Introduction
The Government of Pakistan has embarked on an important initiative to facilitate the adoption of electric vehicles (EVs) in the country. Towards this end, the Ministry of Climate Change drafted a National Electric Vehicle Policy (NEVP) in late 2019, aimed at incentivizing the sale and local manufacturing of EVs.

Between November 2019 and August 2020, at the direction of the Prime Minister’s Task Force on Energy Reforms and the Integrated Energy Planning (IEP) Steering Committee of the Planning Commission, modeling and analysis of the electrification of passenger and freight transport in Pakistan under the provisions of the draft NEVP was carried out under multiyear IEP technical assistance provided by the United States Agency for International Development (USAID). This brief describes the study and its outcomes as a means to enable a quantitative evaluation of relevant policy targets and planning options by the government and relevant stakeholders.

Further details are provided in EV Policy Briefs 2 & 3 in this series.

Key outcomes
To jump to a summary of the main outputs derived from the EV modeling and analysis, click here.

Analyzing the impact of electric vehicles
Widespread vehicle electrification is anticipated to induce the following effects on Pakistan’s economy:

• Reduced transportation fuel consumption
• Increased fuel requirements for power generation
• Decreased net energy-related expenditures as a result of reduced transportation energy intensity
• Foreign exchange savings due to lower petroleum imports
• Lower transportation sector pollutant emissions
• Decreased government revenues from fuel and vehicle taxes
• Increased power sector emissions due to additional thermal generation, and
• A shift in the timing of power demand.

The NEVP suggests import duty, sales tax, and registration incentives to achieve electrification as measured by new electric car, truck, and bus market shares of 30% to 50% by 2030 and 90% by 2040. Market-based EV penetration scenarios have been modeled for the ‘base case’ (without NEVP incentives) and ‘reference case’ (with NEVP incentives) to draw a comparison with NEVP targets and associated impacts on Pakistan’s energy sector.

Modeling approach
Top-down estimates of overall annual distance traveled by passengers and freight tonnage by road were projected through to 2050 using a Pakistan-specific version of U.S. Department of Energy’s (DOE’s) Global Change Assessment Model (GCAM).

Total road distance traveled by passengers and freight each year was attributed to (a) conventional internal combustion engine vehicle (ICEV) or (b) electric vehicle (EV) transport technologies on a least-lifecycle cost basis. Passenger vehicle types considered were two-wheelers (mopeds, scooters, and motorcycles), three-wheelers (autorickshaw), cars (mini, subcompact, compact), light duty vehicles (LDVs), multipurpose vehicles (MPVs) and buses. Freight vehicles were classified by 0-1 metric tons (T), 1-2T, 2-5T, 5-9T, and 9-16T carrying capacities. Lifecycle costs accounted for ranges of purchase costs, taxes, duties, and fees, registration, maintenance, fuel and, as applicable, battery replacement and residential charging infrastructure. Adoption patterns were projected, with and without the NEVP, in terms of EV sales as a percentage of all new vehicle sales.

These different adoption scenarios were then used in a spreadsheet model to calculate impacts to energy consumption in the power and transportation sectors and associated volumetric and economic costs/savings, using a supply chain cost buildup for power generation and ICEV fuels. First, market shares of EVs were applied to ranges of vehicle projections through 2030. Next, transportation fuel use reductions, and power generation increases associated with EVs were quantified. Finally, net energy supply cost savings were quantified over the no-EV base case.

More details on input data and assumptions, vehicle and energy projections used and specific scenarios modeled are provided in Policy Brief 2 in this series, which describes potential energy sector impacts of EVs in Pakistan.
**Penetration of EVs in the Pakistan market**

- **EVs on the road during 2021-2030, with and without NEVP, under a range of economic and technology pathways:**
  - Category-wise EV market penetration scenarios were developed for Pakistan using lifecycle cost parity estimates discounted for assumed price- and risk-sensitive consumer preference for ICEVs over EVs. These show a range of possible EV sales outcomes by 2030.
  - Market-based EV penetrations were computed by GCAM, both with and without NEVP incentives, using different future technology advancement pathways and the extent of local EV manufacturing capability assumed during the study period. These factors affect EV lifecycle costs relative to ICEVs, resulting in ‘high’ and ‘low’ EV penetration rates defining the range of potential market size for EVs in either case.

- **Category-wise EVs as a percentage of total new vehicles added during 2021-2030, with and without NEVP, under a range of economic and technology pathways:**
  - GCAM projections without NEVP incentives show lower EV penetration compared to NEVP targets for 2030, except for three-wheelers.
  - GCAM projections with NEVP incentives show that overall policy-specified EV targets lie within the range of the potential market size, with the exception of heavy vehicles (buses and trucks) owing to the expected slower pace of technology advancement in batteries for such large vehicles.

### EV penetration (as % of new vehicles added)

<table>
<thead>
<tr>
<th>Vehicle category</th>
<th>Without NEVP incentives</th>
<th>With NEVP incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low 2025</td>
<td>2030</td>
</tr>
<tr>
<td>Two-wheelers</td>
<td>8.1%</td>
<td>17.2%</td>
</tr>
<tr>
<td>Three-wheelers</td>
<td>18.5%</td>
<td>28.8%</td>
</tr>
<tr>
<td>Cars/LDVs</td>
<td>1.4%</td>
<td>4.4%</td>
</tr>
<tr>
<td>Buses</td>
<td>2.2%</td>
<td>4.2%</td>
</tr>
<tr>
<td>Trucks</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

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1 For a description of vehicle classification categories, see Policy Brief 2 in this series.
LOAD PEAKS

Initially, EV charging needs could be met through available generation capacity on the grid, but as commercial fast charging infrastructure develops, daytime peak loads will increase.

Additional electricity required for EVs

- **Generation mix assumptions:**
  - Plant-wise 2019 and 2030 energy mix (GWh) across NTDC\(^2\) and K-Electric grids was estimated using IGCEP\(^3\) projections, de-rated (available) plant capacities and weighted-average technology-wise capacity factors.
  - No new generation capacity additions were assumed necessary to service EVs, given sufficient projected reserves and primarily off-peak (nighttime) EV charging loads.

- **Projected EV charging loads:**
  - EV loads will account for less than 3% of Pakistan’s total projected electricity generation of 260.7 TWh in 2030 even under the best case scenario.
  - This requirement could easily be met from available idle generation capacity on the grid.
  - Daytime EV charging loads will rise gradually as commercial public charging infrastructure becomes widely available.

- **Marginal generation sources assumed to service EV loads:**
  - Estimated median shares in projected national generation mix of sources available to cater to EV charging needs during 2020-2030.

![Total electricity consumed by EVs during 2021-2030](chart)

\(^2\) National Transmission and Despatch Company.

\(^3\) Indicative Generation Capacity Expansion Plan, NTDC.
**EFFICIENCY GAINS**

EVs convert over 77% of the electrical energy from the grid to power at the wheels, compared to only about 12%-30% of the energy stored in gasoline converted by ICEVs to useful power.

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**EV-induced fuel and energy savings**

**ICEV fuels displaced by EVs during 2021-2030**

- **Without NEVP incentives**
  - Gasoline: 1.59 MTOnnes of Oil Equivalent (MTOE)
  - Diesel: 0.03
  - LNG: 0.06
- **With NEVP incentives**
  - Gasoline: 4.84
  - Diesel: 5.06
  - LNG: 6.03

**Energy supply cost savings, net of fuels required for additional power generation, during 2021-30**

- **Without NEVP incentives**
  - Low: 0.3 Billion US Dollars
  - High: 0.7
- **With NEVP incentives**
  - Low: 1.1
  - High: 1.3

**Reduction in fuel import expenditure and net foreign exchange savings during 2021-2030**

- **Without NEVP incentives**
  - Low: 0.01 Billion US Dollars
  - High: 0.04
- **With NEVP incentives**
  - Low: -0.44
  - High: 0.09
Key outcomes

- GCAM projections show that the NEVP meets targets for small vehicle classes by 2030, but fails for buses and freight trucks.
  - The incentives proposed in the NEVP can more than double EV adoption rates compared to the no-policy case.
  - In terms of EVs as a percentage of new vehicle sales, NEVP-defined EV targets are likely to be met for two-/three-wheelers and cars/LDVs if the proposed NEVP incentives are implemented, but only three-wheelers are expected to achieve this level even without NEVP incentives.
  - NEVP targets for buses and trucks are likely not realizable because corresponding EV lifecycle costs do not come into parity with ICEVs during the study period.
- EVs use about 30% of the energy of ICEVs, which offers substantial economic and financial savings and reduces reliance on energy imports.
  - Under NEVP, total energy cost savings to the country accruing from EVs could range from $790 million to $1.3 billion during the period 2021-2030.
  - Under NEVP, total automotive fuel savings will lie between 3.8 and 6.1 million tonnes over 2021-2030 due to reduced ICEV sales.
  - Total fuel import savings on account of ICEVs displaced by new EVs will range from $1.5 billion to $2.4 billion over 2021-2030 as a result of NEVP incentives.
  - Ten-year ICEV fuel and foreign exchange savings are halved without NEVP. The NEVP helps decrease gasoline and diesel imports and increase natural gas and coal imports for additional electricity generation.
- Incentive restructuring may be influential to EV adoption.
  - Consumer implicit discounting (or relative favoring of initial vehicle purchase cost savings versus lifecycle cost savings), assumed at 30%, provides a headwind on the order of 5-20% in market adoption of EVs in terms of lower sales.
  - Financial incentives to make initial EV costs lower than fuel-based equivalents are shown to be the most effective in expanding the market. Incentives closer to the time of purchase, such as cash payments as compared to tax rebates, are more successful at promoting EV adoption.
  - Gasoline prices are a significant predictor of EV adoption while electricity rate discounts are not.
  - Policies to force adoption, such as limiting the use of gasoline engines in cities, are very effective, but are generally intrusive.
  - Development of charging infrastructure has an outsized impact on early adopters, which would indicate that a focus on infrastructure investment would be valuable.
- The rate of EV technology improvements, economy-of-scale cost reductions on a global scale, and the development of a local supply chain are key factors to local EV adoption.
  - EV adoption in Pakistan is projected to double every two to three years up to 2030 even without NEVP as EV prices decline and local manufacturing is accelerated.
  - In the moderate to rapid technology improvement scenarios, three-wheeler EVs will exceed NEVP targets even without any policy incentives. However, due to their higher purchase costs, concessional financing and/or swappable battery schemes for autorickshaws may be required to affect the switchover.
- Local air quality will be improved by EV adoption due to particulate matter emission reductions.
  - However, overall CO₂ and non-CO₂ reductions are overshadowed by emissions from other sectors.
  - The quantitative impact of EVs on vehicular exhaust emissions in Pakistan will be covered in additional analyses.

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