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Decarbonizing Road Transport Sector through Electric Mobility in Pakistan

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Abstract

Electric vehicles (EVs) are anticipated to play an important role in meeting global goals on climate change. Electrification of road transport is one of the crucial pathways that can considerably mitigate the emissions in this sector that could limit warming to well-below 1.5°C, which would be inline with the Paris Agreement's targets (Logan et al., 2020).

Road transport sector in Pakistan relies heavily on fuel imports; hence it takes a heavy toll on Pakistan's fuel import bill (Anwar, 2016). Pollution in major cities has reached alarming levels (Usman et al., 2019). Apparently, Pakistan currently faces a power surplus crisis. Increased EVs penetration could serve as a productive power demand to achieve adequate level of utilization of existing power capacity and bring down unit cost of electricity. Electrification of transportation is one of the effective means to reduce energy intensity in the road transport sector (Lee et al., 2021). Besides, EVs offer lower running and operational costs, as well as lower tailpipe emissions. All these factors put together make a strong case for EV adoption in Pakistan.

While recognizing the multiple economic, environmental and social benefits of electric mobility, Government of Pakistan (GoP) introduced its first ever National Electric Vehicle Policy (NEVP) in 2021, which outlines a number of fiscal and regulatory incentives to promote Electric Mobility (eMobility) in the country. The two major drivers behind the rollout of this NEVP are; to reduce Pakistan's heavy reliance on fuel imports to reduce energy intensity and Greenhouse Gas (GHG) emissions in the road transport sector.

Electric mobility is quite a new space in Pakistan and it is at the very initial stages of its development. Hence, the Economic Cooperation Organization Science Foundation (ECOSF) immediately recognized the need for capacity building of various state regulators, market players and grid planners towards accelerated adoption of EVs. This is a critical step to enable evidence and knowledge based policy decision making to help promote the accelerated transition towards eMobility in the country.

In this backdrop, the ECOSF in collaboration with United Nations Development Program (UNDP) provided strategic support to the Government of Pakistan through Ministry of Climate Change (MoCC) and National Energy Efficiency and Conservation Authority (NEECA), Ministry of Energy (MoE) to explore the potential development pathways of the eMobility market. This chapter provides some brief highlights of the work undertaken by the ECOSF on decarbonizing the road transport sector in Pakistan as part of its support program to the Government of Pakistan in meeting its climate goals. Through this effort, we assessed the climate benefits of accelerated adoption of eMobility in Pakistan in terms of lower demand for transport fuels, reduced GHG emissions and the need for grid expansion and strengthening of distribution network in Pakistan (Cornell, 2019).

One of the key outcomes of this work was computing the GHG emissions of road transport sector to assess climate mitigation potential of electric vehicles in Pakistan. The findings of this report served as the primary input to Pakistan's revised Nationally Determined Contributions (NDCs) to the United Nations Framework Convention on Climate Change (UNFCCC) (Gyanchandani, 2016).

1. Electric Mobility to Enhance Nationally Determined Contributions (NDC) Ambitions and Climate Actions of Pakistan

Nationally Determined Contributions (NDC) are non-binding national plans highlighting climate actions, including climate related targets for greenhouse gas emission reductions, policies and measures governments aim to implement in response to climate change and as a contribution to achieve the global targets set out in the Paris Agreement. Under the NDC Partnership program, which supports the revision of Pakistan's Nationally Determined Contribution (NDC) at the MoCC, ECOSF and UNDP jointly contributed to developing a set of crucial guidelines for public and private stakeholders towards implementation of NEVP.

This chapter highlights the execution strategy of Pakistan's NDC targets and vision for the transport sector. It does this by reviewing Pakistan's NDC and the EV policy; exploring the transport sector and most effective policy options for increased adoption of EVs;

2. Measuring the potential climate, technical and economic impact of electric mobility in Pakistan

Projecting GHG Emission Mitigation Potential of EVs.

The GHG emission mitigation potential of EVs was measured in the form of reduced consumption for fuels with increasing number of EVs. Results show that EVs offer tremendous climate benefits in terms

identifying a wide range of barriers and issues that are currently restricting adoption of EVs; and outlining key proposed actions and initiatives for overcoming these barriers.

This work primarily undertook a comparative assessment of Pakistan's national EV policy and emerging EV markets in the US, EU, China, and India in the context of EV deployment targets, carbon emission regulations, fuel economy standards, phase-out plans for Internal Combustion Engine (ICE) vehicles and purchase incentives for EVs (ZImm, 2021).

In addition, this work provides insight into global EV market, highlights key drivers for global EV adoption, reviews national EV policy of Pakistan in comparison to other leading economies and underlines the global EV battery value chain.

Subsequently, the work also examines the key challenges and factors that will drive the EV adoption in Pakistan and concludes with some policy recommendations for accelerated adoption of electric mobility in Pakistan.

of net emission reduction even after factoring in the grid emissions.

We measured the net GHG emission reduction potential based on total emissions avoided by switching to EVs minus the GHG emissions associated with electricity consumption for charging EVs. Figure 1 reflects that EVs offer tremendous environmental benefits in terms of net emission reduction after factoring in the grid emissions. It demonstrates that EV could achieve climate benefits within the range of over 100 MTCO₂-eq in high EV penetration

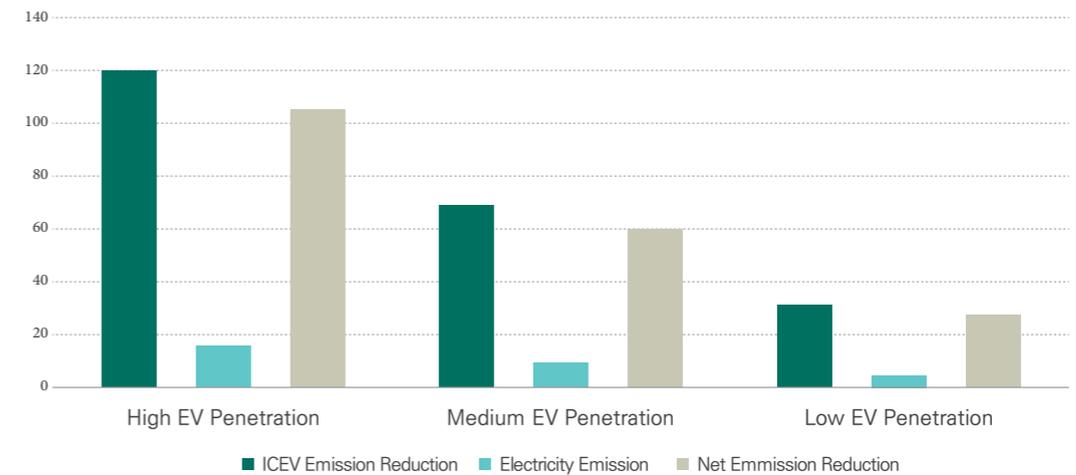


Figure 1. Net GHG emission mitigation potential of electric mobility in Pakistan

scenario to 30 MTCO₂-eq GHG emission reduction in worst case scenario.

This analysis highlights that climate benefits of electric mobility in Pakistan would continue to increase with further decarbonization of the grid if we meet the target of 30% of renewables in total electricity generation as planned under the Alternative and Renewable Energy Policy 2019 (IEEFA, 2020).

Assessing impact on fuel demand with increased EV penetration: EVs were found to reduce fuel consumption, based on high, medium and low EV modeled scenarios. With the best-case scenario, high EV penetration in the market would offer a fuel reduction of over 18 Million Tonnes of Oil Equivalent (MTOE) during the period 2021-2030. Similarly, in a medium EV penetration case, potential reduction in fuel consumption is expected to be about 10 MTOE. While in the low growth scenario, fuel saving potential is estimated to be about 5 MTOE. This translates into fuel savings of over US\$ 12 billion, US\$ 7 billion and US\$ 3.1 billion for high, medium and low EV penetration scenarios, respectively.

EVs Impact on Grid & Distribution Network: The result underlines that even in the high EV penetration case with cumulative addition of over 8.2 million EVs by 2030, our model demonstrated that it is unlikely to cause large increases in power demand through 2030; instead, it potentially adds about 2 percent to

the total and requires an extra about 1.7-2 gigawatts (GW) of generation capacity by 2030.

While the high market EV deployment is not likely to be a major challenge for electricity grid network in Pakistan; EVs are likely to reshape the electricity demand curve and might coincide with existing peak loads in the evening, if majority of EV owners decide to charge at home after work (Engel et al., 2019). To mitigate this impact, Time of Use (ToU) electricity tariff could be employed to influence charging behaviors and incentivize charging at off-peak periods to manage peak demand. This would require the distribution companies (DISCOs) to plan for system upgradation. This may require installing transformers, distribution lines and switch gears to mitigate the network impacts.

Projecting EV Penetration based on Total Cost of Ownership (TCO): We assessed the economic viability of EVs across different vehicle segments and various use cases using the TCO analysis. TCO is the sum of all costs involved in the purchase, operation and maintenance of a given asset during its lifetime (Hou et al., 2014).

Based on TCO analysis, we found that 2W - motorbikes and 3W - autorickshaws are already at TCO parity with their ICE equivalent models. Hence, these two segments are likely to shift to EVs much more rapidly. Whilst TCO equation is not yet

attractive for 4W passenger electric vehicles as of now due to higher upfront costs and lower daily mileage. However, it can economically be viable for 4W electric commercial fleets with high daily utilization rates. Whereas the electric buses have a very high upfront cost differential due to the large size of the battery. TCO parity can be achieved at the daily usage of over 250 km. However, we believe that the adoption in buses would be based on support from government driven demand in the form of additional purchase

3. Key challenges and barriers to mass of adoption of EVs in Pakistan

Worldwide, major barriers to mass adoption of EVs are typically higher purchase cost, limited driving range of EVs, and lack of charging infrastructure. Although policy and fiscal incentives are in place in Pakistan, a range of barriers could restrict greater adoption of electric mobility – These barriers can be identified across four major areas, including; policy and governance, infrastructure, financing and resources and regulatory framework. Our analysis reveals that there are four critical factors that will drive the EV adoption in the country over the next decade – policy support, global battery costs, charging infrastructure and localization of supply chain.

I. Higher purchase costs act as major impediment to EV adoption

Higher purchase costs act as major impediment to EV adoption. While the policy incentives can create momentum for EV adoption, the eventual large-scale adoption will only happen when EVs make economic sense to the end-user. For Pakistan’s market, consumers are especially sensitive to the upfront cost. Thus, policy instruments can play predominant role in scaling up the uptake of electric vehicles. Currently, EVs are significantly more expensive than ICE vehicles in terms of the upfront cost (Kumar and Kanuri, 2020). Hence, the regulatory duty and tax concessions alone would not be able to drive the market for large scale adoption – that will happen only when upfront cost is significantly reduced, and economic parity is achieved in favor of EVs.

subsidies and not on TCO parity.

The work also explored the capabilities of local vehicle manufacturers, how the market is currently positioned in terms of vehicle sales, who are the current leading market players and, most importantly, how the market is expected to change in future, based on TCO analysis.

II. Additional policy support is needed to generate the required traction

Governments around the world have introduced ambitious policies with wide array of subsidies, purchase incentives for EVs and investments in public charging infrastructure to support the transition towards electric mobility. The policy support can be in form of long-term regulatory signals with targets for EV with specific timeframes, CO2 emissions regulations, fuel economy standards, the phase-out of internal combustion engine vehicles and financial support as demonstrated in Table 1 below. These incentives provide a strong signal both to manufacturers and consumers, which is essential to build the confidence at the early stage of market development (IEA, 2021).

Currently, the lack of purchase subsidy and other government incentives restrict the adoption of electric vehicles across various vehicular segments. Leading markets in this space demonstrate that policy incentives are extremely critical to help drive momentum for mass EV adoption.

III. Localization of EV Supply Chain

Localization of the supply chain is critical from the perspective of reducing the cost differential between EVs and ICE vehicles. A well-developed indigenous supply chain could help reduce the cost of electric vehicles. In short term, EV manufacturing in Pakistan would largely be contingent upon imported components. Currently, the scale of EV adoption is too small, which does not justify the localization of critical components. However, going forward, it would be important to develop a road map for scaling

Country	Zero Emission Vehicle (ZEV) Targets	Average vehicle fleet emission target	Fuel Economy Standards (Litres/100KM)	Phase-out of Internal Combustion Engine Vehicle	EV Purchase Incentives
China	30% of New Sales of EV by 2030	117 gCO2/km for 2020	4.0 L/100km by 2025	–	US\$ 3,200 with maximum price of EV at US\$ 42,400
USA	3.3 million EVs by 2025	93 gCO2/KM by 2025	4.25 L/100KM by 2025 for passenger cars, and 5.985 L/100km for light duty trucks by 2025	2050	Tax credit up to US\$ 7500
India	30% of New Sales of EV by 2030	113 gCO2/km for 2021	4.77 L/100km for sedan cars by 2022	Earlier adopted this target for 2030 but later withdrew	US\$ 130/kWh – US\$ 400 for 2/3 wheels and US\$ 2000 for 4 wheels
Europe	30 million zero-emission vehicles on its roads by 2030	95 gCO2/km for 2020	4.1 L/100 km by 2021	Netherland, Iceland, Ireland and Denmark by 2030, France and Spain by 2040, Germany by 2050	US\$ 2000–7000 depending on the type of the vehicle and capacity of the battery
Pakistan	30% of New Sales of EV by 2030	–	–	–	–

Table 1. Incentives/Regulatory Signals and policy driven support for –Electric Vehicles in selected countries (Compiled by the Author)

up the EV market with vibrant domestic supply chain. Lithium-ion battery cells, which are the highest cost component in EVs, are also the most difficult to indigenize due to reliance on critical earth metals (Focus on Catalysts, 2020). Thus, Pakistan is likely to play a limited role in the electric vehicle Li-ion battery value chain. In medium term, the Pakistani EV battery industry is expected to remain limited to battery pack manufacturing wherein the cells may have to be imported.

Likewise, electric motor and controllers are also challenging to localize due to their reliance on rare earth magnets, which could become a bottleneck to domestic motor industry. However, for small motors for light electric vehicles should be easier to manufacture locally.

IV. Lack of fuel economy and emission standards

for automotive sector

Curbing vehicle population growth, reducing travel demand and improving vehicle fuel efficiency are three key elements to reducing overall energy intensity and GHG emissions in the road transport. Fuel economy standardization programs and emission targets have proven to be among the most cost-effective tools in suppressing fuel demand and GHG emissions from motor vehicles (Sen et al., 2017).

Despite the fact that road transport sector heavily relies on fuel imports, Pakistan has not yet established the national fuel economy standards for local automotive manufactures. The idea behind a fuel economy standard is to push automakers to produce vehicles that travel further on the same amount of fuel, thereby reducing the need for petrol or diesel and decreasing pollution. In the absence of these benchmarks,

there is no motivation for automakers to introduce more efficient variants in the markets. Besides, these benchmarks are quite significant in monitoring the progress towards the commitment that Pakistan has made under the Paris climate agreement.

V. Charging Infrastructure

Globally, EV adoption has been supported by widespread charging infrastructure development (Altaieb and Rajnai, 2020). Seemingly, with low market EV penetration, it is expected that the utilization of charging stations would continue to remain low at initial stage. In this case, it would be challenging for private sector to make an investment

4. Conclusion

As the EV revolution is just beginning, Pakistan adopted its first ever National Electric Vehicles Policy 2020 – a move in the right direction. Global EV sector is still in its early stage and it would be wise to ride the wave, as countries with strategic foresight identify the trends early on and develop technological capabilities to emerge as the market leaders.

Electric Mobility can potentially bring a number of benefits to Pakistan: depressing the import bill, reducing vehicular emissions and noise, developing a new value-chain for automakers, creating jobs and adopting cheaper mobility. We demonstrated that EVs offer tremendous climate benefits in terms of net emission reduction even after factoring in the grid emissions. We conclude that following are some crucial areas that require further actions to help achieve sustainable transition to electric mobility in Pakistan.

- Policy implementation through robust regulatory framework to support electric vehicle deployment. While top-level policy is in place, reflecting high-level aspirations, however, there has been a limited action from government setting out clear directives for taxation, import clearance, instructions and procedures for implementation of this national EV policy. The absence of operational-level work is a fundamental barrier to EV market development. For effective policy implementation, key entities need to develop

into charging infrastructure, which in turn would reduce the convenience of EV ownership.

Hence, some kind of infrastructural support from the government may be needed with targeted subsidies towards installation of charging infrastructure. This will not only address the range anxiety issues amongst current EV owners but it will also serve as demonstration effect for general public, which can further improve consumer confidence in this emerging market. While EV policy has provided some incentives for charging equipment with reduced duties and taxes, it requires further regulatory and financial support to help accelerate this transition.

and notify regulations procedures, and standards for EVs, batteries, charging infrastructure. and for licensing of companies engaged with their imports, manufacture, installations, sales, and maintenance.

- Promotion of strategy for ‘Made in Pakistan’ Transition to electric mobility for Pakistan would not be sustainable unless the indigenous capabilities and manufacturing base for EV market are built. This requires channelizing investments into local manufacturing of assembly lines and critical parts, including batteries, motors and electronics for EVs. China dominates the battery production industry, and we can leverage our partnership with China for local manufacturing of lithium-ion cells in the country.
- Development of adequate financing, technical and human resources capacity to scale up the uptake of EVs Currently, there is insufficient expertise on the job market, and inadequate technical support to electric vehicle operators and consumers. This necessitates additional training and skill development for practicing mechanics and technicians in workshops and garages to handle EV related maintenance and operations. Hence, it is essential to introduce capacity building programs with donors’ support for both private and public sector professionals, technicians and engineers.
- Regulatory framework for Charging Infrastructure is critical to streamline the development of uniform EV charging stations across the country. Relevant entities shall define clear permitting,

licensing and approval procedures for setting up EV charging stations. There is an immediate need for designating a federal agency for facilitating one window operation for setting up, permitting, ensuring, compliance and oversight towards development, standardization of EV charging infrastructure in the country. This would be an essential step to develop the set of technical standards and safety precautions that govern the EV chargers to promote and facilitate the sustainable uptake of EV charging infrastructure.

- Charging Infrastructure plays a key role in enabling and supporting EV adoption. DISCOs need to plan for system upgradation to mitigate the grid impacts – transformers, distribution lines and switch gears. Encourage Time of Use pricing models (off-peak and peak electricity rate) to manage the impact of increasing demand on local distribution network. Standardization of charging infrastructure is the key to help develop safe, reliable, accessible and affordable EV charging ecosystem.
- Transport modal shift In addition to promotion of eMobility, Pakistan needs to adopt additional transport measures to encourage mode shift to public transport and railways, improving traffic flow, promoting eco-driving and car sharing, and introducing low-carbon transportation strategies.

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Prospects for hydrogen in Asia Pacific

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In a region responsible for the majority of the world's energy consumption, Asia Pacific countries are faced with a critical tension between a pressing need for energy to fuel economic development and global pressure to reduce carbon emissions. Under the Paris Agreement (which was signed in 2015 by all countries in the Asia Pacific and the vast majority of countries globally), the objectives are to reduce greenhouse gas emissions to limit global temperature increase in this century to 2 degrees Celsius above preindustrial levels, and to pursue efforts to limit the increase to 1.5 degrees Celsius. For these targets to be met, it is critical that the world transitions away from a fossil fuel economy and, for this to occur, a sustainable and green source of alternative energy needs to be found.

Hydrogen (produced from low or no carbon energy), in particular, green hydrogen, has been cited as a potentially key enabler for this energy transition to

occur. Strong government and commercial support, coupled with technological advancements, point to promising prospects for development of clean hydrogen in the Asia Pacific region. However, there remain various significant challenges to be overcome before a true hydrogen economy in the region can mature and take root. In the immediate term, the push for hydrogen as a clean energy source must confront and overcome economic uncertainties brought about by the COVID-19 pandemic. In the longer term, industry and government participants will need to develop both the supply and demand ends of the hydrogen economy (balancing that development so as to ensure its overall commercial viability). This introductory article provides a broad overview of the hydrogen market - introducing some of the market's key concepts and fundamentals, and highlighting some of its key opportunities, challenges and recent developments.

1. Production of Hydrogen

Hydrogen can be produced through different methods and it is common in the industry to categorise those methods through a "colour-coding" system based on the methods of production (differentiated according

to the carbon intensity involved in the production method). Broadly, hydrogen can be divided into brown, grey, blue and green hydrogen (Figure 1).

- Brown hydrogen is produced from the gasification of coal to produce what is known as syngas (which

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