International Transport Forum

Electrifying Postal Delivery Vehicles in Korea

Decarbonising Transport

Decarbonising Transport Initiative

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The International Transport Forum

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Executive summary

What we did

Korea Post plans to replace 10 000 of their current gasoline-powered motorcycles with compact electric vehicles by 2020. This study provides a cost-benefit analysis (CBA) of electrifying Korea Post's fleet of delivery vehicles. The CBA compares the market costs associated with vehicle purchase and maintenance, staff time, and energy, as well as non-market external costs from emissions, safety and noise, between the two vehicle types.

The CBA is informed by a pilot study that was carried out in eight representative cities in Korea. Postal vehicle drivers drove both conventional motorcycles (CVs) and compact electric vehicles (EVs) during a trial period and recorded data on vehicle operations, such as delivery times and energy use, from each vehicle type. A focus group survey of drivers and non-trial participants of Korea Post recorded perspectives on EVs and, where applicable, their experiences during the trial. The study assembles qualitative data from the focus group survey with the results from the economic analysis to arrive at recommendations and conclusions for the introduction of compact EVs in Korea Post's vehicle fleet, and potentially those of other fleet operators.

What we found

The cost-benefit analysis finds that benefits of EV use exceed costs by 243%. Drivers were more efficient when using EVs, taking 6% less time for their deliveries than with motorcycles. Vehicle-kilometres (vkm) driven were also 20% less per delivery equivalent (a unit value that takes into account differences between delivery types) during the EV trial. Fewer return-trips to the post office for EVs account for most of this, as the EVs have a higher load capacity compared to the motorcycles.

Vehicle purchasing and operating costs are 36% higher for EVs, per delivery equivalent. However, savings in time and distance translate to energy savings of 68%, and a reduction in staff costs of 5%. In absolute terms, staff cost savings provide the largest absolute benefit of the categories considered, followed by energy cost savings.

Using EVs for deliveries also reduced all non-market costs. CO_2 and pollutant emissions were lower due to the use of electricity rather than gasoline as the energy source. Costs related to safety and traffic crashes were also lower for the EVs compared to motorcycles. Overall, the use of EVs reduced the [monetised] cost of emissions by 58%, safety-related costs by 87%, and noise costs by 60%.

Drivers appreciated the EVs for their safety, the weather protection they offer, and their larger cargo capacity. The focus groups also revealed that drivers were concerned about charging facilities and found vehicle parking to be difficult, which lead to a perceived loss of efficiency. Drivers expressed preference for EVs over motorcycles in ideal delivery conditions such as when delivering to households in larger complexes and gridded blocks. They preferred motorcycles when navigating denser areas and complicated alleyways.

Overall, the study provides a strong economic case for electrification of urban delivery vehicles. It also identifies implementation challenges that underscore the importance of in-situ pilot studies to understand the context-specific factors important for a successful transition.

What we recommend

Continue replacement of motorcycles in the current delivery fleet with compact e-vehicles

Based on these results of the pilot study, the EV replacement programme should continue. The analysis reveals a strong economic case for transitioning Korea Post's fleet of delivery vehicles from conventional motorcycles to compact EVs. The latter enables cost savings, reduces emissions and noise, and improves safety. Delivery by EVs provides a demonstrable net benefit to society.

Carry out focus group studies to capture qualitative data and pilot studies to reflect local context

Focus groups and surveys provide insights that can be crucial to the success of a fleet electrification initiative. Views expressed in the focus groups during this pilot programme shed light on driver concerns that were not evident from quantitative data analysis. Pilot studies allow the integration of specific local condition into the analysis. This may include reviewing delivery areas and routes and adjusting them for optimal use with EVs.

Prioritise driver confidence through training and clear communication of vehicle safety features

The EVs used in the test offer better protection and more safety than conventional motorcycles. They need to have safety features such as air bags, efficient braking, and anti-lock braking systems. Training will help drivers adapt quickly to the new vehicles and alleviate concerns expressed regarding the braking systems and turning radii of the EVs. The availability of charging infrastructure or back-up batteries, and of on-call repair services, will reassure drivers.

Communicate overall efficiency gains with e-vehicles to drivers

Many drivers perceive delivery with EVs as inefficient. The compact EVs are larger than motorcycles and cannot navigate heavy traffic as efficiently as motorcycles, parking is more difficult, and drivers have to walk longer stretches from their parked EV to the buildings. On balance, the time lost this way is outweighed by the time savings resulting from the EV's higher payload that spare drivers return trips to the logistics centre to reload. Communicating these findings to drivers with data from their own delivery area can help gain their support for a transition to EVs.

Introduction

Decarbonising transport is one of the biggest challenges for the sector. Transport is currently responsible for about 25% of carbon emission, globally (ITF, 2019). Environmental and health concerns from transport emissions and air pollution are a global issue. The rise of e-commerce in the last decade has created an increase of urban delivery traffic and congestion. Postal services and logistics providers have carried out pilot programmes worldwide to examine the impact of electrifying fleets. The choice to gradually replace conventional vehicles (CVs) is being made to take advantage of the environmental, operational and non-market benefits that electric vehicles (EVs) can provide. Public procurement of EVs by agencies like the postal service, play an important role in increasing the visibility and demonstrating the effectiveness of EVs. This can stimulate the entry of EVs into the vehicle market (IEA, 2019).

Korea Post, the national postal service of Korea, announced a plan in 2018 to introduce 10 000 EVs in postal services in Korea by 2020. This will transition the current gasoline-fuelled delivery motorcycles to compact EVs. The conventional delivery motorcycles are referred to as CVs in the remainder of the report. To determine the anticipated impacts of electrifying this fleet the Korean Automotive Technology Institute (KATECH) conducted a pilot study and analysis with the International Transport Forum (ITF).

Korea Post was established in 1884 and plays a crucial role in communications and logistics in the country. After expanding to provide parcel delivery services, it is now one of the most reliable logistics companies in Korea. It currently operates a delivery network of 3 500 post offices, employing more than 20 000 postal workers. Letters have long been the most common form of communication in Korea, but the arrival of the internet and rising smartphone use have led to a gradual decrease in the number of letters, bills, and leaflets sent through the post. At the same time, the number of parcels being delivered has increased due to the increased uptake of e-commerce.

Two-wheeled CVs have served as the primary vehicle of the postal service's delivery fleet for more than 30 years. However, these vehicles come with certain disadvantages. Frequently, the limited maximum load of 35kg of the two-wheelers requires drivers to return to the distribution centres during the day to pick up more parcels. Furthermore, the vehicles are not well-adapted to a range of weather conditions, as they do not protect drivers from extreme temperatures and precipitation. They are also less stable than four-wheeled vehicles in inclement weather. The motorbikes also offer the drivers limited protection from accidents. From an environmental perspective, CVs emit air pollutants such as carbon dioxide (CO_2), particulate matter (PM), nitrogen oxides (NO_x), and sulphur oxides (SO_x) and typically produce a significant amount of noise.

The objective of this study was to develop a cost-benefit analysis (CBA) that compares the current situation; delivery services carried out with conventional two-wheeled vehicles (CVs), with the trial situation, where delivery services are carried out with three models of compact EVs. A pilot study with detailed data collection was conducted in 2019 providing the necessary input data for the CBA. The outcome of focus group surveys, done with the participating drivers and non-trial participating colleagues from Korea Post, provide additional insight into driver experiences, perceptions of EVs, and non-quantifiable aspects of the EV trials. The CBA evaluates the costs and benefits associated with the specific trials that were carried out. It does not generalise findings to the system level, nor does it provide comparisons to other vehicle types that were not used in the current or trial situation, such as electric bikes or electric motorcycles. As such, it is a comparison of the costs and benefits of the currently-used CVs and the compact EVs that Korean Post is considering to use in the future. The CBA tool presented to KATECH by ITF is flexible and can be adjusted as updates to costs and other parameters become available.

The body of this report presents the findings from the CBA of the Korea Post pilot programme, including both market and non-market costs. Market costs include purchase, operating, and maintenance costs. Non-market costs include environmental, safety and noise-related costs. All costs are presented in 2019 Korean won (KRW) unless specified otherwise. Other non-quantifiable impacts of EV implementation are discussed based on the results of a focus group survey. Annex A reviews three other pilot programmes that have tested the use of EVs for delivery service fleets and lists other known trials of electric delivery vehicles. The case studies give insight and better understanding of EV operations from different geographic areas including the United States, the United Kingdom and Hong Kong.

Vehicle field trial and data collected

This pilot study aims to compare quantifiable and non-quantifiable costs and benefits of electric vehicles (EVs) and motorcycles (CVs) used for postal delivery. The quantitative cost-benefit analysis (CBA) is based on data collected during the field trial conducted by KATECH. Korea Post selected representative post offices from eight different provinces to ensure EV use assessment included data from varying population density, delivery volume, road congestion, and delivery distances. The eight study areas were all urban with a mix of apartment and medium-density housing, as noted in Figure 1.

Figure 1. Pilot study locations and urban housing types

Twenty-four postal workers amongst the eight post offices volunteered to participate in this trial. The EV trial took place between 24 May and 19 June, 2019 and data collection for the CV trial took place between 29 July and 30 August, 2019. Each driver participated in both the EV and CV trials with the exception of drivers from the Sejong office. Sejong has been using EVs since before the trial, and these drivers only participated in the EV data collection.

Drivers drove the same routes for both EV and CV trials, though the exact location of deliveries varied day-to-day. They completed forms each day of the trial noting the kilometres travelled, the number of letters, registered letters, and parcels delivered, the time spent delivering, overtime hours, temperature, and weather conditions. In addition, drivers indicated the percentage of battery used for the EV trials, and for the CV trials the amount of fuel used, cost for refuelling, and the number of times they needed to reload during the delivery period. Examples of data sheets are found in Annex B.

The trial programme tested three models of micro-EVs from three separate manufacturers: DANIGO3, by Daechang Motors, D2C, by Semisysco, and MASTA VAN, by MASTA EV. All models carry two passengers and vary in battery capacity, mileage per charge and charging time (see Table 1). Drivers were in charge of refuelling their CVs as needed, while EVs were recharged daily at the postal office overnight.

Table 1. Characteristics of e-vehicle models used in pilot study

	DANIGO3 (by Daechang Motors)	D2C (by Semisysco)	MASTA VAN (by MASTA EV)
Vehicles			
Number of Passengers	2	1	2
Charging Time	4.3 hours (Charging at 3kW)	5.8 hours (Charging at 3kW)	3 hours (Charging at 3kW)
Battery Capacity	13.0 kWh	17.3 kWh	10.2 kWh
One-Charge Distance	72.8 km	92.6 km	64.6 km

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The ITF also developed a focus group survey with ten questions to understand non-quantifiable impacts of this vehicle trial. The questions for the participants were aimed at understanding driver perceptions of safety, ease of operation, convenience (parking, delivery time, walking time), and opinions of family and friends, as well as the public. The questionnaire was translated into Korean, and administered by KATECH. Thirty-five postal service drivers participated in the focus group: the twenty-four drivers who participated in the trial, and eleven non-driver colleagues. Each group spent approximately 30 minutes responding to the survey. Non-driver participants answered questions about perceptions of EVs, their interest in participating in future trials, and personal experiences with EVs. Annex B provides the English version of the survey questions.

Important vehicle trial observations

The trial data shows that drivers typically drove less and spent less time on days when they used EVs compared to the CV trial. The total miles, delivery time and deliveries made during the course of the pilot cannot be directly compared. There are 51 more data entries for EVs because there were more non-work days during the CV data collection period. Further, the Sejong post office only participated in the EV trial. Daily averages per delivery person were calculated to compare use between EV and CVs. Table 2 summarises collected data by vehicle type for totals and daily averages per driver.

EVs, on average, drove 11% fewer kilometres, spent 5% less time overall (delivery and overtime hours), and simultaneously made more deliveries than CVs that had to return to the depot to reload. The delivery 'mix', or types of deliveries made, also differs. During the EV trial, 24% more parcels and 12% more registered letters were delivered, while the number of letters was more comparable to the CV deliveries. Deliveries by CV typically required reloading during the day (study average of 0.82 times per day) while EVs did not require reloading. This explains the lower average daily mileage and time spent when drivers used an EV.

The weather was reportedly sunny for most days in both trials, however, the CV trial took place, on average, during hotter days. This may have impacted perceptions of relative comfort, though temperature effects were not mentioned in the survey. There were also more days with rain during the CV trial. To account for weather conditions, the study compared vehicle-kilometres, delivery time, and overtime, associated with a delivery equivalent, on days with rain and without. EVs showed no statistically significant difference in these parameters, demonstrating less vulnerability to poor weather conditions. CVs only showed a statistically significant difference in delivery time; delivery time is 10% higher on days with rain. The CBA was conducted without altering the data, but the conclusion presents a series of sensitivity tests, one of which reduces delivery time by CV on rainy days by 10%.

Table 2. Summary of pilot study vehicle trial data

	Gasoline-fuelled motorcycle (Total)	E-vehicle (Total)	Gasoline-fuelled motorcycle (daily average, per driver)	E-vehicle (daily average, per driver)	Difference (e-vehicle vs. gasoline-fuelled motorcycle) (%)
Number of observations	307	358			
Operational Data					
Vehicle mileage (km)	7 040	7 310	23	20	-11%
Delivery time (hr)	1 759	2 251	5.73	6.29	10%
Overtime (hr)	293	266	0.96	0.74	-22%
Reloading (no. loads)	251	N/A	0.82	N/A	
Number of deliveries					
Letters	251 001	298 885	818	835	2%
Registered letters	29 944	39 080	98	109	12%
Parcels	9 620	13 962	31	39	24%
Energy use					
Charge used (kWh)	N/A	1912	N/A	5	
Fuel used (L)	292	N/A	0.95	N/A	
Weather Conditions					
Temperature (°C)			32.79	24.34	-26%
Rain (% days)			0.41	0.16	-60%
Cloudy (% days)			0.06	0.15	172%
Sunny (% days)			0.58	0.69	19%

Quantifiable impacts: Cost-benefit analysis for transition to compact e-vehicles

The following section describes the approach of the cost-benefit analysis (CBA) and provides analysis of the market and non-market costs associated with the EV trial. The CBA also considers the costs and benefits associated with both vehicle types, per delivery, to arrive at its final conclusions and benefit-cost ratio (BCR) of 2.43.

Accounting for delivery differences

The CBA accounts for certain mail characteristic differences to evaluate the relative performance of CVs and EVs. The difference in type and number of deliveries between the CV and EV trials meant that costs and benefits associated with the daily averages could not be compared easily. The EV trial involved noticeably more parcels and registered letters, both of which may need a signature from the recipient and require more time from the driver. Parcels are also larger and take more time to load and unload.

Using the delivery time associated with each delivery type (provided by Korea Post via KATECH), ITF developed a series of factors to convert different deliveries to a single unit (Table 3). These conversion factors are a ratio of the average time it takes to deliver a parcel or registered letter divided by the average time to deliver a regular letter. For example, registered letters take approximately 13 times longer to deliver than a regular letter, therefore one registered letter is 13 delivery equivalents. Multiplying the number of deliveries of each type by their respective factors converts the deliveries to a single unit (regular letters) termed *delivery equivalents*. The total delivery equivalents delivered by a driver is the number of regular letters that could be delivered in the time it took to deliver the mix of deliveries they had during each of the trials. On an average day, drivers delivered 2 712 delivery equivalents during the CV trial 3 030 delivery equivalents during the EV trial. Table 4 reports the operational parameters from Table 2, per delivery equivalent.

Table 3. Average time needed for postal deliveries and conversion factors to convert to delivery equivalents

Postal delivery type	Average time per delivery (seconds)	Conversion factor (delivery equivalents)
Regular letters	2.1	1
Registered letters	28	13
Parcels	39.8	19

The following sections discuss each of the market and non-market costs considered in the CBA. The costs and benefits are calculated and compared per delivery equivalent. The report also presents the annual costs and benefits associated with replacing one CV with an EV, which is calculated based on an average 676 000 delivery equivalents made by one vehicle (or driver) per year. The annual number of delivery equivalents is based on the average number of daily delivery equivalents from the pilot study, and an assumed 235.4 working days per year as provided by KATECH.

Table 4. Operating data from pilot study, per delivery equivalent delivered

	Gasoline-fuelled motorcycle	E-vehicle
Daily delivery equivalents	2 712	3 030
Daily operational data (per delivery)		
Mileage (km)	0.008	0.007
Delivery time (hr)	0.0021	0.0021
Overtime (hr)	0.0004	0.0003
Energy use (per delivery)		
Charge used (kWh)	-	0.002
Fuel used (L)	0.00035	-

Review of market costs

Market costs are associated with direct costs or savings to Korea Post. They comprise of vehicle purchase costs, and operating costs associated with maintenance and insurance, energy, and staff costs. While vehicle costs are higher for EVs (36%), per delivery equivalent, our analysis demonstrates savings in energy (68%) and staff (5%) costs.

Vehicle costs

The upfront vehicle costs of EVs are higher than CVs, driven by battery costs and due to the relative immaturity of the market. Costs are expected to decrease as demand and production of EVs increase.

Evaluation of the annual costs associated with each vehicle finds that motorcycles (CVs) currently cost Korea Post KRW 1 786 571 per year, while EVs would cost KRW 2 710 000 (see Table 5). Both values include insurance and maintenance costs. CV costs also include a risk allowance paid to drivers to account for the dangers of the job, and require safety equipment such as helmets. EVs have much lower safety risks and do not need specialised safety equipment. The costs of dedicated charging infrastructure per EV are also included; pricing is based on the 3kW charging stations used during the study. KATECH provided data on the expected leasing costs of the EVs, costs for charging stations, installation and maintenance costs, and also known costs for the current CV fleets.

The Korean government, at the time of this study, provides a subsidy of KRW 5 120 000 for the purchase of EVs. This subsidy comes to the benefit of the leasing company, which then quotes Korea Post a lease cost that reflects these savings. The calculations include the government subsidy in the assumptions. This is because the vehicle lease costs (as provided by KATECH) are inclusive of the subsidy. The future level of the subsidy is unknown. If it is discontinued, costs for subsequent lease agreements may increase but not necessarily by the amount of the subsidy. Cost savings are expected to rise as more EVs purchases increase, lowering vehicle acquisition costs, independent of a subsidy. ITF recommends updating the cost values if the lease cost is to change. The CBA tool is set up so that cost values can be easily adjusted.

Table 5. Vehicle costs and charging infrastructure associated with motorcycles and e-vehicles

	Gasoline-fuelled motorcycle	E-vehicle
Introduction method	Purchase	Lease
Vehicle lifetime in fleets (years)	3.5	5
Vehicle cost		
Initial cost	KRW 1 500 000	KRW 17 620 000
Subsidy	N/A	KRW 5 120 000
Lease cost	KRW 1 500 000	KRW 12 500 000
Maintenance cost (per year)	KRW 401 000	Included in lease
Insurance cost (per year)	KRW 130 000	Included in lease
Risk allowance (per year)	KRW 720 000	N/A
Safety equipment cost (per year)	KRW 107 000	N/A
Charging infrastructure cost		
Purchase cost	N/A	KRW 400 000
Installation cost	N/A	KRW 200 000
Maintenance cost (per year)	N/A	KRW 90 000
Total annual costs (KRW)	**KRW 1 786 571**	**KRW 2 710 000**

Source: KATECH (2019).

Staff time costs

Switching one CV to an EV over the course of a year saves KRW 1 032 000 in staff costs annually. Drivers were more efficient during the EV trial. They drove shorter distances and made more deliveries in less time. The data suggests this is likely because reloading was not needed with EVs. Efficiency gains meant that the overall time required per delivery was 6% less (2% fewer dedicated delivery hours and 30% fewer over-time hours). These time savings are associated with staff cost savings to Korea Post. Korea Post saves KRW 1.53 per delivery based on hourly staff costs for regular and overtime hours (Table 6).

Table 6. Korea Post's staff cost assumptions

Staff variable	Assumption
Staff cost per hour	KRW 12 107
Staff overtime cost per hour	KRW 10 000
Work days per year	235.4

Source: KATECH (2019).

Energy costs: fuel versus electric vehicles

Switching one CV to an EV would result in savings on energy of KRW 195 200 per year. The energy costs associated with operating conventional motorcycles and EVs depend on the fuel and battery capacity used. Table 7 shows the price assumptions associated with each. The CVs use on average 0.0004 litres per delivery, which amounts to a cost of KRW 0.55 per delivery. EVs use approximately 0.002 kWh per delivery, which costs KRW 0.18, saving 68% of fuel costs. Findings from this CBA are comparable to other studies comparing EVs with their petrol or diesel-based counterparts. The studies highlighted in Annex A found 65% to 80% savings in fuel costs, though this is dependent on energy costs in the country, and the fuel type and energy efficiency of the vehicles used.

Table 7. Energy cost assumptions

Energy cost variable	Assumption
Fuel price (per litre)	KRW 1 579
Electricity price (per kWh)	KRW 100

Source: Fuel price from pilot study average, electricity price from KATECH (2019).

Review of non-market costs (externalities)

Non-market costs are externalities of postal deliveries borne by society. These are not explicitly linked to Korea Post. These include the quantifiable environmental, safety and noise impacts of the surrounding areas, as well as non-quantifiable impacts on the drivers such as comfort, perceived safety, convenience, etc. which are explored in the focus group survey. The CBA finds that switching to EV benefits all three quantifiable categories, totalling savings of KRW 0.53 per delivery, or KRW 361 113 annually per vehicle.

Emissions: local air pollutants + CO_2

EVs produce less than half of the environmental costs that CVs contribute to society. The sum of air pollution and climate change impacts are KRW 0.33 and KRW 0.14 per delivery, for CVs and EVs respectively. Annually, this results in environmental benefits worth KRW 131 700 per vehicle replaced by an EV.

This CBA considers the environmental impacts of tank-to-wheel emissions related to climate change and air pollution that have been approved by the European Union(EU) (EEA, 2019a; EEA, 2019b; IPCC, 2006).

It does not account for vehicle manufacturing, transport, or disposal costs, nor energy losses/impacts due to transport or transmission of gasoline and electricity. Where emission factors and damage cost valuations were available from KATECH, the CBA uses these terms. In the absence of some Korea-specific factors, values from European literature are used. All assumptions and sources are in Tables 8 and 9.

Motorcycles (CVs) produce $PM_{2.5}$, NO_x, SO_x (presented as SO_2 equivalents), and non-methane volatile organic compounds (NMVOC). EVs only emit $PM_{2.5,}$ which is primarily due to tyre and brake wear and therefore common to both conventional and electric vehicles. The NO_x and NMVOC emission factors are based on European values for conventional mopeds; SO_2e and $PM_{2.5}$ values are for two-wheelers. $PM_{2.5}$ emission factor for two-wheelers is used as a proxy for micro-EVs as well, based on vehicle curb weight. All pollutant emission factors are based on vehicle-kilometres travelled, which are multiplied by the damage cost valuation factors to determine the monetary cost of emissions due to the two vehicle types.

The study used the mass of CO_2 (presented as CO_2 equivalents) produced per litre of gasoline/petrol combusted during the study and use the energy intensity of electricity generation in Korea to estimate the CO_2e impact of EVs. This gives an indication of impacts on climate change caused by CVs.

Table 8. Assumed environmental emission factors

	Gasoline-fuelled motorcycle	E-vehicle
Local air pollutants (per vehicle-kilometre)		
$PM_{2.5}$	0.034g *	0.034g *
NO_x	0.008g **	N/A
SO_2	0.00018g **	N/A
NMVOC	8.38g **	N/A
Climate change (per litre of gasoline)		
CO_2e	2.32kg **	N/A
Energy intensity of electricity generation in Korea (per kilowatt hour)		
CO_2e emissions	N/A	521g ***

Sources: *= European Environment Agency (EEA, 2019a), **= European Environment Agency (EEA, 2019b), ***= The Intergovernmental Panel on Climate Change (IPCC, 2006).

Table 9. Assumed environmental damage cost factors

	Gasoline-fuelled motorcycle	E-vehicle
Local air pollutants (per gramme)		
$PM_{2.5}$	KRW 423.41 *	KRW 423.41 *
NOx	KRW 16.67 *	N/A
SO_2e	KRW 39.45 **	N/A
NMVOC	KRW 2.45 *	N/A
Climate change (per gramme)		
CO_2e	KRW 0.05 *	KRW 0.05 *

Sources: * = Korean Ministry of Land, Infrastructure and Transport (MOLIT, 2017), ** = Korean Ministry of Environment (Kang et al, 2015).

Safety benefits to society

Benefits to society accrue from lower safety costs associated with EVs and the reduced vehicle-kilometres per delivery. Annually, this means savings of KRW 139 600 per vehicle transition.

Safety and accident costs are partially quantified as the marginal social costs of traffic accidents not covered by risk oriented insurance premiums. EU (Ricardo-AEA, 2014) valuations (Table 10) include expected costs caused by accidents to the person exposed and consequently relatives and friends, and the rest of society, based on accident rates in countries, risk factors, level of urbanisation, etc. The calculations use an EU average associated with motorcycles (CVs) and passenger cars (for EVs) travelling on urban roads and find that the safety related costs are 87% if CVs are replaced with EVs. The EV safety costs are approximated by passenger car values in absence of information specific to micro-EVs. While the additional protection of the compact EVs used in the study are more similar to passenger cars, these do not account for some of the safety concerns associated with the quietness of the vehicles. Since EVs are much quieter than their conventional counterparts, they can be dangerous to vulnerable road users. There are efforts to mitigate these hazards by requiring EVs to emit noise, artificially, when traveling at low speeds (EC, 2019). When reliable damage cost factors become available for EVs, this value can be easily updated in the CBA tool provided to KATECH. The post-trial surveys provide additional perceptions and impacts on safety which are discussed in the next section.

Table 10. Assumed costs for damages associated with safety and accidents to society

	Gasoline-fuelled motorcycle	E-vehicle
Damage cost (per vehicle-kilometre)	KRW 27.94	KRW 4.41

Notes: Used values for motorcycles and cars on urban road. EV-specific values are unavailable, therefore passenger car safety values are used instead.

Source: Ricardo-AEA (2014).

Noise-reduction benefits to society

EVs save 60% of the noise costs associated with CVs, and offer savings of KRW 89 800 per year, per vehicle replaced by an EV. Noise costs are calculated similarly to accident costs. They reflect disturbance to individuals when exposed to traffic noise, and stress-related health impacts associated with long-term exposure to noise. The costs are based on vehicle-kilometres travelled. In the absence of EU valuations of the noise-related costs of EVs, the analysis conservatively uses the lowest estimate for conventional passenger cars as an approximation. The benefit (reduction in noise-related costs) of EVs is due to both the reduced vehicle-kilometres travelled, and the lower noise costs. Due to the very quiet EV technology, EVs are expected to have even lower noise costs, but the EU values are maintained as a conservative assumption. Again, the values can be updated as EV-specific valuations become available.

Table 11. Assumed costs for damages associated with noise to society

	Gasoline-fuelled motorcycle	E-vehicle
Damage cost (vkm)	KRW 26.02	KRW 12.94

Source: Ricardo-AEA (2014).

Note: EV-specific values are unavailable, therefore lowest passenger car noise-related cost values are used as a conservative alternative.

Non-quantifiable impacts: Insights from the focus group survey

The focus group survey results highlight a range of opinions from both drivers and non-driver colleagues on the overall experience, ease of use, safety, convenience (parking, charging, delivery time, walking time), and the opinions of family and friends of drivers. While EVs were well-regarded for their safety, protection from weather and larger cargo capacity, many drivers were concerned about charging facilities and found parking to be difficult leading to a perceived loss of efficiency. Drivers expressed preference for EVs when delivering to large complexes and on gridded streets; drivers tended to prefer motorcycles (CVs) when navigating denser areas and complicated alleyways. The findings are discussed in the following sections and Table 12 summarises the main takeaways.

Perceived safety

Drivers typically felt that the EVs were safer due to greater stability offered by four wheels. They were also less prone to slipping than CVs. Others expressed doubt in the relative safety of EVs, and felt the lack of airbags, the ability to absorb shock, and anti-lock brake system (ABS) made them comparable to CVs. Some of these perceived deficiencies indicate the drivers were not fully aware of the safety features of the vehicles. Opinions varied widely on which of the trialled EVs was safer; each of the three models received criticism and support. Ease of steering, space for the driver, and size of the vehicle influenced driver opinions, though perceptions of the EV models with respect to these factors varied for each respondent.

Ease of loading/unloading

The larger cargo space offered by EVs was generally preferred by drivers who appreciated not having to reload during the day. Cargo was also easier to find compared to when using CVs. They also appreciated that the risk of overloading wasn't there—often a concern when piling packages on the back of CVs. Storage on CVs required advanced planning in order of delivery and larger/heavier packages were difficult to handle.

Respondents reported reloading at intermediate storage areas one to three times on average when using CVs. It should be noted that this was not reflected in the data which on average showed that drivers reloaded 0.82 times. With the exception of rare cases, reloading was not necessary with EVs due to the larger capacity. This value is not used in the CBA calculations so results are not affected. Some drivers acknowledged that not needing to reload was convenient and reduced working time. While the large capacity of EVs was appreciated, many respondents suggested using a model with side doors in addition to the back door that allows accessing cargo easily.

Comfort and ease of driving

Drivers liked the silence of the EVs and shelter from rain and exposure to weather. Most expressed confidence of better performance in snowy conditions. Others were sceptical of performance in slippery conditions due to inadequate braking systems.

Some felt the lack of space in the driver cab led to difficulty steering and seeing traffic. This was particularly cumbersome for taller drivers. Some drivers noted that with EVs they were more compelled to follow traffic regulations, which was inconvenient during traffic jams. EVs were also restricted from driving on some roads open to CVs. Drivers also felt the current designated areas and routes need to be redefined as they are currently based on CV deliveries.

Parking and delivery

Parking was challenging with EVs compared to CVs which drivers mentioned could be parked anywhere, in practice. Drivers felt they had to walk more due to parking difficulties. Some drivers found the D2C model was easier to park given its shorter body. In most cases, EVs could not be parked near entrances to complexes due to restrictions, could not easily enter private apartment complexes, and drivers felt they spent a lot of time finding parking. Most reported that parking was often far away or underground which was inconvenient. Drivers did not pay for parking.

Perceived efficiency and time

Drivers perceived CV-based deliveries to be much faster and more efficient and estimated that their delivery time increased by forty minutes to two hours when using EVs. Estimates of extra walking distances ranged from three to five kilometres. Some expressed concern that having to carry multiple deliveries after parking may result in more letters/packages being lost.

Charging and refuelling

CVs were refuelled every two to three days. While the refuelling took less than five minutes, some reported ten to twenty minutes when travel time is included. EVs were charged at the post office every night at the end of the work day. Battery capacity was usually 40%-50% at the end of the day. All-day use of air conditioning reportedly reduced the battery to 20%-30%, but if the vehicle was turned off while not in use they reported 70%-80% charge left at the end of the day. There was one report of a battery depleting and needing replacement during the day due to car issues.

Drivers found refuelling CVs to be easy. They expressed concerns about the lack of intermediate charging stations for EVs and ability to only charge at the post office since the vehicles do not support fast charging. Some voiced concern over a lack of roadside assistance and emergency battery charging, or back up vehicles for use during repairs. There was also concern on degradation of battery performance which may affect operations in the future.

Public opinion

Drivers found the public viewed EVs as safer for deliveries, were welcoming of the change, and commented positively on the aesthetics of the vehicle. Some expressed concern regarding the speed of vehicles, though it is unclear whether EVs were perceived to be faster or slower. Family members were supportive of EVs particularly due to the safety and shelter from weather.

Vehicle preferences

Drivers of all models pointed out advantages as well as flaws that made driving difficult or unsafe. There were several comments on the poor braking performance of all vehicles, long braking distances, and slipping on steep slopes.

There were several comments on one model with respect to braking issues, water leakage through windows, and large turning radius. This model was considered least convenient to drive due to seat configuration, lack of space for the driver, and difficulty steering. There were also a few comments about the convenience of a larger vehicle. Two of the models were typically preferred by participants, though for varying reasons and both received criticism as well. One of these two models was preferred for its larger body, space for the driver, and vehicle height; others felt the backup camera was inaccurate and there was a lack of cargo space. The other model felt more compact for manoeuvring, the driving experience was most similar to passenger cars, and had a larger battery capacity. Some drivers felt the driver space was restrictive and the cargo capacity was not adequate. These opinions reflect a small sample of drivers and it would be useful for Korea Post to conduct a larger survey prior to making a decision regarding the most suitable EV for the programme.

Overall impressions of non-driver participants

Postal workers who did not participate in the trial echoed concerns about parking, longer delivery times, and navigating some delivery areas, as well as the benefits of larger cargo capacity and shelter from rain. Some were motivated to try EVs after hearing of colleagues meeting with accidents while on CVs. They also had a favourable impression due to the energy efficiency. Some participants were reluctant to try EVs due to time needed to adapt to the new equipment and the extra walking time. Others also felt EVs had a higher probability of collision, and that the ability to drive in reverse made them more hazardous.

Willingness to participate in future trials was limited, largely due to concerns of the driver’s delivery area being suitable for EVs. Those that did wish to participate were curious to test the delivery capabilities, safety and rain protection of EVs.

Table 12. Summary of driver opinions on e-vehicles from focus group survey

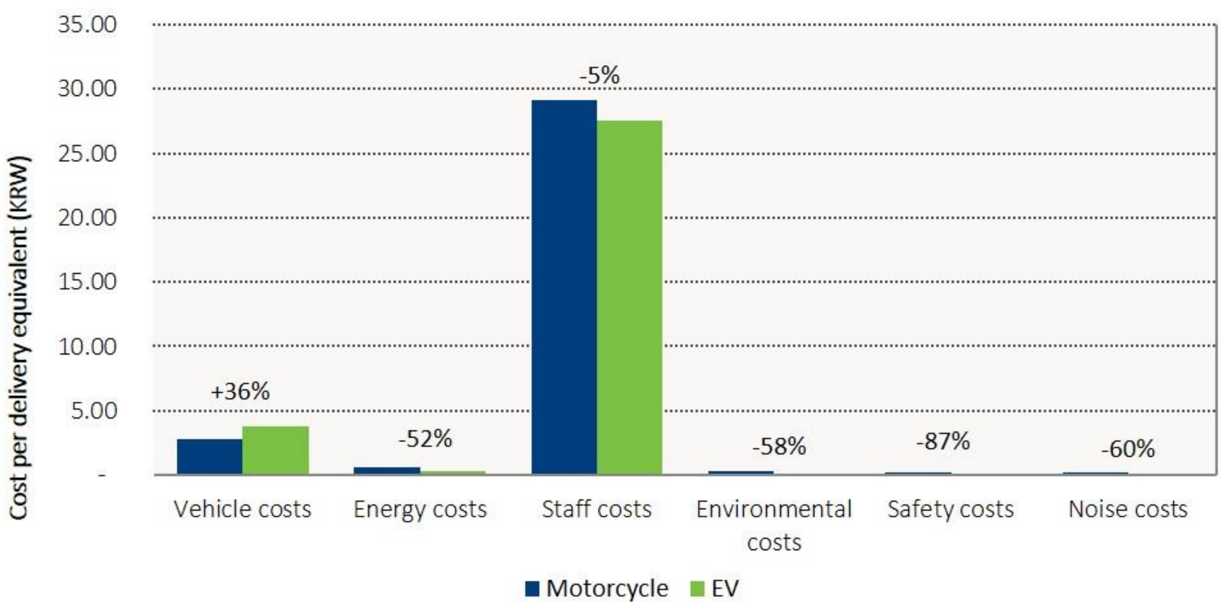
Factor assessed	Positive aspects for e-vehicles	Negative aspects for e-vehicles
Perceived safety	• Greater stability • Less slipping in poor conditions	• Perceived lack of safety features (air bags, anti-lock braking system)
Ease of loading/unloading	• Larger cargo space (no reloading) • Easier access to parcels	• Lack of side door to ease with unloading
Comfort and ease of driving	• Silence • Shelter from weather • Confidence in slippery conditions • More compelled to follow traffic regulations (safer)	• Difficulty breaking • More compelled to follow traffic regulations (slower) • Difficult to navigate some routes with larger vehicle
Parking and delivery	None identified	• Challenging to find parking
Efficiency and time	None identified	• Perceived longer delivery time • Need to walk longer distances • Need to carry multiple letters/parcels after parking
Charging and refuelling	• Recharges overnight	• Lack of intermediate charging infrastructure • Lack of fast-charge capabilities
Public opinion	• Safer alternative for drivers • Design aesthetic • Shelter from weather	None identified
Vehicle preferences	• Adequate space for driver • Smaller vehicles are more convenient for parking and manoeuvring • Larger battery capacity	• Lack of back up camera accuracy • Large turning radius
Overall impressions of non-driving participants	• Larger cargo space • Shelter from weather • Energy efficiency	• Parking challenges • Adapting to new technology

Results and conclusions

The CBA analysis makes a strong economic case for the transition from motorcycles (CVs) to EVs by Korea Post. The BCR of 2.43 demonstrates that for every unit of cost, the associated benefits are 2.43 times higher. It is driven by operational savings to staff and energy costs. In addition, the non-market externalities all provide a net benefit to society in terms of environmental, safety and noise related benefits. The CBA suggests that the upfront vehicle costs are justified by these savings.

Figure compares the costs between CVs and EVs associated with one delivery equivalent. While the vehicle costs of EVs are 36% higher, the operational savings from staff time alone exceeds the extra cost. Staff costs make up 88% of the costs of delivery, so even a 5% saving amounts to a significant absolute monetary value. In addition, Korea Post saves 68% of their energy costs with a switch to electricity rather than gasoline. While the monetary savings are a lot smaller in absolute terms, EVs provide significant non-market benefits as well, saving 58% to 87% of the costs. In total, net of vehicle costs, the transition to EVs saves KRW 1.44 per delivery equivalent, or KRW 970 400 per vehicle annually.

Figure 2. Comparison of costs between motorcycles and E-Vehicles, per delivery equivalent



Sensitivity tests were conducted on vehicle cost, electricity cost, and rain impacts to assess the impact of relevant input assumptions. If the subsidy is removed from the current analysis and the EV lease cost is artificially increased by the subsidy amount, the BCR reduces to 1.0 and still breaks even. If electricity costs increase by 50%, while gasoline costs remain the same, the BCR reduces minimally to 2.35. Even with such changes, the EV transition would be an economically viable decision.

The trial data showed that delivery time was 10% more on rainy days vs. non-rainy days for deliveries by CV. If the delivery time by CV on rainy days is reduced by 10%, the CBA results in a BCR of 1.36. The new BCR shows that in non-rainy conditions, the relative benefit of EVs is reduced, but still economically advantageous. In reality, rainy days occur, and the pilot study data shows that EV performance remains unaffected while CVs are more prone to lower efficiency.

The results and recommendations of this CBA are relative to the context of the pilot study. The trial areas were all urban neighbourhoods, therefore the average daily distance travelled was around twenty kilometres. The range and efficiency of the EV models tested were appropriate for the urban setting but performance cannot be extrapolated to rural areas where range and charging needs will differ.

The evolution of costs of EVs and CVs, and the valuation of external costs use will determine future BCRs. The relatively high cost of EVs is due to a younger market, and primarily dictated by the cost of battery technology. The USD 100 per kilowatt-hour threshold has been cited as a threshold for widespread EV adoption, and manufacturers are close to reaching this tipping point (Matousek, 2019).

In addition to the economic benefits included in the CBA, the focus group survey highlighted advantages of perception of safety, shelter from poor weather, and driver comfort (not explicitly considered in the CBA). They bolster the case for a shift to EVs. There were also reports of inconvenience with using EVs in the current context, and concerns about charging and maintenance needs. These insights from the focus group are important considerations (see Recommendations). Addressing them will ensure a smoother transition and optimisation of the EV programme. Recommendations include high standards for vehicle safety features, driver education and review of existing routes and parking procedures.

EVs are most successful at decarbonising transport in countries with limited fossil fuel-based electricity generation. As countries consider the adoption of EVs in the public and private sector, ensuring clean electricity production should remain a priority.

Electrifying fleets of high visibility public service vehicles encourages and stimulates the entry of EVs into the vehicle market, both in passenger transport and private applications. This increase demand for EVs puts downward pressure on battery prices, making the vehicles more affordable. Fear of inadequate access to charging infrastructure is often cited as a major barrier to EV use. Therefore, establishing charging infrastructure at postal offices is likely to positively influence the uptake of EVs in the private sector as well—an important goal for the overall decarbonisation of transport.

Recommendations

The economic case for the transition to EVs is strong yet the focus group survey highlights a series of significant concerns from the postal workers that will need to be addressed to ensure a smooth transition to the new vehicles. When implementing a transition to EVs from two-wheeled vehicles, review of delivery areas, vehicle standards, easing parking challenges, ensuring adequate repair and charging services, and driver education are all important for the success of the initiative.

Drivers feel that current delivery areas which were delineated for motorcycles (CVs) are not always suitable for the less agile EVs. A review of current areas and routes, taking into account restricted roads, should be implemented, in consultation with drivers. Allowing input in the review of current routes from the drivers themselves will result in more appropriate adjustments and greater support.

While perceptions of safety are generally higher for EVs, there is still doubt that EVs provide safer alternatives. Driver education, and high quality and safety standards of vehicles, should be prioritised to gain driver trust. If possible, highlighting experiences from larger pilot studies, or areas that have already implemented an EV programme would help demonstrate safety improvements. In this study, the Sejong post office is already using EVs for delivery. It would be helpful to demonstrate differences in accident rates using Sejong as an example.

Ensuring high levels of safety and convenience will further help drivers adjust and build confidence operating the new vehicles. Reliable braking systems and safety features (ABS, airbags) is a priority for drivers. Some EV models have better steering capabilities and a smaller turning radius than others; choosing a higher quality model, and providing adequate driver training will result in greater driver satisfaction and perception of EVs. Parking challenges may be reduced in some cases with regulations and special permits. Such agreements may be negotiated between the postal service and city authorities, apartment complexes, parking lot owners, and other stakeholders.

Since EVs are still a relatively new concept, charging and repair facilities are limited. Concerns regarding adequate infrastructure to support drivers in case of breakdown or battery issues are very common. The ITF recommends expanding the charging infrastructure and making EV repair options more convenient, through on-call services, and maintenance centres. Often these infrastructure and service limitations are the barrier to EV uptake in private vehicles as well, therefore investing in these will be crucial to more widespread EV adoption.

The perception of decreased efficiency and increased delivery time is perhaps the most significant criticism of the switch to EVs in this pilot study. Drivers perceived deliveries with EVs to take longer due to extra walking time, slower movement through traffic jams, and restricted routes. However, drivers delivered more parcels on EV trial days than during the CV trial. Study data shows that accounting for the types of deliveries made, each delivery took 6% less time with an EV. Not having to reload during the day saves more time than the other differences such as increased walking time. Demonstrating to the postal workers that there are efficiency gains overall, may improve perception of EVs.

Annex A. Review of e-vehicle pilot programmes in delivery services

This section reviews three pilot studies of non-mail specific delivery services in London, Los Angeles and Hong Kong testing the use of EVs in their vehicle fleets. It concludes with a summary of other known trials in the postal service that have not yet published details of their findings.

The studies demonstrate steps that logistics organisations can take to electrify fleets in an effort to meet decarbonisation and air pollution targets. While the operational and environmental benefits vary on fuel efficiency, prices, source of electricity generation, delivery routes, and region-specific characteristics, they all show that EVs are an economically viable option in the delivery service, and also result in positive externalities to the public, in terms of health and the environment. The studies provide a range of opinions regarding suitability of EVs for long- and short-range trips. Synthesising the results, organisations should maximise the number of vehicle-kilometres travelled by EVs to maximise the clear operational cost savings. They should also be aware of limits to EV range which, depending on battery capacity, can make some poor choices for long trips.

The three studies found that main savings from the transition to EVs are on total operational costs. Environmental benefits found are highly dependent on the methods of electricity generation in their respective locations. The study from London finds that EVs provide a total operational savings of 45%. When generalised to all four billion vehicle-kilometres travelled in London by Light Goods Vehicles (LGVs), annually, this represents GBP 1.7 billion in cost savings to operators and GBP 60 million in non-market impacts on health and the environment for the public (GLA, 2018)., the California study recommends that EVs be first deployed on routes with higher daily distances (greater than 50 miles) to exploit their operational/per vehicle-kilometre savings (Gallo and Tomić, 2013). While the first two studies find maintenance cost savings with EVs, the Hong Kong study found theirs to be higher. Total operational costs, however, reduced by 38%. Their recommendations suggest using EVs for shorter trips due to their issues with vehicle range (Cheung et al., 2016).

Electrifying delivery vans in London, United Kingdom

The electric vehicle market in the United Kingdom is growing rapidly. The number of registered EVs in 2017 was around 87 000, marking a 40% increase compared to the previous year (GLA, 2018). The decreasing price of lithium-ion battery packs used in EVs is one of the most influential drivers of this market growth (McKinsey & Company, 2016). On the other hand, despite the rapid growth of the market, EVs represent only 0.3% of the total number of vehicles in the United Kingdom, suggesting that there is great potential for EV adoption and associated impacts.

Of the 3.8 million licensed light goods vehicles (LGVs) in the United Kingdom, only 5 300 are EVs. As demand for e-commerce and home delivery increases, the number of LGVs and the traffic on the roads are also expected to rise. An increasing number of LGVs will lead to poorer air quality and higher greenhouse gas emissions. The LGVs operating in London contributed an estimated 10% CO_2, 12% NOx and 22% PM_{10} of total emissions in 2010 (Allen et al., 2014). The UK government announced plans to ban the sale of new petrol and diesel vehicles by 2040 and remove all CVs from the road by 2050, which has put more pressure on manufacturers and government regulators to transition to electric LGVs.

The Greater London Authority and Gnewt Cargo Ltd, which specialises in delivering goods using EVs, carried out a study to examine the impact of using EVs for delivery services in London (GLA, 2018). The objective of the trial was to evaluate the relative costs and benefits of EV use in a variety of possible future scenarios. Gnewt Cargo trialled fifty-nine EVs consisting of five Nissan ENV200s and fifty four Renault Kangoos. In order to establish benchmark outcomes against which these vehicles would be evaluated, Gnewt Cargo also collected data from the operation of three conventional diesel delivery vans, including a Nissan NV200, a Fiat Ducato and a Peugeot Expert. Conventional vehicle use was monitored between 1 August and 15 September 2017 in the Greater London region.

Methodology

Gnewt Cargo Ltd fitted both the electric and conventional vehicles with a Fleetcarma telematics device. This device provides real-time information on distance travelled, fuel consumption, efficiency and emissions during the trial period. In combination with this data, vehicle registration and mileage figures from the Department for Transport (DfT) and Transport for London (TfL), as well as emission valuations from the government were used to estimate costs. Costs and benefits were projected for a ten-year period (2017-26) and a discount rate of 5% was assumed.

The predicted growth rates of fuel costs for both diesel and electric vehicles are based on the average increase in electricity and diesel prices between 2007 and 2016, or 4.87% and 2.08%, respectively. Fuel efficiency was projected to increase 0.98% for diesel vehicles and 1.52% for EVs per year during this time. Vehicle taxes, running costs, and maintenance, insurance and lease costs are considered non-fuel operational costs. The most significant portion of the variation in operational costs between diesel vehicles and EVs comes from running costs, particularly due to the London low emission zone charge, from which EVs are exempt. Environmental impacts were estimated using current and forecasted estimates of greenhouse gas emissions per litre of diesel fuel for conventional vehicles, and per kWh of electricity for EVs. While EVs do not emit tailpipe emissions, the electricity that is used to power them can be generated using more or less carbon intensive methods. To evaluate relative costs and accrued benefits of replacing diesel vehicles with EVs, the analysis conducted three assessments: a per-kilometre assessment, a commercial operator assessment and a wider socio-economic assessment.

Results

Findings from the per-kilometre assessment suggest that EV adoption can entail savings of 65% in fuel costs. This assessment compared the relative operational costs of diesel vehicles and EVs, distinguishing between fuel costs and other operating costs. In 2017, the fuel costs of diesel vehicles and EVs were GBP 0.11 and GBP 0.04 per kilometre respectively. Non-fuel operating costs were GBP 1.26 per kilometre for diesel vehicles and GBP 0.90 per kilometre for EVs. In total, diesel vehicle operating costs amount to GBP 1.37 per kilometre, 45% more than operating costs for EVs, at GBP 0.94 per kilometre.

Expected changes in the average prices for diesel fuel and electricity, as well as improvements in energy efficiency in future years will alter the relative operating costs of CVs and EVs. The gap between the two is expected to decrease in the next ten years owing to the fact that electricity prices are expected to grow faster than diesel prices over this period. A valuation of the socio-economic impacts associated with the use of CVs vs. EVs (e.g. impacts resulting from greenhouse gas emissions, noise, and local air pollutants) indicates that operating EVs in London confers GBP 0.02 per kilometre of additional benefits.

To understand the potential benefits that could accrue from EV use over the next decade, the analysis used the same damage-cost estimates that are used by DfT. On average, LGVs drove 6 955 km per week in 2017, amounting to an estimated 362 620 km per year. With total distance and operating costs per kilometre for each type of LGV, they compare annual operating costs between the diesel vehicles and the EVs. If all CVs in Gnewt's fleet were replaced by EVs in 2017, the operational cost saving is GBP 155 221, based on a diesel fleet cost of GBP 496 873 and an EV fleet cost of GBP 341 652. Assuming that the annual travel distance of fleets increases over the appraisal period, the cost saving could be as high as GBP 617 949 in 2026. In 2017, an additional socio-economic value of GBP 5 514 was generated from lower emissions and noise levels.

Costs and benefits were extrapolated to all LGV vehicle-kilometres in London. These were assessed under three possible future scenarios of EV penetration. In the optimistic scenario, 57.5% of total kilometres driven in the city are carried out by EVs, which generates an annual benefit of GBP 1.1 billion in 2026. In the pessimistic scenario, 22.5% of total kilometres driven are by EVs, and the annual benefit will be GBP 428 million by 2026. These estimates account for both the operational savings from EV use as well as the socio-environmental benefit of reduced emissions.

It should be noted that this assessment is based exclusively on the Gnewt Cargo business structure and operational practices, and considers only diesel vehicles rather than other types of conventional vehicles, or on hybrid vehicles. Given that the analysis is based on three years of lease contracts, it also excludes the labour and infrastructure costs that can be associated with EV use. Since the local conditions did not make range issues relevant, this analysis is not subject to this constraint. Despite the limitations, the trial provides useful insight into the practical performance and economic feasibility.

Conclusions

This study suggests that transitioning from diesel vehicles to EVs can yield operating cost savings of GBP 0.43 per kilometre, which amounts to a 45% savings on the current amount. The additional non-market benefits associated with EV use in London are estimated to be GBP 0.02 per kilometre. As delivery distances for LGVs in London are expected to continue to rise over the next decades, these results suggest that the potential implications of replacing diesel delivery vehicles with EVs could be significant. For example, if all four billion vehicle-kilometres travelled by LGVs in London in 2017 were carried out by EVs, this would represent GBP 1.7 billion in operating cost savings to EV operators and GBP 60 million in non-market social and environmental benefits to the public. An update of the report will be produced to evaluate new types of EVs that will be trialled by Gnewt Cargo and it will provide potential implications based on different EV sizes and payloads relative to diesel vehicles.

Electrifying delivery trucks in Los Angeles, California, USA

The California Hybrid, Efficient and Advanced Truck Research Centre (CalHEAT) supports the demonstration and commercialisation of truck technologies. It assists the state to meet 2020 objectives regarding fossil fuel reduction and air quality standards. This study and roadmap was prepared by CalHEAT for the California Energy Commission (Gallo and Tomić, 2013).

The study reviewed here has two objectives. The first objective is to use results to inform a roadmap that outlines actionable steps towards electrification. The second objective is to provide information to fleet operators and E-Truck manufacturers regarding the overall performance of E-Trucks. This assessment is intended to identify improvements to the technology and its use.

The trial took place in Los Angeles, California from 16 March to 7 December 2012. The study also tested a prototype MT E-Cell vehicle through on-road testing, and undertook chassis dynamometre testing for a Smith Electric Newton Step Van. This summary focuses on results regarding in-use data that was collected during the E-Truck delivery operations based out of a downtown facility. The facility operates from 8:00 to 20:00, with most deliveries taking place in the morning and most pick-ups taking place in the afternoon.

Methodology

Four eStar vehicles from Navistar were each tested over six to nine months, and two conventional diesel trucks were used to collect baseline data over a three-week period for comparison. The vehicles served business customers within a 20 mile radius of the downtown depot, located about three miles southwest of the Los Angeles Financial district.

Each E-Truck was equipped with data loggers installed by the vehicle manufacturers to continuously record vehicle, powertrain and battery data during daily vehicle operations. Two conventional diesel trucks were equipped with data acquisition systems to collect vehicle and route information. Information on mileage and electricity consumption was regularly read from each E-Truck in operation at the downtown Los Angeles facility from the end of March to mid-December 2012. The E-trucks included four Navistar eStars (Unit A, Unit B, Unit C and Unit D) and one Freightliner Custom Chassis Corporation (FCCC) E-Cell (Unit E).

Each vehicle was assigned a specific parking space within the facility and each parking space had a corresponding submetre measuring AC kWh consumed. Mileage was read from the vehicles odometre and grid electricity consumption was read from the assigned submetre.

Results

EVs were found to be more efficient than conventional diesel vehicles overall, with EV efficiency being up to four times better than the fuel efficiency of similar diesel vehicles. EVs drove less than 30 miles per day and used less than 20% of the battery capacity approximately 90% of the recorded days when the vehicles were in operation. Electric vehicles also proved less expensive to operate; yearly fuel costs are up to 80% lower than diesel fuel costs. Total charging time required for the Navistar eStars was estimated between 12 and 13 hours. Maximum charging current was recorded at 24.3 A (DC) and maximum grid charging power was estimated at 8.8 AC kW. When using domestically-produced electricity, EVs use almost no crude oil and emit up to 70% less greenhouse gases.

Maintenance savings for EVs versus CVs are estimated to be around USD 250 per year, or USD 0.02 to USD 0.03 per mile (EUR 0.0096 to EUR 0.0144 per kilometre) for a vehicle that drives about 10 000 miles per year, excluding savings on brake and tire maintenance. In general, maintenance savings for EVs compared to conventional diesel vehicles will vary widely depending on driving conditions, vehicle usage, driver behaviour, vehicle model and regenerative braking usage. For a vehicle that drives about 15 000 miles per year and including some brake and tire savings, CalHEAT estimates that maintenance savings would be around USD 1 300 per year, equivalent to USD 0.08 – USD 0.10 per mile (EUR 0.038 – EUR 0.048 per kilometre).

The EVs tested during the trial encountered several issues that made them generally less available than conventional diesel trucks. The vehicles tested were early production vehicles and had limited in-service experience, some maintenance issues were anticipated during the trial period. Because fleet mechanics had limited experience with the maintenance procedures for these vehicles, all major repairs were handled by the EV manufacturers. This, coupled with the fact that EV manufacturers carried a limited inventory of spare parts, resulted in sometimes long repair times.

Conclusions

CalHEAT recommends that EVs should be deployed on routes with daily mileages greater than 50 miles because savings come mostly from operating costs. The report also states that there is a continued need for incentive funding at this early stage of the market for electric delivery vehicles, and emphasises the importance of working together to develop, test, and demonstrate EVs with scalable battery packs, to reduce battery costs, and to develop vehicle-to-grid (V2G) options for EVs in delivery applications.

Electrifying delivery vans in Hong Kong

Improving air quality and public health is a priority for the Hong Kong government. Delivery service companies are encouraged to increase use of EVs in order meet these goals (Cheung et al., 2016). To this end, the government established the Pilot Green Transport Fund to support EV trials. Federal Express Hong Kong (Fedex) was selected to operate a trial with three Smith Edison electric vans. The PolyU Technology and Consultancy Company Limited also participated as a third party to monitor the trial and evaluate the performance of EVs relative to CVs. Three conventional diesel delivery vehicles were trialled over 24 months, from 1 April 2013 to 31 March 2015.

Methodology

A total of six vehicles (three EV and three CV) were used in the trial to deliver goods to three different types of delivery areas as below:

- EV-1 and CV-1 served industrial and residential areas
- EV-2 and CV-2 delivered to university areas such as the Hong Kong Science Park and Chinese University of Hong Kong
- EV-3 and CV-3 were operated in densely populated mixed-use city centre areas.

The EVs used takes eight hours to fully charge and can cover 120 kilometres on a single charge. The EVs tested can support a maximum payload of 1.115 tonnes and the CVs can support 1-1.5 tonnes.

During the trial period, Fedex collected data on total distance travelled, average fuel status, operating costs and time spent charging. As well as the operational statistics, non-quantifiable information such as maintenance work, operational difficulties and driver’s opinions were also reported.

Results

The average total operating cost for EVs was HKD 2.14 per kilometre, 38% lower than HKD 3.44 per kilometre for CVs. Operating costs were comprised of fuel, maintenance, towing fees and vehicle replacement fees. Results indicate that the average fuel-cost saving for EVs (HKD 1.63 per kilometre), outweighed the higher maintenance cost of EVs compared to CVs. Excluding time lost due to the slow response from the vehicle manufacture to repair minor EV damages which were unrelated to vehicle use, the utilisation rates for both types of vehicles were similar, close to 100%.

Most EV drivers were satisfied with the performance of vehicles and did not have serious problems in operating. However, there were minor issues they took into consideration. The drivers felt the hill climbing ability of EVs was poor since the EVs were not accelerating as quickly as CVs. They found the EV's maximum speed of 80 km/h was rather slow. Also, they worried about possible technical breakdown of 12V battery because EV-2 drivers needed to carry a back-up battery after it was completely drained and didn't work.

Conclusions

Research from this two-year trial finds operating EVs can save USD 1.3 per kilometre when compared to CVs. In addition, there are socio-economic benefits in the provision of greener and quieter environments. Even though the EVs used in the trial had minor issues related to vehicle performance, the participants were mostly satisfied with driving EVs. Lastly, considering EV's battery efficiency and limited delivery range, EVs are recommended to be used in operations which required short daily travel.

Other known trials

A number of postal services and delivery operators worldwide have trialled and are transitioning to electric vehicle fleets. Detailed cost-benefit analyses of these trials are not publically available, but this section presents a brief review of these cases.

The first examples are from European countries that have *pre-emptively introduced electric vehicles in the postal delivery sector to reduce carbon emissions.*

Posti, the largest mail and parcel delivery company in Finland, is gradually incorporating electric vehicles into its delivery fleet to establish a more sustainable delivery system (International Post Corporation, 2019). It aims to decrease carbon-dioxide emissions by 30% by 2020. To achieve this, over 3 900 electric vehicles were used to cover around 117 million km in 2017. As a result, carbon emissions decreased by more than 20% between 2007 and 2017. Furthermore, Posti expanded its fleet with 200 new electric freight scooters and 250 electrically-assisted delivery carts in 2018. The new vehicles will be gradually deployed and are expected to play an important role in making deliveries more efficient.

Royal Mail, synonymous with the symbolic red trucks and postboxes in the United Kingdom, also committed to making changes to their operations to reduce environmental impact (Royal Mail Group, 2018). They already accomplished their target of a 29% reduction in carbon emissions since 2005 due to one of their strategies being the deployment of around 100 fully-electric vans. Royal Mail found that electric vehicles are an excellent operational fit and an innovative way to reduce carbon footprint. Royal Mail is now trailing a variety of electric fleets to see which fleet works best and has long-term ambition to transit to a low carbon emission fleet to meet future legislation.

La Poste is a postal service company in France and a pioneer in the electric vehicle field. It owns more than 35 000 EVs (out of a total fleet of 75 000). The company also runs 3 000 three-wheel electric vehicles and 24 000 electrically assisted bicycles. Furthermore, La Poste is replacing its traditional two-wheeled motorcycles with four-wheeled electric vehicles. The postal group commitment to green mobility also fits well with the changes in delivery service as the volume of mail is decreasing by 6% annually, while the size of the parcels is increasing by 6% to 10%. It has banned vehicles using internal combustion engines to drive in Paris, enabling the company to respond to future regulatory changes.

The second set of examples are of delivery operators that have *achieved operational cost savings through the implementation of electric vehicles*.

The logistics company Deutsche Post DHL group used 5 000 electric scooters to deliver mail and parcels across Germany in 2017 (DHL, 2017). Based on 13.5 million vehicle-kilometres, the company saw 60%-70% savings on fuel costs and 60%-80% reductions on maintenance and repair costs compared to similar conventional vehicles. Operating the 5 000 EVs resulted in an annual decrease of more than 16 000 tonnes of carbon emissions. DHL group expanded its charging station infrastructure to meet the present needs. The electric scooters are ready for service every morning after being charged overnight.

In California, DHL plans to add 63 electric vehicles to its delivery fleets. Green vehicles currently account for 13% of the fleet and they aim to reach at least 25% by 2020 (DHL, 2019).

Annex B. Pilot study data sheets

Operational data collection sheets

The following figures are examples of data collection sheets from the motorcycle (CV) and EV trials.

Figure 3. Sample data sheet from gasoline-fuelled motorcycle trial

	Mileage (km)			Refuel			Number of Deliveries						Weather			
Date	Start	End	Today	Litres Refueled	Refueling (O,X)	Cost/ℓ (KRW)	Mail	Registered Mail	Parcel	Delivery Time (Hour)	Overtime (Hour)	Temperature (ºC)	Rain	Cloudy	Sunny	Times reloaded
29/07/2019	968	982	14	-	X	-	304	302	25	5	1	30	○			1
30/07/2019	982	995	13	-	X	-	413	331	75	6	2	31	○			2
31/07/2019	995	1 009	14	-	X	-	412	357	28	5	1	28	○			1
01/08/2019	1 009	1 029	20	-	X	-	422	333	35	5	1	30	○			1
02/08/2019	1 029	1 046	17	-	X	-	433	325	27	6	1	33			○	1

Figure 4. Sample data sheet from E-Vehicle trial

	Mileage (km)		% Charged		Number of Deliveries						Weather				
Date	End	Today	Start	End	Mail	Registered Mail	Parcel	Delivery Time (Hour)	Overtime (Hour)	Temperature (ºC)	Rain	Cloudy	Sunny	AC (Hour)	Heater (Hour)
5.27	20	19	90	40	567	120	35	07:00	1	18	o			02:00	
5.28	41	21	90	56	480	107	91	07:00	2	22			o	2	
5.29	58	17	90	60	1 805	151	37	06:00	1	25			o	2	
5.30	76	18	90	56	613	132	47	06:00	1	26			o	2	
5.31	96	20	92	60	619	142	30	05:30	1	27			o	2	

Note: SOC% = battery capacity

Focus group questionnaire (English version)

1. Could you describe your experience delivering mail and packages with the micro-EV vs. with the motorbike?
    a. Which vehicle (motorbike, M-City, Danigo, D2C) do you prefer most? Why?
2. Did you experience any accidents or hazardous situations while using any of these vehicles during the trial period? If so, which vehicle were you using and what caused the accident/hazard?
    a. Could you describe how safe you feel in general driving a micro-EV compared to a motorbike?
    b. Which of the micro-EVs did you feel safest using?
3. How comfortable is it to drive a micro-EV vs. a motorbike (e.g. with respect to noise, spaciousness and storage space, exposure to the elements, maneuverability, etc.)?
    a. Which micro-EV was most comfortable?
4. How often did you have difficulty finding enough space to park the micro-EV? Were any of the micro-EVs more difficult to park than others? And with the motorbike?
    a. Please describe any differences in walking distance/time you noticed when using a micro-EV vs. a motorbike.
    b. Did you incur any parking fees? If so, which vehicle were you using and how much were the fees?
5. How often did you have to refuel/recharge with micro-EVs and with motorbikes?
    a. How much time did you take, on average, to refuel?
    b. Did you encounter any difficulties with respect to recharging the micro-EVs and/or refuelling the motorbikes? If so, please explain.
6. How many times per day, on average, did you return to the distribution point to collect more mail and packages when using a motorbike? And when using a micro-EV?
    a. Was it easier or harder to load and unload mail and parcels using a micro-EV vs. a motorbike? How so?
7. Did you receive any comments or impressions from friends, family members, or the general public regarding the micro-EV vs. the motorbike? If yes, which?
8. In the future, would you prefer using micro-EVs or a motorbike for your work? Why?
9. For trial non-participants (optional):
    a. What were your observations about the EV-trial and your colleagues? Was there anything that changed on top of what has been already discussed? If yes, what? Why do you think that was?
    b. Would you like to trial micro-EVs as well for your job? Please explain why so, or why not.
10. Is there anything else you would like to share, either with respect to your experience using micro-EVs during the trial or with respect to the use of micro-EVs for Korea Post deliveries more generally? Did you have any other relevant observations that you feel would be relevant to discuss?

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Electrifying Postal Delivery Vehicles in Korea

This report evaluates the costs and benefits of replacing postal delivery motorcycles with electric vehicles in eight Korean cities. It compares operating costs, safety performance, and environmental impacts based on data collected from a field trial with both vehicle types. In addition to the economic analysis, qualitative aspects are also discussed based on the findings of a focus group study. The results from the pilot programme provide an evidence base for policy initiatives in the delivery sector in Korea and beyond.

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