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Putting the foot down: Accelerating EV uptake in Kyrgyzstan

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ABSTRACT

Road transport accounts for around 12% of global greenhouse gas (GHG) emissions. As many high-income countries are moving to decarbonise their road vehicle fleets, Kyrgyzstan – with rapid growth in passenger car ownership – is seeing a significant increase in transport-related GHG emissions and air pollution in urban areas. Whilst a transition to electric vehicles (EVs) is a key part of Kyrgyzstan's Nationally Determined Contribution to the Paris Agreement, the potential for successful EV deployment in the region is under-researched. To fill this research gap, this paper presents an assessment of the potential for EV deployment in Kyrgyzstan. Firstly, we present an investigation of the policy and institutional landscape relating to transport and the promotion of EVs in Kyrgyzstan. Secondly, based on research of 50,000 car sales and interviews with 23 key stakeholders in the country, we present analysis of the existing Kyrgyz vehicle fleet. Thirdly, using information ascertained from the interviews and desk-based research, we conduct a Total Cost of Ownership assessment of EVs versus internal combustion engine vehicles (ICEVs) in the Kyrgyz context. We find that under the current conditions, EVs can have a lower total cost of ownership against similar ICEVs in Kyrgyzstan. However, it is evident that this is not typically the case: the analysis in this paper suggests that cost-competitiveness between EVs and ICEVs is more likely for larger and higher-powered vehicles, for which the ICEV version has a higher retail price. Finally, combining analysis of these results and analysis of the current conditions in Kyrgyzstan, trajectories for EV adoption in geographically and economically similar nations, and data from expert stakeholder interviews, we propose a set of policy recommendations to accelerate EV uptake in Kyrgyzstan.

1. Introduction

New climate strategies feature a strong focus on road transport electrification (SLOCAT, 2021). Kyrgyzstan is no exception, whose updated Nationally Determined Contribution (NDC) submitted for COP26 – which sets a goal to reduce emissions by 16%–44% by 2030 relative to a business-as-usual scenario depending on the level of international support – contains specific mitigation measures related to transport emissions including the replacement of gasoline and diesel-fuelled light-duty vehicles with electric vehicles (EVs[1]), the extension of the electric trolleybus network, the replacement of gasoline and diesel-fuelled buses with gas-powered buses and the development of cycling infrastructure (State Committee on Ecology and Climate of the Kyrgyz Republic, 2021). While the transition from internal combustion engine vehicles (ICEVs) to EVs must be viewed as one part of a wider transition to sustainable low emissions transport, it does have significant mitigation potential. In this paper, we examine the landscape of EV adoption in Kyrgyzstan and make recommendations for policy in accelerating uptake.

Both globally and in Kyrgyzstan, recognition of the environmental, public health and economic benefits of EVs is increasing. EVs are 3–4 times more efficient than ICEVs (Martins et al., 2013), emit no exhaust fumes, and depending on the national electricity generation mix, a transition from ICEVs to EVs almost always reduces CO_2 emissions (Knobloch et al., 2020). EVs can minimise dependence on fuel imports (Hofmann et al., 2016), and through the flexibility in their charging, additional benefits include the ability to charge during periods of surplus renewable energy (Dixon et al., 2020b), the provision of electricity storage via vehicle to grid (V2G) (Dixon et al., 2022) and

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[1] In this paper, we use the term EVs to refer to passenger cars powered purely by a rechargeable battery and electric motor. We exclude other vehicle types, such as motorcycles, buses and minibuses, and hybrid electric vehicles (including plug-in hybrids).

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the opening up of new business models and market opportunities in the energy and transport sectors (Collett et al., 2021). This recognition of EVs' benefits and their rapidly falling upfront costs (Bloomberg New Energy Finance, 2021) is contributing to their meteoric rise. Globally, the number of EVs has surpassed 16 million as of 2022, three times higher than 2018 (IEA, 2021); global forecasts suggest EVs could make up 88%–100% of sales of new passenger cars by 2050 (Bloomberg New Energy Finance, 2021).

The factors influencing the adoption of EVs are many and vary depending on the customer (Krupa et al., 2014). They include peer influence, social networks, attitudes, identity, emotions, and economic factors (Rezvani et al., 2015). Different policy instruments can be used as a tool to promote and facilitate the adoption of EVs. Mandates, regulations, and various financial incentives have been assessed and introduced in several countries (Gass et al., 2014; Steen et al., 2015; Zhang et al., 2014b). On the other hand, the upfront costs of EVs (Egbue and Long, 2012) and the perception that they are less convenient than ICEVs (Dixon et al., 2020a) are often stated as the main barriers to adoption. Yet, comparisons between ICEVs and EVs on the basis of total costs of ownership (TCO) demonstrate that the comparative cost efficiency would depend on distances travelled and size of the vehicles (Wu et al., 2015). While the majority of drivers do not place great significance on the operating cost of owning a vehicle, awareness and recognition of factors like total cost of ownership could lead to faster adoption in the future (Hagman et al., 2016). Extensive literature suggests that to promote EVs a broader range of policies, such as financial incentives, technology support or charging infrastructure, should be introduced by governments (Zhang et al., 2014b).

Whilst it is evident that the transition to EVs will be key to Kyrgyzstan reaching its climate change mitigation targets, the deployment of passenger EVs in Central Asia is poorly documented and under-researched. With a view to this research gap, the contribution of this paper is to cast light upon the transition to EVs in Kyrgyzstan, in the context of low-and middle-income countries (LMICs) and neighbouring countries in Central Asia. In particular, the paper makes the following contributions:

- A collated review of the transport-energy system in Kyrgyzstan, including the main modes of passenger transit, the current status of EV deployment, the governance landscape of transport and key EV-favouring policies.
- A review of policies used to accelerate EV deployment in other countries with geographic and/or economic similarities to Kyrgyzstan.
- Through a set of semi-structured interviews with key stakeholders in-country and further desk-based research, a characterisation of the current Kyrgyz passenger car fleet.
- A comparative TCO assessment between EVs and ICEVs in the Kyrgyzstan context, taking into account results gained from the above mentioned research.
- A set of specific policy recommendations for the acceleration of EV deployment in Kyrgyzstan, with lessons learnt for the wider Central Asian region.

The rest of this paper is organised as follows: Section 2 presents an overview of the Kyrgyz context, including EV deployment pathways in geographically and/or economically similar countries to Kyrgyzstan (Section 2.1) and a review of TCO assessments of EVs versus ICEVs (Section 2.2); Section 3 then details the methodology used for the in-country semi-structured interviews and the TCO assessment; Section 4 presents results for both the characterisation of the Kyrgyz vehicle fleet and the TCO assessment between ICEVs and EVs in the Kyrgyz context; Section 5 presents policy recommendations for accelerating EV deployment in Kyrgyzstan based on the research developed in this paper; Section 6 presents conclusions and recommended pieces of further work from this study.

2. Country context: Kyrgyzstan

2.1. Electric vehicle deployment pathways

Whilst there are significant barriers to EV uptake in Asian LMICs associated with the high upfront cost of EVs relative to income (and limited access to finance to cover this) as well as unreliable electricity access (Mali et al., 2022), the EV market in Central Asia is growing rapidly. There has been a sharp rise in EV imports into both Kyrgyzstan and its neighbour Uzbekistan: in 2021, a total of 209 EVs were imported to Kyrgyzstan (AKIpress, 2022b) and 809 to neighbouring Uzbekistan (Spot, 2022). In the first 8 months of 2022, these numbers were 844 and 1499 respectively (AKIpress, 2022a; Kun.uz, 2022). Because Kyrgyzstan's population is only roughly one fifth of Uzbekistan's, the EV imports to Kyrgyzstan in 2022 are higher when normalised per capita. Following their exemption from taxes (Tashkent Times, 2021), conditions for EV adoption have improved rapidly in Uzbekistan: the number of EVs imported into the country (amounting to 156 EVs) in the first four months of 2021 is a 770% increase on the same period the year before (Kun.uz, 2021). Similarly, Kyrgyzstan has declared EV adoption as one of its key policies to reduce the carbon emissions under the Paris climate agreement and has been actively promoting EVs and, as such, has employed favourable taxation policies: as of 2020, EVs are subject to exempt from import duty (Pwc, 2021) and annual registration tax (Kabar, 2019).

Reducing the tax payable for importing EVs comes with negative consequences for national coffers. Therefore, there has also been varying levels of ambition to bring EV production to Central Asian countries. Kazakhstan has ambitions to be the centre for EV production in the region, with an estimated 2000 new EVs to be produced in 2022 (Official Information Source of the Prime Minister of the Republic of Kazakhstan, 2021). Kazakhstan's car industry has demonstrated that several models of EVs, including NIO, JAC, and Lada, can be manufactured locally (Oreanda News, 2017; The Astana Times, 2020). In Uzbekistan, media reports suggest that a Chinese company plans to manufacture EVs in the country (Narodnoe Slovo, 2018), and the Uzbek government intends to support local production by 2025 (TransLogistica Uzbekistan, 2021). In Kyrgyzstan, a statement of interest has been made in 2022 by the industry bodies on the local production of South Korean EVs (AKIpress, 2022c).

Whilst this acceleration of EV markets in Central Asian countries is promising, the market remains very small as a proportion of total vehicles. Through examination of changing taxation policies for imported vehicles and changing visions for EV manufacturing, it is clear that Central Asian countries including, but not limited to, Kyrgyzstan are gearing up for the transition. Therefore, while this paper examines the Kyrgyz context through policy analysis and semi-structured interviews, the recommendations are applicable to the wider region, including Kyrgyzstan's more populous neighbours of Kazakhstan and Uzbekistan.

Amongst development partners working in Central Asia, only the Asian Development Bank has announced that it is supporting the development of an EV High Technology Roadmap for the wider Central Asia region (CAREC, 2018). Overall, Central Asian countries share a common Soviet past and have inherited similar energy supply structures and transport systems. Therefore, the lessons from EV promotion policies in Kyrgyzstan will be useful for the wider region.

There are several tools available to policymakers in accelerating EV uptake. Financial incentives are frequently utilised to encourage the deployment of EVs. On the demand side, Li et al. (2019) andMa et al. (2017) show significant effects of purchase subsidies on EV diffusion across Chinese cities. However, the effect of purchase stipend is not uniform across countries. Tal and Nicholas (2016) found that in the US, purchase stipends on EVs are much more effective for low-end cars but have only marginal effects on higher-end cars. Similarly, Sheldon and Dua (2020) observed that compared to uniform subsidy,

cutting stipends for high-income consumers to increase subsidy for low-income consumers have resulted in a higher adoption rate of plug-in EVs in China. Other scholars have suggested that subsidies are more effective when invested in the supply side, such as technology development (Yuan et al., 2015) or charging infrastructure provision (Ou et al., 2020; Qiu et al., 2019). For instance, China's subsidy on electric vehicles is differentiated based on technical features of vehicles. While there have been concerns about local protectionism (Zhang et al., 2014b; Chu, 2021) found that differentiated subsidy can encourage innovation and especially the advancement of battery technologies in China.

Deployment of EVs can also be encouraged by non-financial regulatory measures. This usually takes the form of the government granting EV owners with certain rights or exemptions, such as accessing High-Occupancy Vehicle (HOV) lanes or bus lanes (Jenn et al., 2018; Sheldon and DeShazo, 2017; Narassimhan and Johnson, 2017), receiving a driving plate without entering the plate lottery or auction system (Li et al., 2019; Wang et al., 2017c), and being exempted from driving restrictions (Hardman, 2019; Wang et al., 2017a,b). Such measures are particularly effective in LMICs like China and former Soviet republics in Central Asia, where the regulatory power of the government is relatively strong and there are many pre-existing driving restrictions (Wang et al., 2017c; Zhang et al., 2014a). The visibility of these advantages received by EV drivers on the road can also serve as an advertisement and encourage other drivers to switch to EVs (Figenbaum, 2017).

Apart from encouraging the manufacture and purchase of electric cars, electric two-wheelers such as e-bikes and e-motorbikes have also become a key area of promotion in LMICs due to their low upfront cost, high flexibility to use in congested cities, and preexisting popularity of two-wheelers in the local context (Maleesha Kulasekara et al., 2019; Rose, 2012). For instance, Vietnam has adopted an EV deployment strategy centring around importing e-bikes from China, and its e-bike market had grown to 2.5 million units in 2015 (Nguyen and Nguyen, 2015). In Nepal, electric motorcycles have also been proposed as effective solution to save energy and reduce air pollution in the capital (Filippini et al., 2021).

Governments in Asian LMICs have also been engaging in electrifying public transport aside from encouraging private EV uptake. The most prominent example is China, who is actively deploying EVs in public transportation on a massive scale: 99% of electric buses worldwide are operating in China (Finance, 2018). Some local metropolitan governments in China have also designed incentive schemes to encourage taxi drivers to switch to EVs (Zhou et al., 2021; Yang et al., 2018). As for Kyrgyzstan's neighbouring countries in Central and South Asia, some governments have invested in alternative EVs for public transport. For instance, in Nepal and Bhutan, small-scale electric public transport vehicles have been deployed to serve as feeder for public buses (Mali et al., 2022; Zhu et al., 2016).

Two notable early adopters in the Central Asian region are Kazakhstan, which is the largest electric vehicle market in Central Asia with the capability to manufacture electric vehicles and is aiming for a production level of 2000 EVs in 2022 (Kabar, 2020), and Pakistan, which has approved a draft policy to support EV import and manufacturing in 2019, introduced two types of electric cars, and constructed some public charging stations in major cities (Asghar et al., 2021). Affordability has been mentioned as the greatest obstacle for EVs to take off in the region, as most residents can only afford second-hand imported models (Hasnie, 2018).

It can be concluded from the literature on EV deployment in LMICs that a key driver of the rate of EV adoption is the owners' perception of their cost versus alternatives. To this end, TCO assessment comparing EVs and ICEVs in Kyrgyzstan will provide a valuable ground to study the economic and financial viability of EV uptake in Kyrgyzstan and other similar LMICs in Central Asia. This will be further discussed in the next subsection.

2.2. TCO assessments EVs versus ICEVs

The high initial cost of EVs compared to ICEVs, mainly due to the manufacturing costs of batteries (IRENA, 2017), has been identified as a major barrier to their widespread adoption (Egbue and Long, 2012). However, running costs are generally lower as a result of cheaper annual fuel costs, taxes and maintenance requirements (Palmer et al., 2018). To determine whether lower running costs can offset this price premium, TCO assessments are used. Awareness about the TCO[2] of a vehicle can assist customers to consider the costs of operating a vehicle during their initial purchasing decision (Moon and Lee, 2019).

TCO assessments in the literature generally account for the initial purchase price, the cost of depreciation, the interest cost of any financing, insurance, maintenance costs, tax and fuel (or electricity) costs. Some TCO assessments include sensitivity analyses on how the car is used. For example, studies in Kumar and Chakrabarty (2020) and Scorrano et al. (2020) analyse the effect of annual vehicle mileage on the TCO of EVs and ICEVs. In Vanhaverbeke et al. (2017), the EV use case is expanded to vehicle to grid (V2G): the paper evaluates the extent to which revenues from V2G can offset the purchase price of EVs. In Letmathe and Suares (2017), the potential for resale of EV batteries at the end of their useful automotive life is investigated as a potential way of reducing the TCO of EVs.

Many studies have been published in the literature that compare the TCO of EVs and ICEVs, generally in attempting to answer the question: 'when can we expect mass adoption of EVs?', or sometimes more specifically: 'what levels of subsidies are needed in order for EVs to compete with ICEVs on a cost basis?' As most of the components of the TCO of a vehicle, including taxes, import duties, fuel prices, electricity prices and maintenance costs, are strongly dependent on region, the results of a TCO assessment are region specific. Currently, the literature contains TCO assessments of EVs versus ICEVs in the Netherlands (Hoekstra et al., 2017; Lévay et al., 2017), the UK (Palmer et al., 2018; Lévay et al., 2017), Japan (Palmer et al., 2018), the US (Palmer et al., 2018; Liu et al., 2021), Norway (Lévay et al., 2017), China (Ouyang et al., 2021), India (Kumar and Chakrabarty, 2020), Indonesia (Riyanto et al., 2019), Poland (Lévay et al., 2017; Ewelina and Grysa, 2021), Italy (Lévay et al., 2017; Scorrano et al., 2020), Sweden (Hagman et al., 2016), France (Lévay et al., 2017), South Korea (Moon and Lee, 2019), Germany (Bubeck et al., 2016; Letmathe and Suares, 2017), Hungary (Lévay et al., 2017) and Belgium (Vanhaverbeke et al., 2017).

To the authors' knowledge, there are no papers that have assessed the TCO of EVs vs ICEVs in the Kyrgyzstan context. The Kyrgyzstan context presents an encouraging case for the transition to EVs at first glance because electricity is particularly low-cost to consumers: in 2019, domestic electricity retailed at an average of US$0.036/kWh, 77% cheaper than the global median (US$0.156/kWh) (The World Bank, 2022a). While gasoline prices are also comparatively low, the proportional difference is less stark: in 2016, the pump price in Kyrgyzstan (US$0.56/l) was 43% lower than the global median (US$0.97/l) (The World Bank, 2022b). Comparison of these data with data from other countries in Central Asia in terms of driving distance (i.e. US$/km) is shown in Fig. 1.[3]

As shown in Fig. 1, the Kyrgyz case is generally reflective of the Central Asian region, that both gasoline and electricity prices tend to be significantly below global median values. Of the years where World Bank data is available for both electricity and gasoline prices (2014

[2] It should be noted that other factors (vehicle design, brand loyalty, driving sensation, relationship with the car dealer, influence from friends and family, etc.) can also have an impact on the final purchase decision of the consumer (Lebeau et al., 2011).

[3] To produce this figure, the average fuel consumption of an ICEV is assumed as 9.3 litres per 100 km (United States Environmental Protection Agency, 2021) and the average electricity consumption of an EV is assumed as 19 kWh per 100 km (database, 2022).

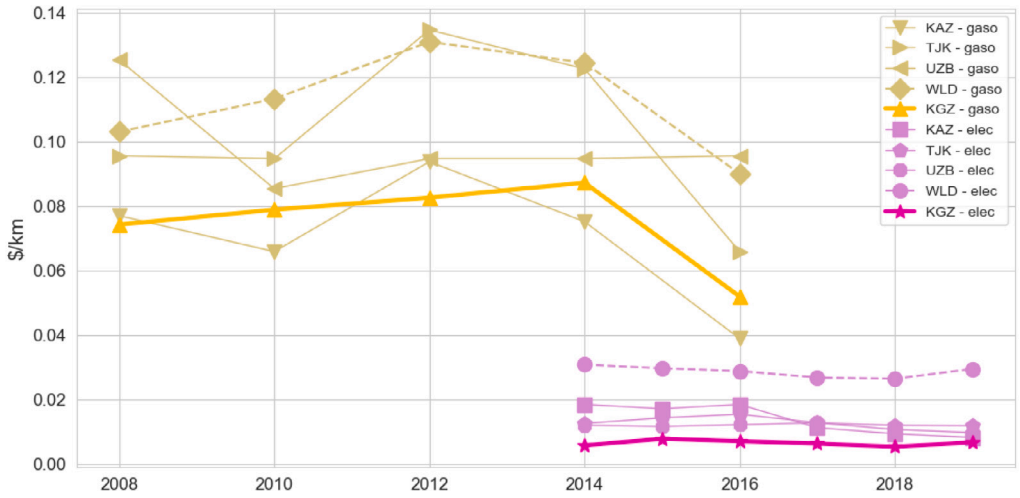

Fig. 1. Prices per km for electricity and gasoline-powered cars based on electricity and gasoline prices in Kyrgyzstan (KGZ), Kazakhstan (KAZ), Tajikistan (TJK) and Uzbekistan (UZB), compared to world median values (WLD) – data from the World Bank (The World Bank, 2022a,b).

and 2016), the ratio of electricity price to gasoline price is the lowest in Kyrgyzstan in 2014 and second-lowest (to Uzbekistan) in 2016 out of the Central Asian countries in Fig. 1. This supports the assertions that, firstly, Kyrgyzstan is a promising region for road vehicle electrification based on the projected running costs of electric vehicles, and, secondly, that the results in this study are applicable to the wider Central Asian region.

This paper was written during the 2022 Russian invasion of Ukraine, that has had and will continue to have significant impacts on gasoline prices around the world. Though the specific effects on Kyrgyz gasoline prices are beyond the scope of this paper, we recommend that further work be undertaken on researching what the mid- to long-term effects of the conflict will be on the relative prices of gasoline and electricity in Kyrgyzstan.

3. Methodology

3.1. Data collection

3.1.1. Vehicle registrations and sales

We analysed the structure of the current vehicle market in Kyrgyzstan (considering both ICEVs and EVs) to derive insights about the potential size of the future EV market. Unlike other countries where statistics on the vehicle market are published on a regular basis, information on the transport sector in Kyrgyzstan is extremely scarce. In most European countries, information about the vehicle market is publicly accessible through both national entities like the UK Driver & Vehicle Licensing Agency, the German Kraftfahrtbundesamt and specialised non-governmental organisations like the International Council on Clean Transportation (ICCT). The ICCT publishes the European Vehicle Market Statistics Pocketbook on a regular basis and provides extensive data and analysis on technical information, emission levels, and registration volumes for most EU member states. In Kyrgyzstan, the National Statistics Committee publishes data on total imports of vehicles, fuel import and fuel consumption, total turnover from the sale of vehicles in the country, passengers carried by types of transport and the number of traffic accidents. There is no publicly available information on the age, engine displacement, emissions, fuel type, fuel efficiency, or market share of manufacturers or types of vehicles. General vehicle registration statistics were obtained from press releases from the State Registration Service (SRS), as the SRS itself is not publishing official statistics. Online vehicle sales platforms were the main source of data on used vehicles. The data collection effort was complemented by visits to individual car dealerships and the open-air car market outside Bishkek.

Additionally, specialised car sale-related print publications and dedicated Instagram accounts were reviewed. The online sales platforms that were analysed included www.mashina.kg, www.cars.kg, and www.driver.kg The criteria for the selection of the platforms was based on a minimum number of 5000 cars available for sale. When combined, the three platforms list more than 50,000 offers that are younger than three months. Search queries with set parameters were undertaken on a weekly basis in the period of May to June 2018. The offers on the platforms were analysed to derive age, price, engine size, fuel type, and vehicle classification profiles of the vehicles on offer based on the share of offers corresponding to the set parameter. Altogether, more than a million data points were analysed. Information from corporate auctions and sales from car rental companies were excluded from the research as these are rare, difficult to identify, and not well documented.

3.1.2. Policy analysis and stakeholder interviews

Analysis of relevant policy documents and interviews with expert stakeholders in the transport sector helped collect data and gain insights about the possible options for promoting EVs in the country. Semi-structured interviews with 23 key stakeholders from the public and the private sector were carried out. The four sections of the interview included overall assessment of the car market trends, challenges for EV deployment, role of the government and priority policy measures. In the last three sections the interviewees were asked to identify main obstacles, describe the current and potential government actions and what should be the priority measures. The interviewees included 2 representatives from the Ministry of Economy, 2 representatives of the Ministry of Transport, the Directors of the Bishkek Transport Management Department and the Bishkek Trolleybus Management company, 3 owners of electric vehicles, 2 car dealers, 1 director of a taxi company, 2 vehicle service centres, 10 individual taxi drivers and 1 supplier of EV chargers. Interviews were undertaken in Russian or Kyrgyz.

3.2. Total cost of ownership (TCO) analysis

3.2.1. TCO model

A model to estimate the TCO of EVs and ICEVs using parameters adjusted for Kyrgyzstan was developed: for this study, a 5 year window was used as a basis on which to compare TCO between EVs and ICEVs. Cost differences according to car class were conducted through pairwise comparisons. For the calculations, technical data of the latest car generation was used. Retail price, engine size and fuel efficiency data were obtained from the official websites of the dealers or manufacturers respectively.

Table 1
Parameters used for the calculation of TCO for EVs and ICEVs.

Propulsion	Model	Engine power (kW)	Retail price (US$)	Consumption (per 100 km)
ICEV	Kia Sportage	112	31,100	8.2 l
EV	Nissan Leaf	110	29,990	18.6 kWh
ICEV	Chevrolet Cobalt	78	13,400	6.2 l
EV	Dongfeng S50EV	90	22,000	14.3 kWh
ICEV	Renault Kaptur	86	19,600	7.4 l
EV	JAC iEV7s	84	28,500	13.9 kWh

The parameters used for the TCO assessment in this paper can be divided into two main groups: the purchase costs (initial purchase price, import tariffs), and the operating costs (annual fuel costs, yearly automobile tax, maintenance costs). The formula that has been used to calculate the TCO for both EVs and ICEVs in Kyrgyzstan is (1).

$$TCO = \sum_{t=1}^{5} \frac{I + f \cdot m \cdot e + a + x}{(1+r)^t} \quad (1)$$

where I is the vehicle's initial price (US$), f is the annual fuel or electricity price (US$/l or US$/kWh), t is time (years), m is the annual distance travelled (km), e is the vehicle's conversion efficiency from fuel or electricity (l/km or kWh/km), a is the vehicle's annual maintenance cost (US$), x is the annual tax (US$) and r is the annual discount rate.

3.2.2. Vehicle comparison

To compare TCO of EVs and ICEVs 'like for like', pairs of car models were selected in terms of size and peak power output (in accordance with the approaches used in Hoekstra et al. (2017) and Lévay et al. (2017)). The choice of EVs for the comparisons was made based on the availability on regional markets and certification for the Eurasian Economic Union (EAEU) market. The three EV models selected are Nissan Leaf, Dongfeng S50EV and the JAC iEV7s. The justification for these three vehicles is the following: the Nissan Leaf is one of the best-selling EVs in the world; the Dongfeng S50EV is now on sale in Bishkek (Ministry of Economy and Commerce of the Kyrgyz Republic, 2022) and is a popular EV in Russia; the JAC iEV7s is available in the EAEU market and manufactured in Kazakhstan. The corresponding ICEVs for the Nissan, Dongfeng and JAC respectively are the Kia Sportage, the Chevrolet Cobalt and the Renault Kaptur. These were selected as they are similar in output power and size. Details of all models are given in Table 1.

3.2.3. TCO assumptions

The assumptions required to perform the calculation in (1) were informed by research of policy documents and interviews with drivers and vehicle repair service providers in Kyrgyzstan. The assumptions are stated as follows:

- **EVs in Kyrgyzstan are exempt from import duties.** As of 2020, the import duty on vehicles powered purely by battery and electric motor is zero (Pwc, 2021).
- **ICEVs in Kyrgyzstan are subject to an import tariff.** This tariff, which is notionally based on 5% of the average market value of the vehicle type, depends on the category of vehicle (e.g. passenger car), the country of origin during import (whether it is within the EAEU or not), the year of production and the engine capacity (in cubic centimetres). Import duty for ICEVs can be calculated using an online tool from the SRS (State Registration Service of the Kyrgyz Republic, 2022b).
- **EVs in Kyrgyzstan are exempt from annual registration tax.** In 2019, the SRS declared that EVs are exempt from such charges (Kabar, 2019).
- **ICEVs in Kyrgyzstan are subject to an annual re-registration tax.** This tariff, which is notionally based on 0.3% of the average market value of the vehicle type, depends on the category of vehicle (e.g., passenger car), the manufacturer country (whether it is within the EAEU or not), the year of production and the engine capacity (in cubic centimetres). Annual re-registration taxes for ICEVs can be calculated using an online tool from the SRS (State Registration Service of the Kyrgyz Republic, 2022a).
- **ICEV owners pay a higher relative fixed annual maintenance cost.** The yearly maintenance cost for ICEVs is assumed to be US$88, which was reported as the average for costs of engine oil, transmission fluid, and coolant replacements by interviewed vehicle dealerships and garages in Bishkek. Other maintenance costs were excluded as these are assumed to be similar for both EVs and ICEVs.
- **The cost of insurance is not included for EVs or ICEVs**. Motor vehicle insurance is not mandatory in Kyrgyzstan, therefore these costs were left out of analysis.
- **The annual distance driven for both ICEVs and EVs is assumed to be 14,000 km**. Based on interviews with drivers, this was taken to be a reasonable assumption for Bishkek residents.

4. Results

4.1. Characteristics of the passenger vehicle market

Unlike other countries where statistics on the vehicle market are published on a regular basis, information on the transport sector in Kyrgyzstan is extremely scarce. In most European countries, information about the vehicle market is publicly accessible through both national entities like the UK Vehicle Certification Agency, the German Kraftfahrtbundesamt and specialised non-governmental organisations like the International Council on Clean Transportation (ICCT). The ICCT publishes the European Vehicle Market Statistics Pocketbook on a regular basis and provides extensive data and analysis on technical information, emission levels, and registration volumes for most EU member states. In Kyrgyzstan, the National Statistics Committee publishes data on total imports of vehicles, fuel import and fuel consumption, total turnover from the sale of vehicles in the country, passengers carried by types of transport and the number of traffic accidents. There is no publicly available information on the age, engine displacement, emissions, fuel type, fuel efficiency, or market share of manufacturers or types of vehicles.

The data available from the SRS, the newly registered vehicles (i.e. new vehicles plus imported second hand vehicles) is shown in Table 2.

Results presented in this paper allow for a more detailed characterisation of the vehicle supply in the country. In comparison to the total number of newly registered vehicles (Table 2), according to the car dealerships interviewed the market for new vehicles is notably small: used vehicles dominate the market. As in many developing countries, the Kyrgyz car market mainly consists of second-hand cars imported from developed countries. Based on the desk research and analysis of available car import data, we estimate that more than 70% of the passenger cars in the Kyrgyz market are older than 10 years, and that the average age of passenger cars in the country is estimated to be just over 16 years.

Fig. 2 shows the results of the analysis of sales offers based on the age of vehicles. The legend below the chart shows which colour boxplot the age (years), denoted by x, corresponds to. According to our analysis,

Table 2
Newly registered vehicles in Kyrgyzstan by year, 2012–2019.
Source: State Registration Service of Kyrgyzstan.

	2012	2013	2014	2015	2016	2017	2018	2019
Newly registered vehicles	118,520	145,209	155,989	93,772	101,886	137,697	344,550	440,011

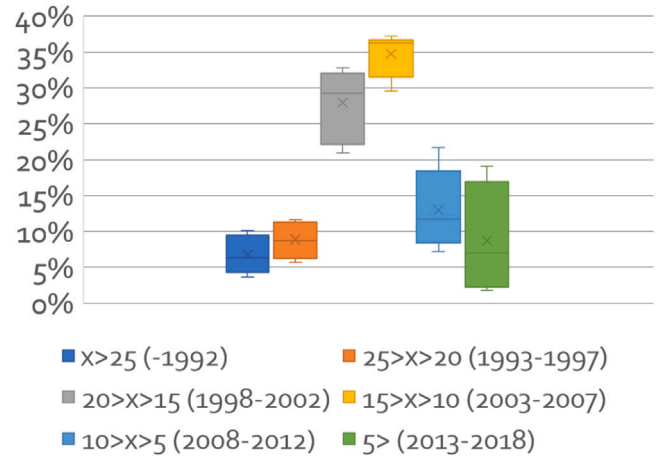

Fig. 2. Share of vehicles surveyed by age, years. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

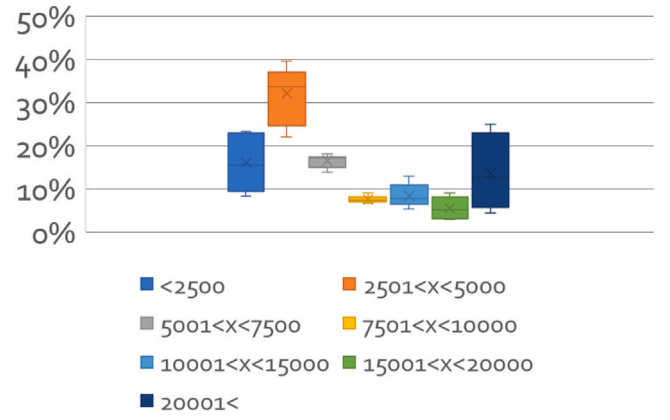

Fig. 3. Share of vehicles surveyed by asking price, US$US.

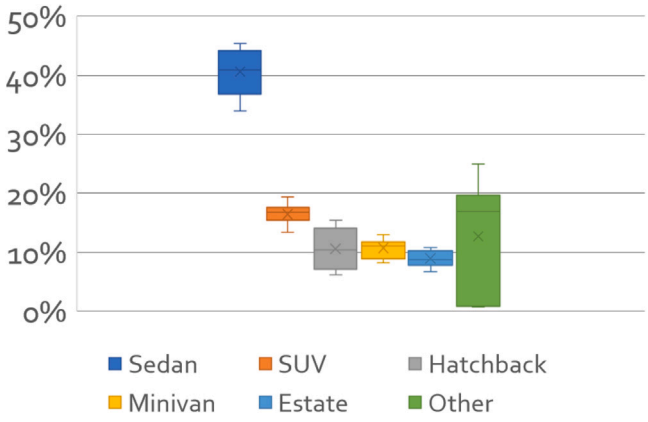

Fig. 4. Share of vehicles surveyed by body type classification.

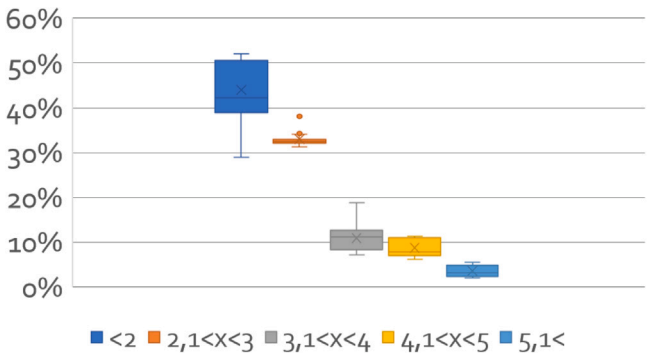

Fig. 5. Share of vehicles surveyed by engine size, litres.

during the study period (May–June 2018) across the different sales platforms, less than 10% of the vehicles offered on the Kyrgyz market were younger than 5 years. The relatively large interquartile range for this vehicle group suggests that the market for new vehicles during this period was dynamic with the share of vehicles offer across the platforms ranging between 2%–19%.

Fig. 3 shows the results of analysis of the sales offers in terms of price (all prices converted to US$). As before, the legend shows which boxplot corresponds to what vehicle price, again denoted by x, bracket. Our analysis suggests that the willingness to pay for vehicles in Kyrgyzstan is low. More than 70% of car offers have an asking price of less than US$10,000. Interviews with car dealers suggest that there is, however, a growing number of customers looking at purchasing more expensive cars costing upwards from US$20,000.

Fig. 4 shows the breakdown of sales offers by body type. Sedans appear to be the preferred type of vehicle in Kyrgyzstan followed by SUVs. Interviews with car dealers suggested that SUVs are increasing in popularity, especially among customers with higher purchasing capacity. Drivers for this demand are persistently low fuel prices and an aspiration on the side of the customers to demonstrate social position.

Fig. 5 shows the breakdown of sales offers by engine capacity. While fuel economy has not been indicated to be a major driver for purchasing decisions and fuel consumption of more than 10 L/100 km to be considered normal, our analysis of vehicles on the market demonstrate that the mean engine capacity is just over 2 litres. In Europe, the engine size of new vehicles has decreased from just under 2 litres in 2009 to 1.60 litres in 2017 (ICCT, 2017).

4.2. TCO assessment of EVs vs. ICEVs in the Kyrgyz context

The results from the calculation of total cost of ownership over a period of 5 years is presented in Fig. 6.

The results in Fig. 6 demonstrate that under the current conditions in Kyrgyzstan, EVs can have a lower total cost of ownership against a similar vehicle with an internal combustion engine. However, it is evident that this is not typically the case: in Fig. 6, only the Nissan Leaf offers a lower TCO than the Kia Sportage; the Dongfeng S50EV and JAC iEV7s are both more expensive than their ICEV counterparts. The data in Fig. 6 suggests that cost-competitiveness between EVs and ICEVs is more likely for larger and higher-powered vehicles, for which the ICEV version has a higher retail price.

A limitation of the TCO analysis is that the cost of charging infrastructure has not been considered. Such costs can be significant and prevent customers from opting for electric vehicles. While household

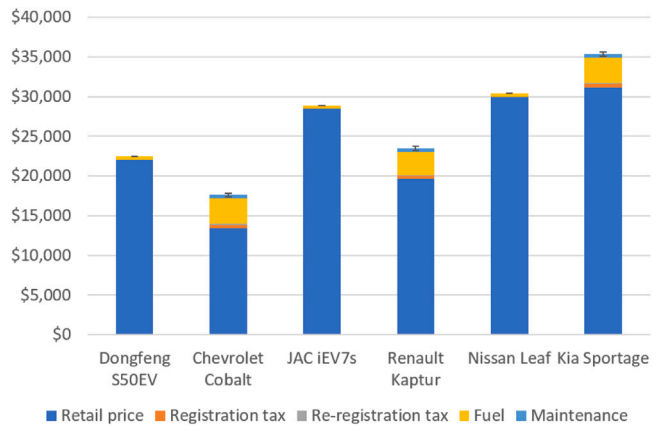

Fig. 6. Total cost of ownership for different EV and ICEV models over 5 years.

level charging stations cost several hundred US$, the costs of fast charging stations can cost anywhere in the range US$2000–10,000. Another limitation of the analysis is the difficulty in calculating the avoided cost of pollution and emissions of GHGs. If these were considered, the economic attractiveness of EVs in Kyrgyzstan would improve even further as a result of the low grid emissions in the country and the high level of pollution of the existing vehicle fleet.

5. Policy recommendations for accelerating EV deployment in Kyrgyzstan

The policy recommendations based on the analysis presented in this paper are relevant to many LMICs, particularly in Central Asia where countries share a common past and have similar energy supply structures and transport systems.

A transition to EVs in Kyrgyzstan is likely to produce significant environmental and economic benefits. At the level of the household, EVs can save costs on transport. Taxi and delivery services, whose fleets cover larger distances, are among the potential beneficiaries with largest gains from switching to EVs.

The government can also reduce costs from switching to EVs. Currently, government offices in Bishkek are allocated 50 litres of fuel (equivalent to about US$25) per vehicle per week. According to interviewed government officials, this is enough to cover approximately 300–350 km per week. If the government vehicles were electric, driving the same distance could cost only a small fraction of these costs (Fig. 1), leading to a significant reduction in costs for the public budget. Saving costs on fuel for companies and households could free up resources for productive investments, thus driving economic activity. At the macroeconomic level, EVs can help reduce spending of foreign exchange on fuel imports and spur entrepreneurship and job creation. The recent removal of import duties and taxes for EVs has demonstrated the Kyrgyz government's interest in promoting electric vehicles. Nevertheless, to capitalise on the benefits that EVs offer, additional policy efforts and active mobilisation of private investment will be required as well. Several interventions are identified in the subsections below, which if implemented simultaneously could accelerate the adoption and use of EVs.

5.1. Awareness raising

Most of the experts interviewed highlighted that the level of awareness about EVs of the average car owner in Kyrgyzstan is very limited. This was confirmed by interviews with taxi drivers and vehicle service centres. While these interviews were not representative of the entire population, it was notable that significant misunderstandings about EVs exist in Kyrgyzstan. Some individuals were not aware that vehicles can run on electricity, and others believed that EVs can only travel at speeds of less than 50 km/h or that they could only be used for short distances. Making information on EVs, their benefits and disadvantages in local languages is likely to help change public perceptions about such technologies. In other countries, efforts to increase the general knowledge about electric vehicles are supported by government. In the UK for example, a cross-departmental body is working with local authorities on developing and deploying communication campaigns that are aimed at helping the roll-out of EVs (Heidrich et al., 2017).

5.2. Government procurement

There was a general agreement between the interviewed individuals that the government should lead by example. Suggestions were made that some of the government offices or public companies should progressively switch their fleets to electric to demonstrate EV technologies and help inform the average consumer of their benefits. Such procurement could also help in increasing the availability of used electric vehicles on the market in the medium term. Existing discussions to develop legislation on green procurement in the country could provide a legal basis for government procurement of EVs and secure funding through allocations from the central budget. As demonstrated in Section 3.2.2, the cost of ownership of EVs can be lower than for ICEVs and, over time, the savings in operational costs will offset the initial difference in purchase price. Government procurement of EVs is likely to attract attention from international donors and could help the Kyrgyz governments secure additional concessional finance or grants from international sources.

5.3. Investments in charging infrastructure

At the initial stage of this research in 2018, there were no public charging stations in the country. One of the EV owners interviewed in 2018 as part of the research highlighted that they had received permission from the management of a commercial centre to charge their EV in the parking lot of the centre through a standard AC plug. The availability of charging infrastructure has been shown to be one of the main factors influencing the adoption of EVs (Sierzchula et al., 2014).

As of January 2022, there are 10 public charging stations for EVs in the capital Bishkek. The network of charging station has been built in the course of 2021 and is reported to be fully operational. Charging at one of the 10 chargers is free of charge. The lack of charging infrastructure is considered a stress factor for owners of EVs in Kyrgyzstan. The recent establishment of a network of charging stations is expected to help reduce the range anxiety of EV owners and overcome one of the concerns of potential adopters. Fast charging stations, which are the preferred option for charging infrastructure outside cities, are yet to be installed along the major transport corridors of the country.

Particularly on routes like Bishkek–Karakol, Bishkek–Osh, Bishkek–Torugat, fast charging stations could enable long distance EV travel. The development of charging infrastructure could be pursued in the framework of public private partnerships or, like in the case of Georgia, by the private sector with limited support from government. Important enabler for the development of charging infrastructure are technical standards and regulations about the type, safety and installation of charging stations. It is important that such standards are adopted through a process of consultation with experts from the energy utilities, EV owners, vehicle importers and electrical installers.

5.4. Financial incentives and access to capital

The recently adopted import duty exemption for EVs has the potential to increase the imports of electric vehicles into Kyrgyzstan.

However, against the high initial purchase price of EVs (Fig. 6), the exemption is shown to make a relatively marginal difference to the TCO of EVs. As was shown in Fig. 3, only 12.5% of passenger cars offered on the market are in the same price category as passenger EVs (above US$20,000). Enabling a larger share of the population to afford EVs would require additional promotion instruments. Amongst interviewed stakeholders in Kyrgyzstan, several experts were supportive of subsidies and tax rebates. Stakeholders from the public sector were, however, generally sceptical of the government's ability to afford such tools to promote passenger vehicles and stated that the government is more likely to channel such funds to public transport. Additional funds for subsidies would have to be raised through taxation or charges, which could be unpopular. One of the options proposed was to explore possibilities for introducing a levy on the sale of petrol and diesel and use the proceeds to offer a subsidy towards the purchase of an electric vehicle.

Leasing can also be used to tackle the issue of the upfront cost of EVs: by buying a vehicle on a credit basis, the fuel and maintenance savings can more practically offset the higher capital costs. Until now, leasing is not a common practice in Kyrgyzstan. However, in the framework of this research one local company has been identified which offers vehicle leasing for electric vehicles (Aiyl Bank, 2021). The European Bank of Reconstruction and Development (EBRD) has introduced in Kyrgyzstan a financing scheme for energy efficiency and renewable energy products called KyrSEFF which offers low interest loans and grants to households and companies. As of January 2022, the programme does not cover EVs, however the energy efficiency gains and GHG mitigation arising from the switch to EVs suggest that it could be worthwhile considering EVs for inclusion into the programme.

5.5. Capacity development

EVs are a new technology in Kyrgyzstan and large-scale adoption would require that capacities at various levels are developed for their promotion, marketing, servicing and operation. Currently, there is limited understanding among policy makers about which promotion instruments for EVs could be most effective. Interviews with policy makers suggested the need to inform policy makers about possible promotion instruments, their design aspects, advantages and disadvantages. For example, the recent removal of import duties was implemented with limited assessment of the policy impact on EVs. The rule was adopted as part of a more general import duty reform aimed primarily at the renewal of the general vehicle fleet in the country. Effective implementation of the new rule would also require development of capacities at relevant agencies in Kyrgyzstan. Interviews with the Tax Authority in Kyrgyzstan suggested that tax officers have difficulty distinguishing between EVs and ICEVs, and therefore expose EV owners and potential buyers to a risk of paying higher taxes based on vehicle purchase value and not engine capacity as is the case for ICEVs.

There is a need to develop capacities also along the value chain of vehicle marketing, sales and servicing. Interviews conducted with vehicle dealers suggested that sales officers have limited awareness about vehicle emissions and fuel efficiency. Amongst the service centres interviewed, only one company was identified which has staff trained on servicing hybrid vehicles. In late 2021, a local dealership of Tesla has opened doors in Bishkek and is offering services for Tesla models (Teslacenter kg, 2022). Government supported demonstration of EVs and targeted training for dealers and service providers could help develop capacities and establish confidence.

5.6. Summary

All the interventions listed above are likely to require the development of amendments and additions to existing laws, regulations, and other legislative acts of the Kyrgyz Republic and Central Asia. Specifically, new legislation in the area of manufacturing, import, installation and operation electric transport, related equipment and components thereof might be required. With regards to the technical standards, it is important to establish simplified procedures and streamline legislation regarding the siting, land acquisition, construction and grid connection of electric vehicle charging and servicing infrastructure.

6. Conclusion and further work

The purpose of this research has been to provide an analysis of the situation with electric vehicles in Kyrgyzstan, review the existing policy framework and present options for accelerated adoption. An assessment of the total costs of ownership was also part of the analysis. It has been shown that different types of EVs are already present in Kyrgyzstan. Their penetration level is low as a result of factors related to their costs, lack of knowledge about EV technologies and their advantages, and limited availability of EVs on the Kyrgyz market. Several measures were identified which could facilitate a wider adoption of EVs. These include awareness creation, government procurement, financial incentives and capacity development.

Recent policy changes offer hope for the deployment of EVs in Kyrgyzstan. Nevertheless, avoiding bottlenecks to a sustainable market development and a fast transition to sustainable transport would require additional research. For example, it would be important to analyse the public perceptions towards EVs and obtain better understanding about driving patterns, to further understand the technical requirements for EVs in the Kyrgyz context. Quantification of the environmental and health benefits of EVs would also help substantiate the discussions in the country about different pollution mitigation options. Assessments of the impacts on the electricity grid under different EV deployment scenarios could inform plans for charging system development and future energy investments. Finally, policies to support EV adoption in Kyrgyzstan must be placed within a robust set of policies for transport-specific climate change mitigation and adaptation. This includes making the transition to EVs part of a wider agenda on sustainable transport, including – particularly in urban areas – specific focus on public transport provision and infrastructure for walking and cycling.

This paper was written during the 2022 Russian invasion of Ukraine, that has had and will continue to have significant impacts on gasoline prices around the world. Though the specific effects on Kyrgyz gasoline prices are beyond the scope of this paper, we recommend that further work be undertaken on researching what the mid- to long-term effects of the conflict will be on the relative prices of gasoline and electricity in Kyrgyzstan.

CRediT authorship contribution statement

Bozhil Kondev: Conceptualization, Methodology, Writing – original draft. **James Dixon:** Formal analysis, Writing – original draft, Writing – review & editing. **Zhaoqi Zhou:** Writing – original draft, Writing – review & editing. **Rahat Sabyrbekov:** Writing – review & editing. **Kanat Sultanaliev:** Investigation, Writing – original draft. **Stephanie A. Hirmer:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors are unable or have chosen not to specify which data has been used.

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References

Aiyl Bank, 2021. Elektromobili v lizing ot OAO [Leasing for electric vehicles from JSC]. [Online]. Available: https://bit.ly/3OTCCRQ.

AKIpress, 2022a. 844 electric cars imported to Kyrgyzstan since year start. [Online]. Available: https://bit.ly/3U9KqBY.

AKIpress, 2022b. Kyrgyzstan imported 209 electric cars in 2021. [Online]. Available: https://bit.ly/3FIYSMC.

AKIpress, 2022c. Kyrgyzstan interested in joint production of electric cars with South Korea. [Online]. Available: https://bit.ly/3T7x33A.

Asghar, R., Rehman, F., Ullah, Z., Qamar, A., Ullah, K., Iqbal, K., Aman, A., Nawaz, A.A., 2021. Electric vehicles and key adaptation challenges and prospects in Pakistan: A comprehensive review. J. Clean. Prod. 278, 123375.

Bloomberg New Energy Finance, 2021. Electric Vehicle Outlook 2021. Tech. Rep., Bloomberg New Energy Finance, [Online]. Available: https://bit.ly/3NvcknL.

Bubeck, S., Tomaschek, J., Fahl, U., 2016. Perspectives of electric mobility: Total cost of ownership of electric vehicles in Germany. Transp. Policy 50, 63–77.

CAREC, 2018. Minutes of the 27th CAREC Energy Sector Coordinating Committee Meeting. [Online]. Available: https://bit.ly/3OMsevz.

Chu, Y., 2021. How China Promotes New Energy Vehicles: Historically, Now, and in the Future. ICCT, [Online]. Available: https://bit.ly/3ORPc3K.

Collett, K.A., Hirmer, S.A., Dalkmann, H., Crozier, C., Mulugetta, Y., McCulloch, M.D., 2021. Can electric vehicles be good for Sub-Saharan Africa? Energy Strategy Rev. 38, 100722.

database, E., 2022. Energy consumption of electric vehicles cheatsheet. [Online]. Available: https://bit.ly/3QUwFpj.

Dixon, J., Andersen, P., Bell, K., Trætholt, C., 2020a. On the ease of being green: An investigation of the inconvenience of electric vehicle charging. Appl. Energy 258.

Dixon, J., Bukhsh, W., Bell, K., Brand, C., 2022. Vehicle to grid: driver plug-in patterns, their impact on the cost and carbon of charging, and implications for system flexibility. eTransportation 13, 100180.

Dixon, J., Bukhsh, W., Edmunds, C., Bell, K., 2020b. Scheduling electric vehicle charging to minimise carbon emissions and wind curtailment. Renew. Energy 161, 1072–1091.

Egbue, O., Long, S., 2012. Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. Energy Policy 48 (2012), 717–729.

Ewelina, S.-M., Grysa, K., 2021. Assessment of the total cost of ownership of electric vehicles in Poland. 14, 4806.

Figenbaum, E., 2017. Perspectives on Norway's supercharged electric vehicle policy. Environ. Innov. Soc. Transit. 25, 14–34.

Filippini, M., Kumar, N., Srinivasan, S., 2021. Nudging adoption of electric vehicles: Evidence from an information-based intervention in Nepal. Transp. Res. D 97, 102951.

Finance, B.N.E., 2018. Electric Buses in Cities Driving Towards Cleaner Air and Lower CO_2. Tech. Rep..

Gass, V., Schmidt, J., Schmid, E., 2014. Analysis of alternative policy instruments to promote electric vehicles in Austria. Renew. Energy 61, 96–101.

Hagman, J., Ritzén, S., Stier, J.J., Susilo, Y., 2016. Total cost of ownership and its potential implications for battery electric vehicle diffusion. Res. Transp. Bus. Manag. 18, 11–17.

Hardman, S., 2019. Understanding the impact of reoccurring and non-financial incentives on plug-in electric vehicle adoption – A review. Transp. Res. A 119, 1–14.

Hasnie, S., 2018. How the Kyrgyz Republic can become Central Asia's electric vehicle hub. [Online]. Available: https://bit.ly/3Ov9gcp.

Heidrich, O., Hill, G.A., Neaimeh, M., Huebner, Y., Blythe, P.T., Dawson, R.J., 2017. How do cities support electric vehicles and what difference does it make? Technol. Forecast. Soc. Change 123, 17–23.

Hoekstra, A., Vijayashankar, A., Sundrani, V.L., 2017. Modelling the total cost of ownership of electric vehicles in the netherlands. In: EVS 2017 - 30th International Electric Vehicle Symposium and Exhibition. pp. 1–13.

Hofmann, J., Guan, D., Chalvatzis, K., Huo, H., 2016. Assessment of electrical vehicles as a successful driver for reducing CO_2 emissions in China. Appl. Energy 184, 995–1003.

ICCT, 2017. European Vehicle Market Statistics - Pocketbook 2017/2018. Tech. Rep., Berlin.

IEA, 2021. Global EV Outlook 2022. Tech. Rep., IEA, Paris, [Online]. Available: https://bit.ly/3u8II8U.

IRENA, 2017. Electric Vehicles - Technology Brief. Tech. Rep., Abu Dhabi.

Jenn, A., Springel, K., Gopal, A.R., 2018. Effectiveness of electric vehicle incentives in the United States. Energy Policy 119, 349–356.

Kabar, 2019. Starting from 2019, electric vehicles are exempted from paying the registration fee - State Registration Service of the Kyrgyz Republic. [Online]. Available: https://bit.ly/3I1PeUA.

Kabar, 2020. Kazakhstan plans to manufacture 1,200 electric vehicles in 2021. [Online]. Available: https://bit.ly/3NyVB2K.

Knobloch, F., Hanssen, S.V., Lam, A., Pollitt, H., Salas, P., Chewpreecha, U., Huijbregts, M.A., Mercure, J.F., 2020. Net emission reductions from electric cars and heat pumps in 59 world regions over time. Nat. Sustain. 3 (6), 437–447.

Krupa, J.S., Rizzo, D.M., Eppstein, M.J., Lanute, D.B., Gaalema, D.E., Lakkaraju, K., Warrender, C.E., 2014. Analysis of a consumer survey on plug-in hybrid electric vehicles. Transp. Res. A 64, 14–31.

Kumar, P., Chakrabarty, S., 2020. Total cost of ownership analysis of the impact of vehicle usage on the economic viability of electric vehicles in India. 2674 (11), 563–572,

Kun.uz, 2021. Uzbekistan considerably increases import of electric vehicles. [Online]. Available: https://bit.ly/39ZnDXt.

Kun.uz, 2022. EV imports tripled over 8 months. [Online]. Available: bit.ly/3E03Hjj.

Lebeau, K., Turcksin, L., Mairesse, O., Van Mierlo, J., Macharis, C., 2011. How expensive are electric vehicles? A life cycle cost analysis. In: IAMF International Advanced Mobility Forum, March 8-9, Geneva International Motor Show.

Letmathe, P., Suares, M., 2017. A consumer-oriented total cost of ownership model for different vehicle types in Germany. Transp. Res. D 57, 314–335.

Lévay, P.Z., Drossinos, Y., Thiel, C., 2017. The effect of fiscal incentives on market penetration of electric vehicles: A pairwise comparison of total cost of ownership. Energy Policy 105, 524–533.

Li, W., Long, R., Chen, H., Chen, F., Zheng, X., Yang, M., 2019. Effect of policy incentives on the uptake of electric vehicles in China. Sustainability (Basel, Switzerland) 11 (12), 3323.

Liu, Z., Song, J., Kubal, J., Susarla, N., Knehr, K.W., Islam, E., Nelson, P., Ahmed, S., 2021. Comparing total cost of ownership of battery electric vehicles and internal combustion engine vehicles. Energy Policy 158, 112564.

Ma, S.-C., Fan, Y., Feng, L., 2017. An evaluation of government incentives for new energy vehicles in China focusing on vehicle purchasing restrictions. Energy Policy 110, 609–618.

Maleesha Kulasekara, V., Kavalchuk, I., Smith, A., 2019. Smart key system design for electric bike for Vietnam environment. In: 2019 International Conference on System Science and Engineering. ICSSE, pp. 451–455.

Mali, B., Shrestha, A., Chapagain, A., Bishwokarma, R., Kumar, P., Gonzalez-Longatt, F., 2022. Challenges in the penetration of electric vehicles in developing countries with a focus on Nepal. Renew. Energy Focus 40, 1–12.

Martins, J., Brito, F.P., Pedrosa, D., Monteiro, V., Afonso, J.L., 2013. Real-life comparison between diesel and electric car energy consumption. In: Grid Electrified Vehicles: Performance, Design and Environmental Impacts.

Ministry of Economy and Commerce of the Kyrgyz Republic, 2022. New electric cars of representatives of the Dongfeng plant presented in Bishkek. [Online]. Available: https://bit.ly/3bHCbf6.

Moon, S., Lee, D.J., 2019. An optimal electric vehicle investment model for consumers using total cost of ownership: A real option approach. Appl. Energy 253, 113494.

Narassimhan, E., Johnson, C., 2017. The role of demand-side incentives and charging infrastructure on plug-in electric vehicle adoption: analysis of US States. Environ. Res. Lett. 13 (7).

Narodnoe Slovo, 2018. Kitayskaya kompaniya namerena proizvodit elektromobili v Uzbekistane [Chinese company intends to produce electric vehicles in Uzbekistan]. [Online]. Available: https://bit.ly/3NvPkov.

Nguyen, X.T., Nguyen, Q.H., 2015. Service issues: overview of electric vehicles use in Vietnam. In: 3rd Armand Peugeot Chair International Conference: Electromobility Challenging Issues.

Official Information Source of the Prime Minister of the Republic of Kazakhstan, 2021. Production of electric vehicles, new plant and access to export markets — development of Kazakhstan's mechanical engineering in a new reality. [Online]. Available: https://bit.ly/3noRpb9.

Oreanda News, 2017. "Asia Auto" presented the electric LADA Vesta. [Online]. Available: https://bit.ly/3uMWaR1.

Ou, S., Lin, Z., He, X., Przesmitzki, S., Bouchard, J., 2020. Modeling charging infrastructure impact on the electric vehicle market in China. Transp. Res. D 81.

Ouyang, D., Zhou, S., Ou, X., 2021. The total cost of electric vehicle ownership: A consumer-oriented study of China's post-subsidy era. Energy Policy 149 (November 2020), 112023.

Palmer, K., Tate, J.E., Wadud, Z., Nellthorp, J., 2018. Total cost of ownership and market share for hybrid and electric vehicles in the UK, US and Japan. Appl. Energy 209, 108–119.

Pwc, 2021. Kyrgyzstan. [Online]. Available: https://pwc.to/3AfyyHk.

Qiu, Y.Q., Zhou, P., Sun, H.C., 2019. Assessing the effectiveness of city-level electric vehicle policies in China. Energy Policy 130, 22–31.

Rezvani, Z., Jansson, J., Bodin, J., 2015. Advances in consumer electric vehicle adoption research: A review and research agenda. Transp. Res. D 34, 122–136.

Riyanto, R., Riyadi, S.A., Nuryakin, C., Gerald Massie, N.W., 2019. Estimating the total cost of ownership (TCO) of electrified vehicle in Indonesia. In: ICEVT 2019 - Proceeding: 6th International Conference on Electric Vehicular Technology 2019. pp. 88–99.

Rose, G., 2012. E-bikes and urban transportation: emerging issues and unresolved questions. Transportation 39 (1), 81–96.

Scorrano, M., Danielis, R., Giansoldati, M., 2020. Dissecting the total cost of ownership of fully electric cars in Italy: The impact of annual distance travelled, home charging and urban driving. Res. Transp. Econ. 80.

Sheldon, T.L., DeShazo, J.R., 2017. How does the presence of HOV lanes affect plug-in electric vehicle adoption in California? A generalized propensity score approach. J. Environ. Econ. Manag. 85, 146–170.

Sheldon, T., Dua, R., 2020. Effectiveness of China's plug-in electric vehicle subsidy. Energy Econ. 88, 104773.

Sierzchula, W., Bakker, S., Maat, K., Van Wee, B., 2014. The influence of financial incentives and other socio-economic factors on electric vehicle adoption. Energy Policy 68, 183–194.

SLOCAT, 2021. Climate Strategies for Transport: An analysis of Nationally Determined Contributions and Long-Term Strategies. Tech. Rep., [Online]. Available: https://bit.ly/3QWvhmb.

Spot, 2022. Imports of electric vehicles over the past year increased by more than 6 times. [Online]. Available: https://bit.ly/3DEQ5Zp.

State Committee on Ecology and Climate of the Kyrgyz Republic, 2021. Updated Nationally Determined Contribution 2021. Tech. Rep., Bishkek, [Online]. Available: https://bit.ly/3OykjSb.

State Registration Service of the Kyrgyz Republic, 2022a. Calculation of the cost of 0.3% assessment for the initial registration of the vehicle. [Online]. Available: https://bit.ly/3xWcpLe.

State Registration Service of the Kyrgyz Republic, 2022b. Calculation of the cost of 5% assessment for the initial registration of the vehicle. [Online]. Available: https://bit.ly/3OMsAlT.

Steen, M.v.d., Van Schelven, R., Kotter, R., Van Twist, M., Deventer MPA, P.v., 2015. EV policy compared: An international comparison of governments' policy strategy towards e-mobility. In: E-Mobility in Europe. Springer, pp. 27–53.

Tal, G., Nicholas, M., 2016. Exploring the impact of the federal tax credit on the plug-in vehicle market. Transp. Res. Rec. 2572 (1), 95–102.

Tashkent Times, 2021. Electric vehicles exempted from car tax. [Online]. Available: https://bit.ly/3noGcrl.

Teslacenter kg, 2022. Teslacenter kg instagram page. [Online]. Available: https://bit.ly/3AaemGH.

The Astana Times, 2020. Kazakhstan plans to launch electric car production by 2021. [Online]. Available: https://bit.ly/3ucXMSK.

The World Bank, Getting electricity: Price of electricity. [Online]. Available: https://bit.ly/3bqXf9i.

The World Bank, Pump price for gasoline (US$ per liter). [Online]. Available: https://bit.ly/3ytdr2O.

TransLogistica Uzbekistan, 2021. Uzbekistan to launch production of electric vehicles by 2025. [Online]. Available: https://bit.ly/3rKm8Cy.

United States Environmental Protection Agency, 2021. Highlights of the Automotive Trends Report. Tech. Rep., Washington, D.C., [Online]. Available: https://bit.ly/3yupwoB.

Vanhaverbeke, L., Schreurs, D., De Clerck, Q., Messagie, M., Van Mierlo, J., 2017. Total cost of ownership of electric vehicles incorporating vehicle to grid technology. In: 2017 Twelfth International Conference on Ecological Vehicles and Renewable Energies. EVER.

Wang, S., Li, J., Zhao, D., 2017a. The impact of policy measures on consumer intention to adopt electric vehicles: Evidence from China. Transp. Res. A 105, 14–26.

Wang, N., Pan, H., Zheng, W., 2017b. Assessment of the incentives on electric vehicle promotion in China. Transp. Res. A 101, 177–189.

Wang, Y., Sperling, D., Tal, G., Fang, H., 2017c. China's electric car surge. Energy Policy 102, 486–490.

Wu, G., Inderbitzin, A., Bening, C., 2015. Total cost of ownership of electric vehicles compared to conventional vehicles: A probabilistic analysis and projection across market segments. Energy Policy 80, 196–214.

Yang, J., Dong, J., Hu, L., 2018. Design government incentive schemes for promoting electric taxis in China. Energy Policy 115, pp1–11.

Yuan, X., Liu, X., Zuo, J., 2015. The development of new energy vehicles for a sustainable future: A review. Renew. Sustain. Energy Rev. 42, 298–305.

Zhang, X., Rao, R., Xie, J., Liang, Y., 2014a. The current dilemma and future path of China's electric vehicles. Sustainability (Basel, Switzerland) 6 (3), 1567–1593.

Zhang, X., Xie, J., Rao, R., Liang, Y., 2014b. Policy incentives for the adoption of electric vehicles across countries. Sustainability 6 (11), 8056–8078.

Zhou, M., Long, P., Kong, N., Zhao, L., Jia, F., Campy, K.S., 2021. Characterizing the motivational mechanism behind taxi driver's adoption of electric vehicles for living: Insights from China. Transp. Res. A 144, 134–152.

Zhu, D., Patella, D.P., Steinmetz, R., Peamsilpakulchorn, P., 2016. The Bhutan Electric Vehicle Initiative: Scenarios, Implications, and Economic Impact. Tech. Rep., World Bank.