public transport is well underway, while informal transport, such as tuktuks and microbuses remain essential. The latter continues to fill a large gap in mobility needs, e.g. in the two thirds are of Greater Cairo constituting the unplanned/informal settlements majority. In other market segments, transport network companies (ride hailing services) are also expanding rapidly, supporting the cultural shift away from vehicle ownership and toward shared use.

2 National Priorities

The current national priorities revolve around economic development, reform, and job creation. The topic of E-mobility is therefore viewed from the lens of economic development as a main driver rather than the equally-important environmental concern. This implies the focus of public authorities on prospects for local production on one hand, and advancing electrified public transport modes on the other, such as through introduction of electric buses. However, with regards to the latter, scaling up fleets of natural gas fueled vehicles is seen as a more immediately available and feasible solution. This is due to the already available relevant experience and infrastructure for Compressed Natural Gas (CNG) fueled vehicles.

In the case of the new administrative capital however, infrastructure is being planned to cater to private electric cars. This is primarily for branding purposes, with intention to position the new capital as a leader in showcasing technologies and concepts of sustainable and futuristic cities.

The environmental and health impact motives are nevertheless still emphasized and championed by environmental authorities. This is in recognition of its alignment with the United Nations Sustainable Development Goals (SDGs)[5], and with Egypt's Vision 2030[6], whereby Egypt is commits to both reducing emissions of Green House Gases (GHG) to curb climate change and reducing local air pollution emissions for the sake of public health. It is also in recognition of the substantial impact that diesel fuel in specific has on public health due to the poor diesel fuel quality in Egypt. Electrification of transport in Egypt would have a larger impact on reducing various types of local pollution compared to other countries with cleaner fuels.

It is notable however, that there remains a challenge for national authorities to address the disparities between different messages about sustainability. There remains a gap between the stated notions of sustainability and the actual translation into action, such as the delays in mainstreaming walkability (and cycling-friendliness) concepts in urban planning and in national laws and regulations and ensuring enforcement and adequate budget allocations.

Different types of pollution of concern include carcinogens and smog forming pollutants; fine particulate matter (PM2.5), Nitrogen Oxides (NOx) and Sulfur Oxides, and Hydrocarbons.

2.1 Diesel fuel quality crisis

One of the key challenges in Egypt is addressing the low fuel-quality of Diesel fuel in specific, for which the Sulfur content is more than 100 times the international standards; exceeding 2600 ppm (see Figure 2). Sulfur is a catalyst poison; it inhibits the effectiveness of emission control technologies, resulting in increased vehicle emissions of carbon monoxide (CO), hydrocarbon (HC), nitrogen oxide (NOx) and particulate matter (PM), while in itself results in SOx emissions as well[7].

Furthermore, advancements in fuel efficiency improvements in engines do not function well with high levels of Sulfur in diesel fuel, so purchasing high-standard vehicles does not result in the expected emission reduction and fuel savings without compatible fuel quality. In the meantime, diesel fuel consumption continues to grow rapidly with economic growth and increased fleets of public buses and microbuses.

The diesel fuel consumption has almost doubled over years 2000-2015 (see Figure 1, including forecast), while consumption of the public buses in Greater Cairo alone has doubled in the past 10 years, while the diesel quality remained at hazardous levels to date.

As a reference, the evolution of Sulfur limits in diesel fuel according to Euro standards started with 500 ppm (Euro 2) in 1994, followed by further gradual reduction (350 and 50ppm respectively) to finally reach the latest imposed limit of 10 ppm in 2009 (Euro 5). The global status of fuel quality is illustrated in Figure 2.

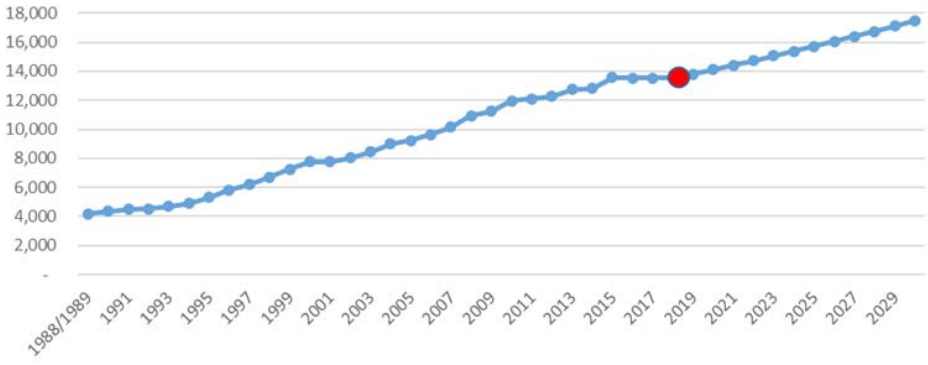


Figure 1: Diesel consumption in Egypt up to 2018 and forecast consumption (sources: Ministry of Supply and Internal Trade; Egyptian General Petroleum Company, and CEDARE analysis)

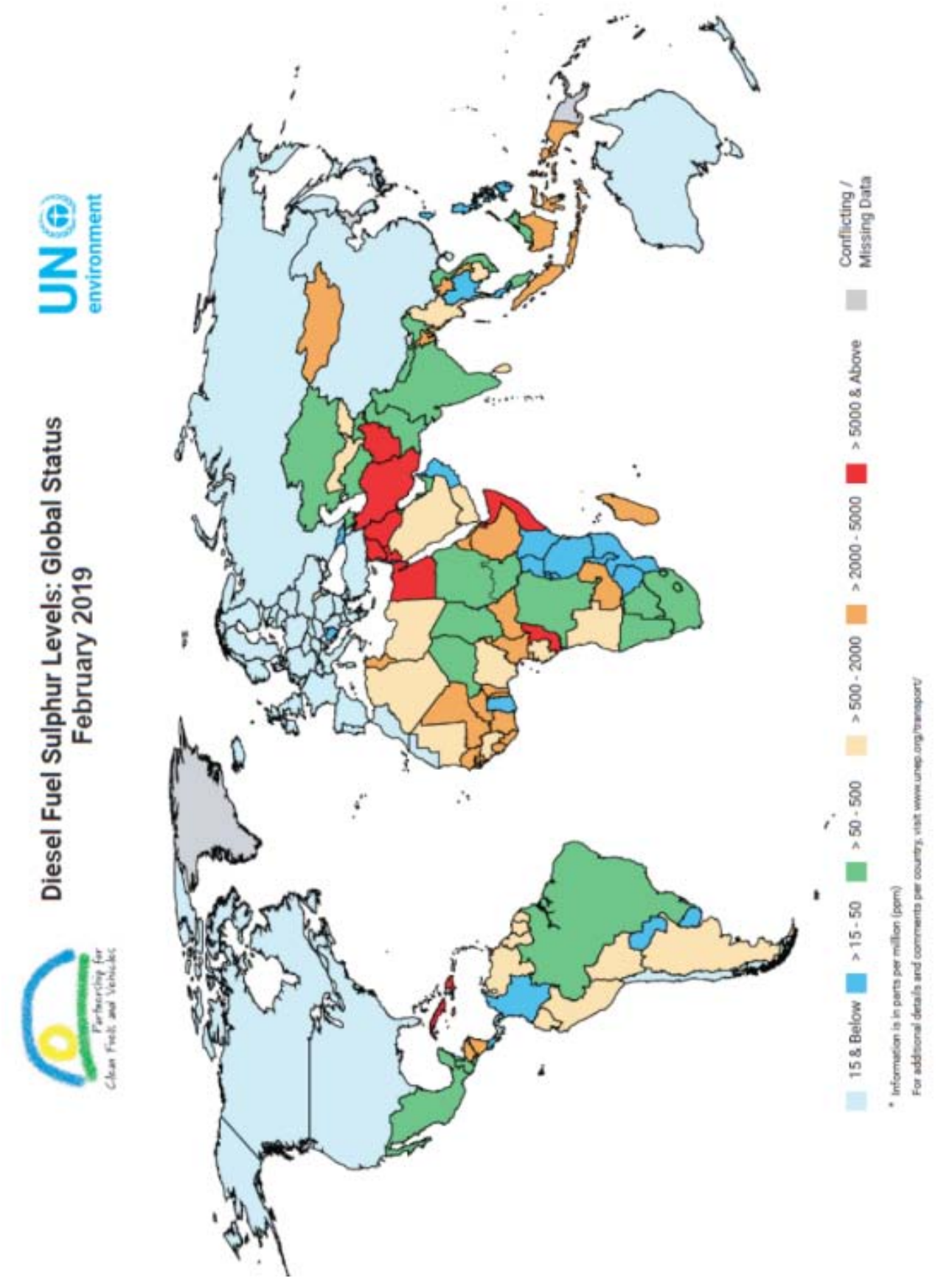


Figure 2: Global status of diesel fuel quality compiled by the Partnership for Clean Fuels and Vehicles (PCFV)

2.2 Congestion and public space crisis

Among the challenges of sustainability in Egyptian cities is the battle for public space and the rapid encroachment of cars over public spaces. This is especially of concern due to the lax enforcement of traffic regulations. Through people-centric urban design (rather than car-centric), combined with adequate public transport and Travel Demand Management (TDM) measures to reduce car-dependence, public spaces can be conserved and equitably distributed among road users including promotion of walking and cycling. A cultural shift away from ownership and towards shared use is thereby encouraged, reducing the footprint of vehicles in the city.

There is general agreement in Egypt over the priority of relieving cities from congestion, but a controversy over the various approaches that should be followed and how to define the problem of "congestion". Although the simplistic approach of street widening is still a prevalent approach, there is increasing acknowledgement among relevant authorities that such approaches are obsolete, and that more holistic streets-for-all approaches combined with Travel Demand Management (TDM) measures should be pursued instead.

The role of EVs in this vision for conservation of public space is in the prospect for the coinciding advent of shared vehicle services, where electrification and connectivity solutions go hand in hand. Such approaches facilitate the reduction in vehicle ownership, especially among youth (as common early adopters), and encourage the growth in more sustainable alternatives, such as shared micro mobility options and other sharing services. Accordingly, many European cities, and other advanced cities elsewhere around the world, are indeed encouraging the growth of ride-hailing and vehicle-sharing businesses, and noting a decline in vehicle ownership among youth.

In this respect, the introduction of EVs would only have a significant impact on traffic congestion or on public space conservation if it is combined with promotion of shared uses and along with disincentives for private car ownership and use, as well as scrapping of old vehicles.

In order to ensure policy-coherence with regards to sustainable cities, walkability and conservation of other sustainability elements of the city are therefore fundamental in order to avoid a techno-centric approach to city development.

Figure 3 shows an example of streets characterized by sustainability elements, including shading elements and green spaces, etc., that have been removed in 2019 to make way for cars; a strong reminder that EVs should not be promoted without accompanying plans for vehicle-sharing and micro-mobility alternatives to reduce the overall vehicle foot print in the city in anticipation of the "induced traffic" phenomenon.

Figure 3: Sustainable streets and public spaces in Cairo that have been removed in 2019 to make way for cars (Abdelaziz Fahmy Street, photo credit: Sarah Rifaat); a strong reminder that EVs should not be promoted without ***accompanying*** plans for public space conservation, such as favoring electrified micromobility and electrified car sharing services

3 Understanding e-mobility basics

In response to the escalating environmental impact of Gasoline and Diesel-powered vehicles, the alternatives of electric vehicle (EV) technologies are rapidly proving themselves as viable cleaner alternatives. Hybrid Electric Vehicles (HEV) combine both the traditional Internal Combustion Engine (ICE) and an electric propulsion system in various configurations to improve the overall fuel economy of the vehicle (e.g. Toyota Prius). The specific subcategory of Plugin Hybrid Electric Vehicle (PHEV) refers to hybrids that can further be plugged into an external power source for charging and not only depend on its on-board engine and generator (e.g. GM's Chevrolet Volt, Mitsubishi Outlander P-HEV, etc.). The Battery Electric Vehicle (BEV) refers to EVs that are fully electric, and thus alternative names are 'fully-electric' or 'battery-only' electric vehicles (e.g. Nissan Leaf, Tesla Model S, etc.). Various categories are similarly found in other vehicle types such as buses, trucks, motorcycles, scooters, e-bikes (hybrid electric bicycles), three-wheelers, etc., with varying degrees of success and progress.

3.1 Smart Charging Infrastructure

Electric Vehicle Supply Equipment (EVSE) refers to charging stations or charge points, which charge EV batteries and commonly communicate with the vehicle to ensure an appropriate and safe flow of electricity is supplied[8]. EVSE is rapidly developing to improve charging speed and safety. Types of charging include destination charging, where vehicles can be left to charge for a few hours when parked at a destination (typically residential charging, work charging, and street charging), and otherwise the substantially more expensive DC fast charging, where vehicles need to recharge on the go, comparable to the case with refueling stations, but still requiring substantially more time. Advancements in EVSE and battery technology are proving even further reductions in charging time. Various standards are in place for various connector types and EVSE modes of operation, and various alternative technologies for charging are also under development, such as inductive charging whereby charging is conducted without a cable connection.

Countries striving towards 'future-proofing' infrastructure are rapidly advancing toward development of improved decentralized bi-directional smart charging grids (and smart grids in general). This involves various standards and open communication protocols to allow roaming[a] and interoperability between public chargers, and management of billing processes as well as managing charging time to make best use of renewable energy (e.g. lower electricity prices in midday encourages charging when solar power is in excess) or otherwise discharging (selling) to the grid when necessary, among other benefits of connectivity, etc. Such possibilities facilitate reducing peak demand, optimizing grid capacity, and decarbonizing electric transport, while reducing costs for consumers.

For success of a smart charging grid, governments advocate open standards for the benefit of consumers and society as a whole. Using open standards has two key advantages: Stimulating innovation since new entrants can participate with novel solutions, and avoiding lock-in (monopoly) to ensure better competition and lower costs for consumers.

3.2 Association with Renewable Energy

EVs mean that local emissions are simply zero, clearly addressing local pollution and health concerns.

However, further to this achievement at the local level, the next challenge is to address the global (carbon dioxide) emissions from use of electricity, i.e. the power grid, in order to address climate change at large. Although EVs would still emit less carbon emissions even if considering power grid emissions in most cases, this reduction can still be further improved if power grids depend more on renewable energy.

Today's grid emission factor of about 0.5 kg CO_2/kWh[9], would gradually decrease with expansion in renewable energy, together with efficient technologies and fuel choices used in fossil-based power generation. With increased numbers of electric vehicles over the long run, the fleet of EVs itself may prove useful as an integral part of grid operations, which requires both grid-impact assessment as well as development of plans to benefit from the collective storage capacity of vehicles.

3.3 Batteries and falling prices

Despite declining prices, a medium-size EV today is still about 40% more expensive than its comparable conventional vehicle, mainly due to the expensive batteries[15]. Although costs are in gradual decline, government incentives are still needed

a Similar to the concept in the Telecom industry, for EVs, ‚roaming' would refer to allowing EV drivers charge their EV at charging stations that are not part of the charging network of their Charge Point Operator (CPO) using the same identification.

today to create competitiveness with ICE vehicles. However, observing trends in battery prices, thanks to improvements in battery chemistry and scaling up production, average prices today have fallen below 200 USD/kWh, about half the average price less than five years ago[10,15] (see Figure 5).

For reference, a battery price of approx. 100 USD/kWh is found necessary for an electric car (BEV) with a 200km range to be cost competitive with a conventional car, assuming typical mileage and fuel prices in industrialized countries[15].
Prospects for cost-parity are specifically better in countries where fuel saving would be greater and in specific cases where vehicle use is greater (i.e. high-mileage uses such as taxis); government incentives would not be necessary in such cases. Adapting battery sizes to specific travel needs may also results in net TCO savings by avoiding oversized batteries.

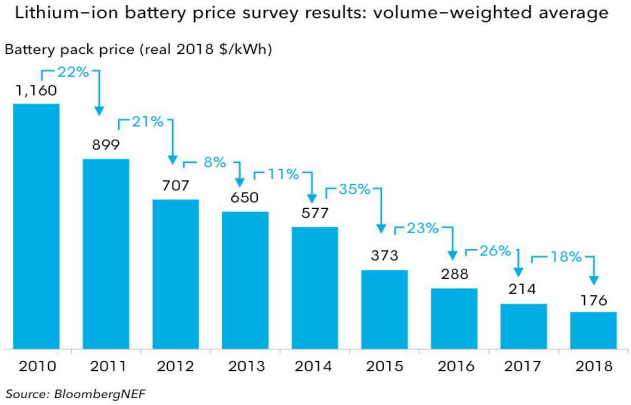


Figure 4: Li-ion battery pack price over time (volume-weighted average)[10]

3.4 Batteries from cradle to grave

Automotive batteries are also subject to much scrutiny with regards to environmental and social costs along their supply chain. The most common material needed according to battery chemistries today are lithium, aluminium, graphite/carbon, copper, nickel, cobalt, and manganese.
Among the challenges involved is the sustainability of the supply chain of these materials as they become increasingly demanded in the future. Among key concerns is the concentration of Cobalt resources in the Democratic Republic of Congo (DRC) and the associated unsafe artisanal mining.

Accordingly, much is being done at an international level to ensure traceability and transparency of supply chains. Examples include the establishment of the Global Battery Alliance, the development of the Due Diligence Guidance for Responsible Mineral Supply Chains of the Organization of Economic Co-operation and Development (OECD), the Strategic Action Plan for Batteries developed by the European Batteries Alliance, and the studies and guidance provided by the Responsible Minerals Initiative (RMI), among various other initiatives.

With regards to end-of-life management, common approaches aligned with the Reuse-Reduce-Recycle (3Rs) are increasingly being adopted and improved:

- Reuse: Using old batteries for energy storage purposes elsewhere, while optimizing batteries' first- and second-life duration to maximize the economic return over the lifetime. This implies planning the second-life usage in advance.
- Reduce: Avoiding oversizing of battery packs through improved sizing solutions such as using big data for improved sizing of batteries in respective applications.
- Recycle: Recovering material and pursuing closed-loop schemes for recycling through cooperation between the automotive industry and the material producers and in alignment with principles of Extended Producer Responsibility (EPR). Government regulations greatly ensure such measures (e.g. EU's Battery Directive banning landfilling and incineration, and China's program of interim measures to reduce battery waste, among others.)

With improved understanding of reuse options, advanced business models may internalize the consideration of second lives of batteries in feasibility studies in order to optimize the economic return over the batteries' first and second life uses.

3.5 Global trends and available support

The Paris agreement, enforced in 2016, set the global commitment to limit the increase of global temperature to 2°C above pre-industrial levels[11]. Given that close to a quarter of global emissions come from the transportation sector, the global community considers cleaner vehicle technologies, most prominently Electric Vehicles in specific, among the key areas of improvement to meet emission reduction needs.

The following highlights indicate substantial progress to date, in both developed and developing countries as assessed in key references including the 2019 Global EV Outlook of the International Energy Agency (IEA)[12,13,14,15]:

- Governments are still investing. Advancement in leading countries continues to be largely supported by strategic policies by the government such as fuel economy standards and associated incentives and economic instruments including various tax exemptions and subsidy schemes to bridge the cost gap between electric and conventional vehicles, along with support in the costly deployment of charging infrastructure.
- Fuel tax revenues are in decline, and governments need alternative revenue sources. In many countries, an emerging challenge is that transport-related tax revenue (fuel taxes) due to the successes in reducing consumption (more efficient ICE vehicles, better urban planning, new technology, improved environmental awareness and shift to public transport and cycling, etc). In this respect, promising solutions pursued include increases in taxes on conventional fuels, as well as a shift toward distance-based (or per-use) charges in order to maintain necessary tax revenue.
- EV uptake rising, but mostly cars, putting the issue of public space scarcity in question.
    - Global electric car stock by the end of 2018 increased from 1 million to over 5.1 million since 2015. Electric car market-shares per country remains modest. Despite the highest, being in Norway (46%), the second and third largest market shares are 17% and 8% in Iceland and Sweden respectively and substantially lower in the rest of the world.
    - Electric two-wheelers have reached 260 million (by far dominated by China) in 2018, and together with three-wheelers exceeded 300 million. Low-Speed Electric Vehicles (LSEVs) also exceeded 5 million units in 2018 (a vehicle category not requiring similar registration requirements as regular cars due to size and capabilities).
    - Buses and light commercial vehicles are also on the rise reaching 460,000 and 250,000 respectively, while heavier vehicles are still in much earlier phases of growth.
    - The vast majority of chargers installed globally are levels 1 and 2 slow chargers at homes or work places.
- Battery lifecycles and supply chains are under the spotlight, greatest future demand will be cars in specific. With increased EV uptake, more attention is being directed toward the cradle-to-grave (or cardle-to-cradle) life cycle of batteries at global and national levels. Improved regulation is being developed to ensure sustainable sourcing of raw material for batteries, and improvements in re-use options and battery end-of-life management are underway, whether through advancing second-life applications or through improving recycling and disposal regulations and practices as well as battery design. Technology development is progressing accordingly.
- Power grid operators preparing to accommodate future power demands and integration with renewable energy. According to announced policy ambitions and targets, the global EV stock is expected to exceed 130 million vehicles (excluding two/three wheelers) by 2030, with global EV sales of 23 million by then. Improved power system management is needed to accommodate the foreseen increase in electricity demand implied (640 TWh in 2030) and to balance loads and synergize with renewable energy sources (grid balancing).
- Hybrid vehicles favored over full-electric in cases of countries with most carbon-intensive power grids. Carbon savings of full-electric vehicles are substantial since EVs continue to have lower emission rates than conventional vehicles, even on a Well-to-Wheel basis. However, in countries where power generation has high carbon emission values (e.g. dominated with coal and lacking renewable energy sources), then hybrid electric vehicles may be found to emit less WTW carbon emissions than fully electric vehicles[b]. Other emissions (local emissions) however will be of concern. In total, the global emission of the EV stock in 2018 was

b Grid electricity emissions in Egypt are lower than the global average than 0.52 $kgCO_2/kWh$

38 million tonnes of CO_2 (almost half of what would have otherwise been emitted by conventional cars on a WTW basis).

- Original Equipment Manufacturers announcing ambitious targets. Numerous OEMs are increasingly shifting toward electrification of their offered models, whether cars or other vehicles, and investments in battery technology, most notably in Europe and China, is substantially growing.

- Costs in decline. Costs of production continue gradual decline, mainly thanks to advancements in battery chemistry and economies of scale, but also through other cost cuts such as improvements in vehicle manufacturing platform designs, and application of big data to improve battery sizing decision. Whether in commercial fleet vehicles, private cars, or otherwise, rightsizing is an emerging promising contributor to cost-reduction developments.

3.6 Shared Mobility and Micromobility

In observation of global trends, the advancements in urban mobility are shaping into three major transformational changes: Sharing, Electrification, and Automation, which have been labeled by some as the "three revolutions" in the transportation sector[16].

Automation, mainly referring to autonomous (driverless) vehicles, or vehicles with various levels of autonomy. Shared mobility refers to purchasing the ride and not the vehicle. It involves a cultural shift towards the shared economy and generally refers to two common types of services: (a) Ride-sharing or ride-hailing (e.g. Careem, Uber, Lyft, etc) and (b) Car-sharing (or other vehicle sharing), where publicly available vehicles are available for public use (e.g. Car2Go, Zipcar, etc). The terminology, definitions, and models are in continual development and vary between countries.

Although Electrification and sharing are not mutually dependent, they are rapidly developing in tandem, while even elements of autonomy are also involved. Shared electric microcars is a clear example. The density of cities, scarcity of public space, and increasing air pollution, are all driving innovation in mobility solutions towards lower-emission and lower vehicle ownership for more livable cities.

Shared mobility stakeholders are therefore significant actors in the advent of EVs. In one prominent example, Uber is phasing in LEVs in London until all its fleet in the city become hybrid or fully electric vehicles by 2020[17,18]. Elsewhere, electrified micromobility services, such as shared electric kick-scooters are rapidly expanding in many cities around the world.
An example of future visions for sustainable streets with adequate distribution of public space and rights-of-way is illustrated in Figure 6. suggested by the Institute of Transport Development Policy (ITDP). It highlights the role of electrification and micromobility in the bigger picture of a sustainable city, where pedestrianization and cycling-friendliness are prioritized over cars, and where EVs are favored in the forum of micromobility options if not public/collective transport.

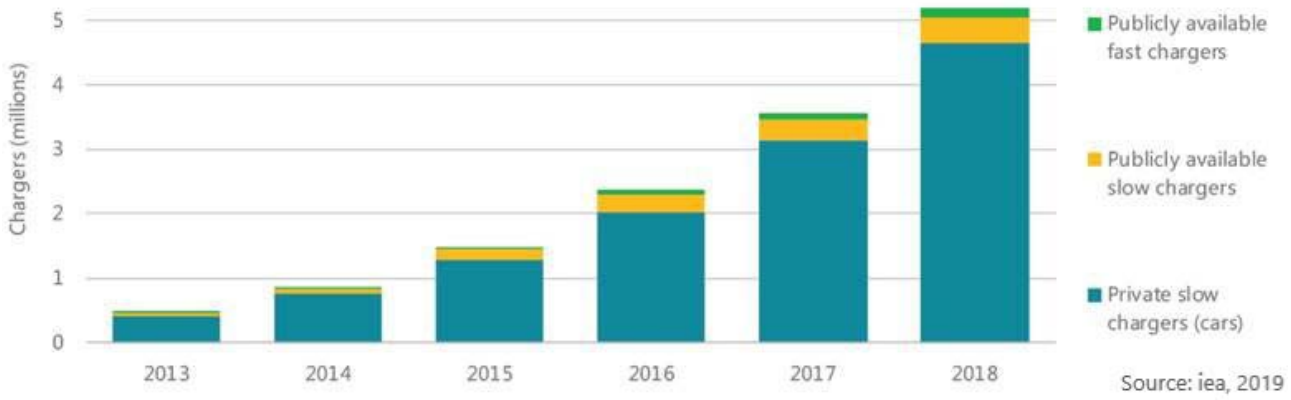


Figure 5: Global installation of electric LDV chargers, 2013-2018 indicating the vast majority being private slow chargers[15].

3.7 Low Emission Zones and car restrictions

Low-emission zones (LEZs), are zones where regulations are set in place to constrain polluting vehicles, such as old vehicles. Sweden introduced the first of such programs in 1996, and is today introducing levels of constraints that restrict certain regions from all gasoline and diesel vehicles ("Class-3" zones), allowing only electric, fuel cell, and Euro 6 natural-gas vehicles[23]. Many other cities in Europe are following similar paths. Restrictions however can vary widely in the geographic coverage the extent of constraints, but in all cases significantly improving the liveability and real estate value.
Restriction typically involve bans on polluting vehicles or imposed charging, as well as schemes for retrofitting, e.g. Euro 3 vehicles can be incentivized to install Diesel Particle Filters (DPF) to meet Euro 4 vehicle requirements in the LEZ[24]. Other than typical LEZs, some areas can be subject to a complete ban of ICE vehicles altogether.

The concept of LEZs may also be applied to historical sites, and near sensitive ecosystems. An example is the Taj Mahal site in india, where a ban has been imposed on internal combustion engine vehicles in its vicinity (within 500 m), while introducing electric three-wheelers (e-tuktuks) as an alternative.

> ***"Children's right to breathe clean air takes priority over the right to drive all kinds of cars on every single street. We are now giving the municipalities the powerful tool they have long been requesting so that they can tackle hazardous air pollution"***
>
> *Minister for the Environment of Sweden Karolina Skog[23].*

HIGHLIGHT: REGULATING MICROMOBILITY IN GERMANY

In June 2019, a new regulation was introduced in Germany allowing the use of personal light electric vehicles (LEVs) such as e-scooters and segways on public roads for anyone over the age of 14[19]. The *Regulations on Personal Light Electric Vehicles* defines LEVs as motor vehicles with an electric drive, a handle bar, and a top speed of 20 km/h, and meeting certain specifications for limited weight, size, and power, among other attributes. Riders must use bike lanes wherever available, or otherwise allowed to use the road.

The regulation sets the requirements for use on public roads such as type-approval, insurance, and vehicle identification number and data plate, and further enlists rules of conduct and penalties.

LEVs are seen as an additional alternative for cars and a mobility solution for short distances and last-mile trips, and are popular as ride-share vehicles. Nevertheless, one of the notable challenges requiring careful monitoring is the competition over public space, especially with cyclists. Other concerns revolve around safety of other road users. Similar concerns have been faced in other European countries with high roll outs of e-scooters[20]. For this purpose, the implementation of the Regulations on Personal Light Electric Vehicles has been carefully drafted to strike a balance between various needs of various road users, and is further being monitored and evaluated in a scientific manner by the Federal Highway Research Institute[21].

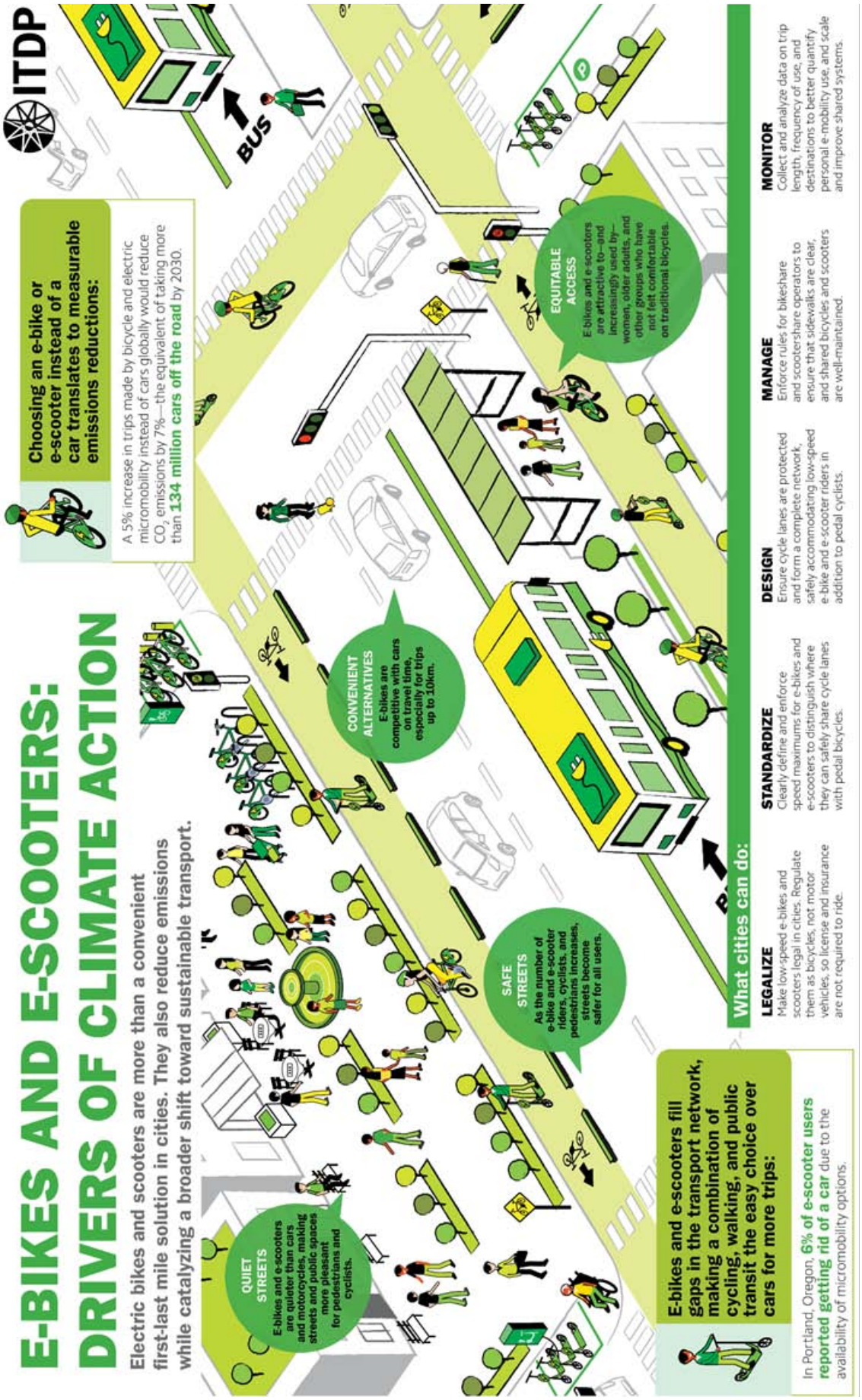


Figure 6: Micromobility options such as E-bikes and E-scooters must be integrated with other elements of sustainable design, such as adequate planning for pedestrians and cyclists and provision of enjoyable public spaces [22].

The viability of LEZ enforcement has been largely enabled by the available technologies, including ultra-low-emission (high Euro standards) and zero-emission vehicles (EVs), together with the enabling digital infrastructure for monitoring and enforcement. Examples of protecting certain designated areas vary in scope and coverage. There are city-wide applications such as central London, where a combination of congestion charging and environmental restrictions are imposed, or in various cities of Germany, including the 88 km^2 Environmental Zone in Berlin, or elsewhere in cases of smaller designated areas.

(a) Milano, Italy

(b) Stockholm, Sweden

Figure 7: (a) Traffic zone segmentation in advanced cities facilitate regulation enforcement: As of October 1, 2019 Euro 4 diesel cars are banned from entry into Milan's larger Area B zone; (b) Hornsgatan in Stockholm, Sweden, set to be a "Class 2" low emission zone limiting passenger cars, mini buses and vans as of January 15, 2020.

4 Situation Analysis: E-mobility in Egypt

4.1 Policy Context and Regulations

The policy environment in Egypt is yet under development to accommodate nation-wide rollout of EVs, but there are a number of key strengths that may provide a stepping stone for a larger framework of action; there is already custom duty exemption in place for electric cars and regulations allowing imports of used cars, and secondly, with regards to institutional experience, there is an accumulation of know-how and experience in vehicle replacement programs initiated by EEAA that can be tailored to serve replacement programs for EVs, including the experience of the Micro- Small- and Medium Enterprises Development Agency (MSMEDA) in its ongoing financial services facilitating vehicle replacement for promotion of cleaner vehicles (currently Compressed Natural Gas). Furthermore, with regards to new urban communities, the new administrative capital is being developed with the intention to showcase leading sustainability concepts, including EV charging infrastructure. There is also advancement in developing local capacity for manufacturing.
However, following the initial phase of ad hoc policies and initiatives, the private sector players demand the development and disclosure of a clear government strategy for EVs; covering plans for stimulating the market, enabling industrial production and innovation, planning infrastructure, setting tariffs, etc. This is to remove the prevailing uncertainty in policies and regulations and enable private stakeholders to invest in developing the sector.

4.1.1 Vehicle licensing

Among the steps forward taken in 2019 has been the facilitation of licensing processes for EVs. Until 2018 each EV purchased in Egypt was licensed on a case-by-case basis through a written request to the Ministry of Interior, and it could then be assigned an engine size-equivalent (cc-equivalent) as a temporary solution for licensing and registration. This implies an inconvenient hassle for owners and also an inconsistent log of EV vehicle specifications in the registration databases. In 2019, formal registration procedures dedicated to EVs was initiated (see Figure 8).

A remaining challenge however is that the plates handed by the Ministry of Interior are temporary and licenses require continual renewal at very short intervals, inconvenient for EV owners. Improving regulations and procedures however are in process.

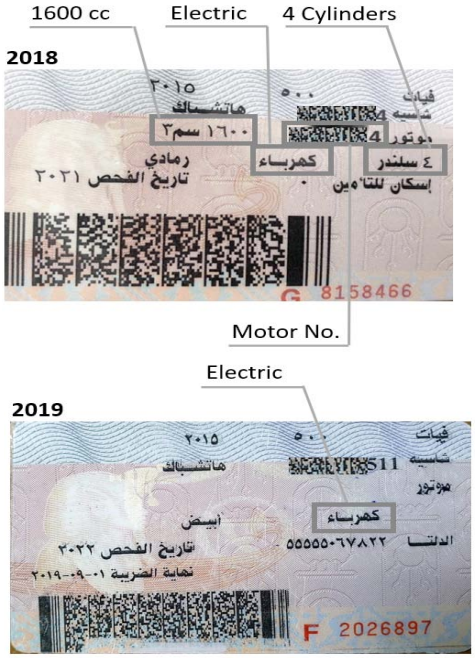


Figure 8: Marking Egypt's transition to EVs, licenses issued before introducing formal procedures had for long included ICE vehicle specifications 'equivalent' figures (left), and in 2019 eventually corrected (right), yet pending further formalization procedures.

4.2 A closer look at import tariff exemptions

In 2013, a decree was issued by the Shura Council (consultative council) of Egypt providing electric cars with a 100% exemption from custom duties and this exemption was maintained in the recent presidential decree for import tariffs, issued on September 9th, 2018[26]. This is the main incentive in place in Egypt specifically dedicated to electric vehicles, but only specific to 'cars'. It was not part of an overall national strategy, and was not supported with plans for development of charging infrastructure or with mainstreaming into relevant laws and regulations.
Notably however, there is no similar explicit exemption for other types of electric vehicles, such as those used for large collective transport or for electric two-wheelers.

In later developments, a further incentive of allowing import of used vehicles has been initiated by a decision by the Ministry of Trade and Industry to exempt electric cars from the restriction on the import of used vehicles. Otherwise, there is a general ban on the import of used cars in Egypt. With this recent exception, used electric cars now can be imported on the condition that they are no more than three years old[27]. Among the controversial issues that concern environmental authorities however, is that incentives have been put in place for cars, but not vehicles used for public transport, and another concern is the lack of inter-ministerial coordination to plan for handling end-of-life batteries.

4.2.1 Discussing electric "Cars" vs. electric "Vehicles" at large

Despite the praised exemption of electric cars from import tariffs, this exemption is controversial since it has been made available for cars, but not for the other types of vehicles that are in more need for such incentives. As an example, fully electric buses are subject to 40% import tariffs while cars (light duty passenger vehicles) are fully exempt[28].
Furthermore, among the challenges facing the stakeholders interviewed from both the public and private sector, is that the Arabic translation of the word 'motor cars' is also used as the translation of 'motor vehicles' that include vehicles that carry 10 or more passengers as per the translated HS code nomenclature, which includes buses. Limited awareness about the definitions and translations creates difficulty in public and private stakeholder consultations and discussions, as well as difficulty in timely operationalization of regulations. This is demonstrated in Table 1, where the items noted are indicated with the respective import tariffs imposed on electric buses (under HS code 8702.40) and electric cars (under HS code 8703.80).

Exempting buses from import tariffs, along with other vehicles used for transport services is seen as an incentive to stimulate market uptake and accelerate the learning process in Egypt with regards to procurement, operation, and maintenance of EV fleets. On the other hand, bus manufacturers highlight the eventual need to re-introduce import tariffs and other protective measures once local manufacturing starts, which can be implemented gradually.

4.3 Status of EV recognition and mainstreaming

There are clear indicators of interest in exploring introduction of EVs among public authorities. This is evident in the decision by Alexandria Passenger Transport Authority (APTA) to purchase and operate a small fleet of electric busses. It was planned since 2016 and completed in 2019 with the com-

missioning of the fleet of 15 electric buses in operation today. Elsewhere, the deployment of demonstrational charging stations in Cairo is also in progress, although in very early exploratory stages. The breadth of the issues to tackle however are very wide (standards, regulations, infrastructure, parking policies, tariffs, market segmentation, etc.), making it challenging for planners to decide on where to start.

There is therefore a substantial need for capacity development amongst stakeholders as well as a need for continual exchange of information and experience both within Egypt and internationally to cope with this rapidly developing field, in parallel to the gradual consolidation of the ad hoc activities that cater to the deployment and mainstreaming of EVs.

With regards to the language barrier, due to the rapidly evolving nature of new technologies, educational modules are needed (e.g. special courses, workshops, online courses, awareness programs etc.), but such content is mainly available in English. Arabization of (regularly-updated) educational content is scarce. This further challenges the dissemination of information and updates about EV technologies and related topics about policies and regulations, etc., and limits its dissemination throughout public authorities, universities, and popular media.

4.4 The move towards CNG put into perspective

In recent years, with vast discoveries of natural gas reserves in Egypt, most prominently in the Mediterranean Sea, the energy sector is experiencing transformation change. Egypt achieved self-sufficiency in Natural Gas in 2018, witnessing an average production of 6.6 billion cf/day, meeting total domestic needs[29] .

Given the substantial dependence on imports to satisfy domestic diesel fuel needs, the government is seeking all viable opportunities to shift from diesel fuel to natural gas wherever possible, including in transport.

Throughout October-December 2018, a national committee was established[c] to initiate a strategy to put into effect such a switch, including the discussion of potential policies to require all taxis and microbuses (14-seater privately-owned transport services) to maintain or switch to a dual-fuel system (CNG and gasoline, or CNG and diesel). The policy aims to target the approximate 141,000 taxis and 98,500 microbuses that are still operating with their conventional fuel type (gasoline and diesel respectively), while considering electric vehicle alternatives on the longer run.

HS Code and description [En]	Import tariffs (%)	HS Code and description [Ar]
8702: Motor **vehicles** for the transport of **ten or more persons**, including the driver ... *- 8702.40: With only electric motor for propulsion*	40 %	٨٧.٠٢: سيارات معدة لنقل عشرة أشخاص أو أكثر بما فيهم السائق. ... - ٨٧.٠٢,٤٠: مجهزة فقط بمحرك دفع كهربائي.
8703: Motor cars and other motor vehicles principally designed for the transport of persons (other than those of heading 8702), including station wagons and racing cars *- 8703.80: Other vehicles, with only electric motor for propulsion*	0 %	٨٧.٠٣: سيارات ركوب (خاصة) وغيرها من العربات السيارة المصممة أساسًا لنقل الأشخاص (عدا الداخلة في البند ٨٧.٠٢)، بما في ذلك سيارات «الأستيشين» وسيارات السباق. - ٨٧.٠٣,٨٠ : سيارات أخرى، مجهزة فقط بمحرك دفع كهربائي.

Table 1: Custom duties for (a) fully electric buses, 40%, and (b) fully electric cars, 0% (in English and Arabic) unchanged in 2019

c The committee included all relevant public authorities representatives as well as external experts, including CEDARE.

Subsequent plans under study include mainstreaming CNG use in public transport large buses as well, with plans to replace large portions of existing diesel-powered fleets. However, the impact of such policies and measures is challenged by the increasing annual consumption of diesel and gasoline, as well as the time required for implementation. The continuing trend of rising consumption of diesel fuel might overshadow the impact of such slow-penetration alternatives of CNG or electric vehicles. However, if adequate supportive policies are put in place to curb consumption, such a scenario can be avoided.

4.5 EVs will not address the air pollution crisis – Enforcing *diesel fuel specifications* will

The challenge of increasing consumption of diesel fuel and its low-quality is highlighted in a recent study on refinery upgrades, highlighting threats to public health and costs to the economy[30]. With conservative assumptions of increased diesel fuel consumption and with all foreseen refinery upgrades up to 2030, Sulfur levels in diesel fuel in Egypt shall still remain more than 100 times higher than common international standards. Accordingly, fuel quality is the priority.

With regards to air pollution, setting safe specifications for diesel fuel in Egypt is found to be the priority, preceding all other interventions such as slow-penetration clean(er) technologies, whether EVs or CNG powered vehicles.

Due to low-quality diesel fuel, higher Euro-standard diesel buses cannot be introduced in Egypt and exhaust treatment devices cannot be introduced (Sulfur is a catalyst poison). There is therefore a policy inconsistency in addressing climate change and air pollution in the transport sector, where EVs are rightfully promoted as cleaner technologies, but the diesel fuel quality crisis is not being addressed.

4.6 Central Business District and Areas of Historic and Cultural Significance

Policies to reduce congestion, promote pedestrianization, and reduce local air pollution in historical and cultural heritage sites have for long been discussed amongst planning authorities in Egypt, with some precedents of trials to promote e-mobility in historical sites in Cairo[31] and in Luxor[32]. These initiatives however have not been part of an integrated sustainable mobility plan and are rarely monitored and evaluated, and are not explicitly associated with measures for emission reduction or restriction of high-emission vehicles.

Figure 9: A pedestrian street in downtown Cairo with adequate seating and shading elements is more friendly for potential micromobility options.

Nevertheless, in a substantial demonstration of improved awareness about principles of sustainable cities, there is gradual introduction of elements of sustainable street design and sustainable mobility in downtown Cairo, such as pedestrianization of streets that has proven successful, as well as the planned introduction of bicycle lanes and bike-sharing systems. The latter is part of activities led by the UNHABITAT in cooperation with the relevant public authorities.

Downtown Cairo has for long been known for traffic congestion, but rather than widening streets, the authorities are increasingly becoming aware of more sustainable alternatives: Catering to pedestrians and cyclists in order to drive people away from car-centered lifestyles and improve the livability of cities, and strictly enforcing vehicular traffic control and parking regulations. Such demonstrated early stage of awareness can facilitate introduction of further interventions to enable sustainable mobility, such as electric micromobility options.

4.7 Charging Infrastructure

Throughout 2019, installed charging points in Egypt have exceeded one hundred points (see Figure 1), predominantly of AC chargers. The Egyptian start-up company, Revolta Egypt, has established notable presence through cooperation with state-owned fuel distribution company National Petroleum Company (NPCO, a.k.a. Wataneya) to install EV charging stations at their gas stations. The first station of such has been launched in February 2018, while previous demonstrational charging stations have also been tested at limited work places and shopping malls. Following a learning-by-doing approach they envision deployment of 300 charging stations throughout year 2020, along with further plans to initiate after-sales services for EVs as well as explore deployment of electric taxi services. Key challenges have been the lack of accompanying regulatory and administrative considerations to facilitate EV ownership and licensing and certainty about the regulatory environment and tariff scheme to be implemented.

Another emerging player is the Egyptian company Infinity-e rolling out EV charging points at gas stations and selected gated communities. Developments in new urban communities are also increasingly considering charging infrastructure at the early stages of development, such as evolving plans in the new administrative capital as noted in the following section.

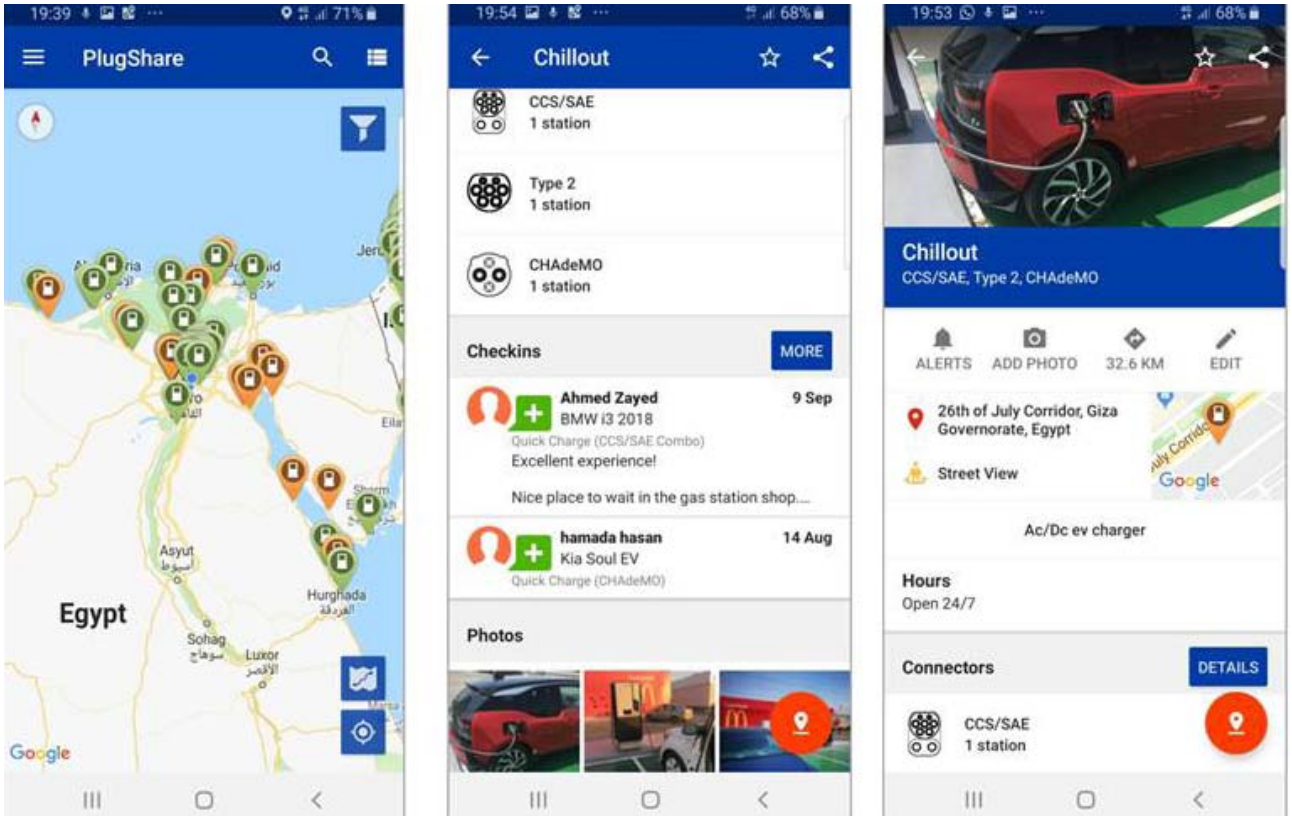


Figure 10: Charging stations exceeded the mark of 100 points throughout 2019 across Egypt on PugShare[d].

d PlugShare is a community based application that guides users to public charging locations throughout the world through crowd-sourcing.

4.8 New Cities

There are solid steps taken by the government to promote electric mobility in Egypt with evident political will, while other elements of sustainability are yet to be introduced, such as walkability and cycling-friendliness that require mixed use and compact/human-scale development.

With regards to charging infrastructure, focus is on integration of charging infrastructure in new cities, and primarily the New Administrative Capital. The intention is to ensure that new cities are designed to be future-proof and showcasing leading-edge technologies, for both the functionality and also for the sake of a futuristic image and sustainability branding.

Such measures are taken in combination with expanding capacities and diversity of public transport modes, primarily buses, with priority to natural gas powered buses, as well as electrified inter-city railways[33].

Current focus on infrastructure provision is directed toward the New Administrative Capital under development, where announcements by the state-run company, the Administrative Capital for Urban Development (ACUD), indicate that the plan is to provide charging points interspersed along the streets and in selected destinations[34]. The plan is under development, with intention to also locate charging points along the streets at light posts so as to ensure widespread access and reduce urban clutter according to ACUD.

4.8.1 The threat of low walkability and cyclability in new cities

Among the challenges to the current trends in new cities developments is to align E-mobility together with the broader scope of Sustainable Cities.

Ensuring a holistic approach to designing sustainable cities is yet to be addressed due to the fact that planning in new cities in Egypt remain in favor of sparse (low-density) development[35]. This is contrary to the principles long established by the discipline of sustainable cities planning, which advocate compactness, mixed land-use, human-scale built environments, and high walkability and cyclability[36,37].

Notably, human-scale sustainable cities design further caters to small electric vehicles should they be promoted for last-mile commute, whether private vehicles or through shared-use schemes (e.g. e-scooters, e-bikes, etc, rather than electric cars), and saves public space otherwise consumed by large vehicles.

The current low-density planning with wide and high-speed road networks have been established to be a challenge to environmental sustainability due to the implied higher dependence on cars and inhibited ability for residents and visitors to meet mobility needs within walking and cycling distances. A higher carbon footprint and an adverse impact on the liveliness and livability of the city and outdoor urban environment is therefore expected in such cases. Among the crucial issues associated with public space conservation is not only walking and cycling infrastructure and green spaces for aesthetic and comfort reasons, but also for reasons of carbon emission reduction, mitigating heat island effects, and providing habitat for urban animals and insects, among other positive impacts of various green space interventions.

4.9 The controversial case of Tuktuks

Among the challenging cases in developing regulations is the case of Electric Three-Wheelers, the so-called e-Tuktuk. The Ministry of Environment, maintains the position that three-wheelers are one of the valuable areas for demonstrational intervention for deployment of EVs as an approach to combine ongoing formalization efforts together with vehicle fleet renewal efforts, while addressing the air pollution impact noted in informal stations.

In most informal settlements, tuktuks facilitate access to employment, education, medical care, leisure, and commercial activity for a very large portion of the population, and offer job opportunities for families to exit a cycle of poverty. In many uses of tuktuks they are also employed for collective transport (for multiple users), and also frequently used by children in informal settlements in their trips to school[38]. Notably, more than half of the entire population of Greater Cairo live in informal settlements[39].

This mode also allows weaker and vulnerable persons (e.g. elders, disabled persons, etc) to have a convenient alternative to walking, and thereby offering an important empowerment function for various marginalized segments of society in dense unplanned areas with narrow unpaved roads. It has also been associated with access to emergency services in difficult-to-reach areas[40]. It has in fact been part of programs to reduce maternal mortality rates in certain difficult-to-reach areas in upper Egypt experiencing medical care challenges faced by pregnant women; an example of profound relevance to people's needs and livelihoods[41].

Although latest statistics indicate approx. 125,000 licensed tuktuks in Egypt[42], the actual number is estimated by relevant authorities to be in a more likely range of three million or more. The vehicle, despite its prevalence is stigmatized by some authorities in Egypt as only being a nuisance rather than as a compensation for unmet transport needs. Limited data and studies conducted on this transport mode poses a challenge to policy impact assessment. It is sometimes labeled as an escape vehicle for criminals and a threat to security, or otherwise a profession that wrongfully attracts children[43].

These are common arguments for the common restrictive interventions that are enforced such as bans and phase-out programs[44,45,46].
On the other hand, other perspectives advocate management measures rather than banning measures, as practiced in many highly populated countries in West Asia such as Indonesia, India, Vietnam, Sri Lanka, among others[47]. The challenge in Egypt however is associated with the practicalities and trade-offs related to the ability, competences, and resources needed to enforce management measures.
Today, the major intervention in process is a scheme to replace tuktuks with natural-gas powered minivans[48]. This plan is spearheaded by the Prime Minister in attempt to pursue a practical approach to formalize transport services in informal areas while promoting the use of natural gas in transport. Due to lack of information about such services, the support of extensive studies on informal transport is needed to better support decision-makers in improving plans for more sophisticated and socially equitable measures addressing tuktuks, and to help assess policy impact.

Figure 11: Tuktuks responding to diverse life needs for mobility services in dense settlements

Figure 12 : Launching the first of 20 fully-electric Tuktuks in El-Gouna in 2018, operating to date with various system-level solutions for transport services.

4.9.1 Electrification and system-level solutions

With regards to potential electrification of motorized three-wheelers, apart from various minor ad hoc initiatives, one proof-of-concept project stands out in a high-end gated town by the Red Sea; El-Gouna. In 2018, an Egyptian startup, Solectra, initiated a roll-out of electric Tuktuks using Li-ion batteries to complement the existing fleet of conventional Tuktuks already operating in El-Gouna. Today, a fleet of 20 fully-electric tuktuks operate with support of ride-hailing apps. Charging is partly supported with solar-PV power at grid-connected charging stations and a battery-swapping system is used. Notably, the operation model involves integration of adequate information technology to enable online payment, improve management and monitoring of drivers and vehicles.

4.10 Prospects for electric boats

Prospects for advancing electric boats in Egypt is still in its initial stages in Egypt. However, two examples of early attempts have been noted in the research on the topic. A team of young Egyptian engineers supported by the Higher Technological Institute have developed a demonstrational solar-PV powered boat, with trials since 2018 to date, in attempt to explore enhance local production and replace diesel-powered boats. Elsewhere, In TU-Berlin El-Gouna Campus, researchers in the Energy Department have initiated another early attempt to demonstrate an electric boat by retrofitting an existing diesel boat.

Results were satisfactory, and future developments would need to address the speed challenge as it was yet too slow for the original function of the retrofitted/replaced boat. However, it was a successful attempt and future plans are under discussion to further enhance the demonstrational idea (see Figure 13).

Among the common challenges were that importing components (e.g. propeller) were very difficult since it is an unfamiliar product among authorities. Other challenges were the choice of battery technology, deciding on trade-offs between weight and costs, and ensuring reliable operation and adequate speed. Wider recognition and further support for these exemplary initiatives to facilitate further development is needed.

4.11 Local Production and Competitiveness

Among the challenges in promoting local production in Egypt is striking a balance between fostering local innovation (e.g. researchers, young entrepreneurs, etc) on one hand, and supporting large investments in the automotive sector on the other (e.g. strategic partnerships with OEMs).

In June 2018, Mercedes-Benz Cars signed a Memorandum of Understanding with the Egyptian Government to initiate Plans to assemble passenger cars in Egypt with a local partner[49]. Through resuming assembling in Egypt once more, after a four-year halt, the foreseen developments involve the design of flexible production lines to potentially allow assembling of electric vehicles as well, which the Egyptian Government is vocally interested in

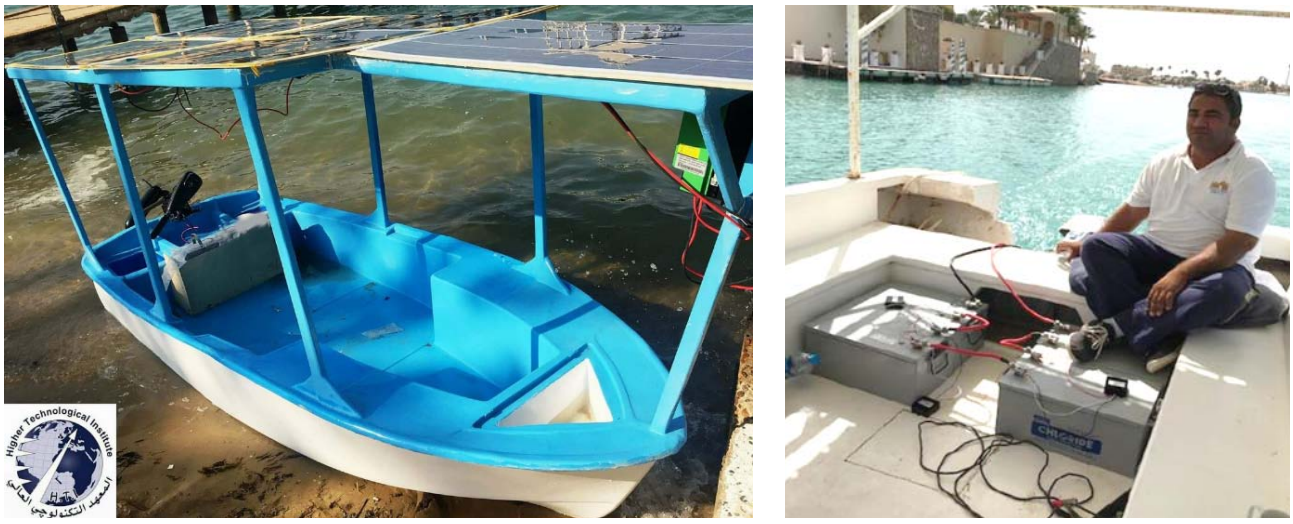


Figure 13 Examples of the earliest actors in Egypt demonstrating and advancing the concept of electric boats in Egypt: (a) Entrepreneurial initiative supported by the Higher Technological Institute since early 2018 (left) (b) Retrofitted electric boat supported by TU Berlin Campus El Gouna in winter 2018/2019 (right).

exploring. Conceivable developments also potentially include expansion of their dealer network nationwide, establishing a logistical hub in the Suez Canal Special Economic Zone, and establishing a training center [50].

Other prospects for local production include plans by German companies such as ZF and the startup e-trofit exploring potential to retrofit existing diesel buses to become fully electric in partnership with public transport authorities in Egypt. Furthermore, the Egyptian company Manufacturing of Commercial Vehicles (MCV) is also exploring prospects for producing electric buses, while currently already manufacturing CNG buses for the domestic market. MCV already exports diesel buses to various countries, meeting Euro-6 standards, indicating capabilities to meet international standards. A major challenge however is securing market demand and ensuring regulatory certainty with regards to protection from predatory pricing from foreign competitors.

Furthermore, other plans elsewhere are underway as evident in various exchanges of visits, MoU signatures, and agreements by various private public and private stakeholders proactively exploring opportunities or initiating partnerships at various stages commitment[51,52].

In this respect, a notable step forward was an agreement signed during the visit of Egyptian President and his accompanying ministerial delegation to China on the sidelines of the Belt and Road Forum held in April 2019. Among the highlights of the visits, the Ministry of Military Production (MoMP) and Ministry of Trade and Industry (MTI) oversaw the signature of an agreement to initiate production of Electric Buses in Egypt. The agreement was between MoMP's factory Harby-200 and the Chinese company Foton Motor. It aimed to lay the foundation for plans to upgrade Harby-200 facilities to jointly produce fully electric buses, with targets of 500 units produced per year, with 45% local components, and eventually producing 2000 buses over four years[53,54,55]. Other follow-up discussions between other Chinese companies and the MoMP continued, pursuing opportunities to build on the existing vast available production capacity of military authorities in Egypt and the political will and supportive policies[56]. Further plans also involve prospects to produce mini-cars in Egypt, starting with slow-moving-vehicle versions, recently showcased with the brand name "e-motion", and eventually producing mini-cars for use on public roads in future plans[57,58].
The MoMP also oversaw signature of a Memorandum of Understanding between its affiliated National Organization for Military Production (NOMP) and Chinese automotive company Geely as reported by Egypt's State Information Service[59]. The MoU aims to initiate cooperation to enhance technology transfer and local production of electric vehicles using the available capacity of NOMP's plants. Activities are in line with a national strategy for EV production that has been developed by MOMP.

Furthermore, the Ministry of Public Business Sector, is striving to similarly initiate partnerships with leading manufacturers in China to capitalize on the existing capacities of the state owned El-Nasr Automotive Manufacturing Company as well as the Egyptian Engineering Manufacturing Company[e] (EAMCO), as evident in ongoing discussions with the China Association of Automobile Manufacturers (CAAM) and exchange of country visits[60,61]. The state-owned Arab Organization for Industrialization (AOI)[f] is also a key stakeholder of interest with potential production capacity[62].

An overarching national strategy to lay the foundations for local production is yet to be developed for this specific sector. However, the Ministry of Industry, within a larger scope, is advancing Egypt's agenda for local manufacturing at large, with focus on specific technologies found to be suitable for current capabilities and competences in Egypt.

4.12 Key stakeholders

The key stakeholder currently leading the advancement of local manufacturing of EVs is currently the Ministry of Military Production (MoMP). They aim to eventually to provide for the domestic market and replace existing fleets, and eventually export EVs.

On the other hand, the key stakeholder responsible for introduction of EVs in Egypt as climate action is the Ministry of Environment in its role through its executive arm, the Egyptian Environmental Affairs Agency (EEAA) as a coordinating body and potential host for demonstrational programs. Such distribution of mandates however, has not been concluded to date. Variation in ownership can vary depending on the national agenda, whether

e Nasr is Egypt's state owned company and the first Arab vehicle manufacturer, established in 1960
f AOI is a state-owned organization established in 1975 primarily serving the defense industry, administered by a supreme committee chaired by the president of Egypt.

interest is in framing E-mobility to be primarily associated with climate and air pollution as presented herein, or otherwise primarily associated with industrial development, or sustainable cities, sustainable transportation, or smart grid development, etc.
Coordination would consequently be ensured with the Ministry of Electricity and Renewable Energy as the provider of electricity (and its affiliated New and Renewable Energy Authority), the Ministry of Interior for vehicle licensing and registration, the Ministry of Finance and its subsidiary Customs Authority for regulating custom duties, the Ministry of Trade and Industry for setting standards and overseeing specifications and permits for EVs and EVSE imports (and potential manufacturing), through its subsidiary General Authority for Export and Import Control (GOEIC) and the Egyptian Organization for Standardization (EOS), and the Ministry of Housing (and its affiliated New Urban Communities Authority) for sustainable urban planning.
The Ministry of Transport, is responsible for regulation and planning, while operating bodies are in place to oversee and operate public transport vehicle fleets at the governorate level in the major cities: The Cairo Transport Authority (CTA), in Greater Cairo, and Alexandria Passenger Transportation Authority (APTA), in Alexandria.

Furthermore, for new cities, there are authorities that may introduce transformational change as part of their mandates of developing new urban settlements: The aforementioned New Urban Communities Authority (NUCA), and the National Projects Department of the Ministry of Defense overseeing Egypt's new administrative capital being developed East of Cairo.

Other key influencers include associations of the automotive industry, most prominently the Automotive Marketing Information Council (AMIC(, the Egyptian Automobiles Manufacturers Association (EAMA), the Egyptian Automobiles Feeders Association (EAFA), and the Federation of Egyptian Industries (FEI) (specifically, the transport branch of its Engineering Chamber). These are the stakeholders that voice the concerns and aspirations of the automotive sector, pursuing growth, job creation, and expanding local production.

In terms of Research and Development, Zuweil City for Science and Technology has demonstrated several proof-of-concept projects in recent years implemented in Egypt for development of EVs and integration of renewable energy, including a recently received international patent for a high-efficiency DC/DC converter. Activities supporting local production of EV and EVSE components are in process, including pursuit of IEC-compliance of components in cooperation with other public, private, and academic stakeholders, demonstrating available local capacity for innovation and quality. Ain Shams university is similarly positioning itself among the leaders in advancing EV-related competences. Among the highlights in this respect was their successful Electric Car Rally held in October 2019, launched with the Academy of Scientific Research.

Cairo University has four tracks of e-mobility activity: an educational program of competitions for demonstrational EVs; a track for electric bicycles development including development of inverters and PV-connected charges and regular chargers (which led to two spin-off companies); a track for electric threewheelers (e-tuktuks); and a track dedicated to exploring development of electric passenger-car components, and similarly so, Ain Shams University is developing technical capacity in developing EV components and training in integration.

Furthermore, key supporters currently engaged in providing assistance include the following:

- European Bank for Reconstruction and Development (EBRD) started an E-mobility Strategy and Market Study in late 2018, to offer a first solid step in developing a baseline and a proposal of assessed policies, plans, and programs to initiate the sector. Study results are expected to be disclosed in the following year.
- German-Egyptian Joint Committee for Renewable Energy, Energy Efficiency, and Environmental Protection (JCEEE) is monitoring Egypt's readiness for EVs and will continue in more depth in an upcoming 4-year phase of cooperation starting in June 2019. The sector is currently seen as driven by political motivation, which is argued to be insufficient to justify investment in the sector; a systematic study of the sector and its value chain is recommended, including studying costs, benefits and impacts. In 2019, they completed a study on Evaluating the impact of integrating EVs in the Egyptian electricity sector.

4.13 Challenges and Opportunities

There are several opportunities in Egypt that support the widespread deployment of EVs:

1. Urban density: The nature of the urban environment in Egyptian cities is characterized by high density, which favors use of EVs and reduces necessary investment costs in infrastructure and space requirements for gas stations.

2. High stop-and-go city traffic: The nature of the slow and frequent stop-and-go driving in Egyptian cities, which is associated with congestion and urban density, further increases the relative benefits of EV use compared to conventional vehicles in this scenario compared to other settings with smoother driving cycles and high use of highways.

3. Low grid emission factor with introduction of nuclear power, Combined Cycle Gas Turbine (CCGT) power plants, and expansion in renewables: The power grid is foreseen to have a lower emission factor over time (average emissions per kWh of electricity) with the foreseen expansion in renewable energy and nuclear power, as well as higher efficiency CCGT plants, thus promising an even higher relative reduction of emissions due to EV-use compared to conventional vehicles or to carbon-intensive power sectors elsewhere.

4. Interest from public and private sector: There are already commendable ad hoc initiatives and interventions in place that can be coordinated and leveraged:
   - The public authorities' engagement indicated in the active custom duty exemption for electric cars, the recognition of EVs in the upcoming new traffic law, age limits on old public transport vehicles to encourage fleet renewal, and the recent landmark agreement for the purchase of E-buses in Alexandria.
   - The private sector engagement indicated in the initial sales of several electric cars and numerous e-bikes to early-adopters, as well as advocacy for improved regulations and recognition, and the recent installation of demonstrational charging stations.

5. Institutional experience in relevant incentive schemes: Various schemes for vehicle scrapping and replacement (CNG taxis, CNG buses, and four-stroke motorcycles) are already in place, indicating suitable institutional experience and familiarity with such programs and incentive schemes.

6. Political will to support solutions for diesel consumption: The government is prioritizing reduction in diesel fuel consumption in specific as a pressing matter, both from a financial point of view (due to high import-dependence compared to gasoline) and an environmental and public-health point of view (due to hazardous levels of Sulfur content) as well as the ensued impact on vehicle performance and efficiency.

On the other hand, the key challenges to initiate the sector in Egypt are associated with the delay in developing the enabling policy environment and regulatory framework, albeit in progress, along with limited financial resources as well as other competing priorities in the national development agenda.

Furthermore, the are various usual barriers associated with new technologies prevalent, such as uncertainty about technical and financial feasibility, necessary legal and regulatory prerequisites, market response, impact on employment and on the local industry, etc. There are also several technology-specific challenges. In the case of EV deployment, these uncertainties about impact on the power grid (in the case of high-penetration scenarios), implications for urban planning and understanding means to cater to apartment dwellers (given the lack of off-street parking in Egypt), uncertainty about battery life and performance in hot climates, etc.

Data availability for fuels and vehicles are also a key challenge. A major blind-spot in planning for cleaner vehicles is the stock dedicated to informal transport use, such as tuktuks and 9-seat buses (vehicle types and numbers, routes, fuel consumption, job opportunities and social aspects, etc), which requires dedicated baseline studies to inform policy makers and planners[63]. This would also facilitate the transition toward formalization of the sector.
To address the various challenges, it is notable that novel technologies of similar nature have often been initiated in the past in Egypt with support of international development organizations to support this initial phase of penetration and to provide experience exchange. Examples in the past include the introduction of LED lighting, solar and wind power, and CNG powered vehicles. This approach

of support, in light of the current stage of development, is favorable and necessary (i.e. preliminary studies, capacity building, demonstrational projects, facilitating access to funding, etc) in tandem with guidance in developing the legal and regulatory requirements needed and feasibility studies for various interventions.

5 Recommendations

The recommendations herein are in alignment with an overall long term vision to deploy and mainstream EVs in Egypt in terms of market penetration as well as eventual local production for the purposes of enhanced economic development and competitiveness, environmental sustainability, savings in energy and fuel costs, and integration into the wider scope of sustainable mobility and livable cities.

In this respect, the recommended priorities are as follows:

- Diesel fuel standards before EVs if we are serious about air pollution. Despite promises presented by EVs for the environment, the priority to address air pollution still remains to be the Diesel fuel quality crisis, referred to as the "elephant in the room". The recommendation is to set and enforce safe Diesel fuel specifications as a prerequisite to the e-mobility solution to air quality. This also in turn reduces impact of Short-Live Climate Pollutants (SLCPs) from incomplete combustion and lack of emission control devices due to incompatible fuel quality.

- Plan for people, not for technology. This moto means that focus should not be on EVs as a "silver bullet" for sustainable cities, but rather a wide mix of interventions is necessary to cater to people's quality of life as the goal. EVs are only a contributor. Future cities must be primarily walkable, cycling friendly, characterized by mixed use and compact development, and equitably distributing public space and conserving heritage, before introducing elements of emerging technologies in the city such as EVs and the emerging micromobility options.

- Public space conservation means alternative solutions accompanying EV introduction are necessary, i.e. shared mobility, micromobility, and NMT, along with rationalizing ownership and parking regulations and enforcement. EVs partly address air pollution challenges, but for sustainable cities, the loss of public space must also be addressed.

- Shared services and public transport must be the context of EV mainstreaming rather than private ownership. Combine public transport policies with private-car restriction policies and support to limit the loss in public space and reduce emissions from aging vehicles, while promoting the culture of sharing and public transport use and integration with sustainable last-mile solutions.

- Introduce fuel economy labeling schemes to inform consumers about energy savings and emission reductions, and to enable eventual introduction of Low Emission Zones (LEZs) schemes, whether in the Central Business District or in other historical and cultural heritage sites or areas of sensitive ecosystems.

- Scrap and replace. Targeting vehicle scrapping and replacement approaches is necessary rather than merely market penetration of EVs in order to accelerate the improvement of the average fuel economy and emissions of the overall vehicle stock, curb congestion, and stimulate the automotive sector.

- Develop strategy through a wider participatory approach. For longer term plans, develop national and/or city-wide masterplans as a fundamental prerequisite prior to further interventions, building on existing studies developed or under development and through sharing and disseminating results to coordinate efforts. Ensuring participatory planning implied alignment with global best practices and also national law (e.g. Environment and Social Impact Assessment legal obligations requirements).

- Tap into available international support. There are numerous opportunities of available technical and financial assistance and cooperation dedicated to support climate change mitigation measures, and electric mobility in specific that must be recognized and used through improved coordination and sharing of information.

- Life cycle management of batteries must receive more attention over the coming year. It was suggested to strengthen channels for experience exchange with neighboring countries at similar stages, such as Jordan. A new chal-

lenge in Jordan is the 22,000 EVs in use, soon having large numbers of end-of-life batteries that need adequate management and disposal, and similarly so in Egypt. For environmental authorities, this is highlighted as an important sub-topic for future studies for mainstreaming e-mobility in countries like Egypt and Jordan. Development of centers for certification of the State-Of-Health (SOH) of batteries of imported used vehicles has been also noted by experts as a necessary measure.

- Establishing the enabling environment for EVs, comprising suitable policy and regulatory interventions:
    - Expanding the existing incentive of custom duty exemption, to not only target 'motor cars' but also all vehicle types ('motor vehicles') and charging equipment as well (so as to include E-buses of various sizes, electric two-wheelers and three-wheelers, etc, as well as charging stations) similar to promotional considerations made for renewable energy.
    - Establishing standards and procedures for licensing and registration of EVs of various vehicle types and integration into the upcoming drafting of the executive regulations of the new traffic law under revision.
    - Including EVs as recognized sustainable products advisable in Egypt's Sustainable Public Procurement (SPP) policies in alignment with the guidance document for Egypt's Sustainable Public Procurement developed in reference to Law 89/1998 for tenders and auctions.
    - Setting the tariff scheme for vehicle charging and incentives.
    - Commit to the conversion of historical sites and other environmentally sensitive zones into Low-Emission Zones (LEZs), in combination with pedestrianization plans.

- Continuing support to demonstrational projects and interventions but ensuring monitoring and evaluation of results in order to ensure accumulation of experience.

- Furthermore, enhancing, consolidating, and marketing the government's indicators of commitment in terms of various policies and regulations in place or in preparation, as well as infrastructure plans, which will encourage private sector engagement, local production, and attract foreign investment as well as encourage multilateral development banks (MDBs) and other international development organizations and environmental/climate funds and facilities, that would support the development of the EV market and industry.

- Together with the policy recommendations, next steps in terms of studies should be the development of a baseline assessment to enable monitoring, evaluation and reporting of any implemented interventions, and to provide basis for objective planning and modeling, such as in modeling the future impact on the power grid, or developing scenarios for nation-wide fuel and emission reductions. This demands improved data collection and sharing as well as harmonizing nomenclature/definitions between public authorities. This ongoing effort would likewise facilitate Egypt's UNFCCC reporting commitments as well, namely the biennial update reports and national communications.

- In parallel, in order for stakeholders to appreciate the complexity and diversity of the topics that underlie EV deployment, it is imperative to provide extensive capacity building and awareness programs (including production of Arabic content) as well as experience-exchange programs with countries/cities of various levels of development.

E-mobility to date has been looked upon with a political interest in adopting 'future' technologies in Egypt and making way for foreseen local industrial development. What this policy brief aims to emphasize, is that a more holistic approach is necessary to ensure that e-mobility is part of a larger integrated picture of sustainable mobility with all its diversity of topics, and association with sustainable cities at large. This is noted repeatedly throughout this report, emphasizing many opportunities for climate action, real practical measures for air pollution improvement, and improvement in quality of life through such appreciation of the bigger picture.

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