Study and Recommendation for Application of E-Mobility in Mongolia

E-Mobility Readiness Assessment

October 2024

a company of Royal HaskoningDHV

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Notice

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Executive Summary

Introduction

Mongolia presents a unique context for e-mobility adoption. The country experiences extremely cold winters, has an exceptionally low population density (outside of Ulaanbaatar), and the lowest cost (to user) and most carbon-intensive electricity in Asia. These all affect the technical, economic and policy case for electric vehicle (EV) deployment.

This Technical Assistance (TA), *Study and Recommendation for Application of E-Mobility in Mongolia*, seeks to support the World Bank, Government of Mongolia (GoM), and Municipality of Ulaanbaatar (MUB) to develop and shape the Mongolian EV transition. The TA consists of two components, for which this report constitutes the first. These are:

1. **E-Mobility Readiness Assessment**, providing an in-depth assessment of Mongolia's e-mobility context and a multi-criteria appraisal of EV readiness.
2. **E-Mobility Roadmap**, which develops scenarios of EV growth targets in high readiness segments, together with policy recommendations to unlock this growth.

Context of this report

The E-Mobility Readiness Assessment has been developed based on broad stakeholder engagement, including two missions to Ulaanbaatar (June 2023 and January 2024) and extensive data gathering across public and private sector sources. The study has taken an exploratory approach across transport, energy, and environment sectors, enabling the identification of key themes and issues for analysis.

In agreement with the World Bank client team, including its e-mobility specialists, the analytical framework for this report is focused on E-Mobility Readiness, both for e-mobility as a technology and as it relates to individual vehicle segments in use in Mongolia.

Framework of e-mobility readiness

The E-Mobility Readiness Framework that has been used in this report considers both market readiness (factors affecting EV demand and supply) and public policy readiness (how EVs contribute to Mongolia's public policy goals).

- **Market readiness** considers the technical suitability, economic competitiveness (vs. ICEVs and HEVs[1]), and supply availability of EVs in different vehicle segments, considering extreme climate, energy mix and other factors.
- **Public policy readiness** considers how EVs in different segments contribute to public policy goals including Green House Gas (GHG) reductions, air pollution, and sustainable urban mobility.

[1] ICEV: Internal Combustion Engine Vehicles, HEV: Hybrid Electric Vehicles

The assessment also considers any 'showstoppers' for different vehicle segments, in which major challenges or barriers exist that prevent EV growth in the short-medium term.

Readiness summary

Overall

Economics: The economic readiness of e-mobility varies greatly by vehicle segment. Low energy costs (around US$0.04/kWh for residential and US$0.05/kWh for industrial/commercial) support the economic viability of the high-use commercial segments (taxis and light goods vehicles) and even new private automobiles. The higher the use of a vehicle, the greater the fuel savings, balancing the higher upfront costs of EVs over the course of their usage. For instance, while an electric standard taxi is typically around 2.5 times more expensive to purchase than its ICE counterpart, the Total Cost of Ownership (TCO) of the standard electric taxi was found to be 25% less expensive than its ICE counterpart.

TCO modelling produced similar results for most vehicle segments. However, battery electric bus (BEB) TCOs remained higher than their ICE equivalents, due to slow bus speeds. Despite the low operating costs provided by low energy costs, high local financing costs and availability present a major challenge for mass market and informal commercial sectors to overcome the difference in upfront costs.

There is an established and growing distribution network for both new and used EVs, formal EV financing is available, and stakeholders are broadly positive about EVs. However, in the short- to medium-term, a restricted supply of used EVs of equivalent age and specifications to Mongolia's existing fleet (due to the nascency of the market globally) is a barrier to large scale EV growth in the country. This will be amplified for Mongolia by Japan's comparatively slow EV adoption rate (as Mongolia's predominant supplier of mass market vehicles) notwithstanding the increased competitiveness of other markets such as China.

Technology: The technological readiness of e-mobility in Ulaanbaatar is moderate to high. Almost all journeys are short enough that the range of EVs is of little concern for most vehicle segments during most of the year. The principal technology challenges relate to older mass market EV automobiles (unlikely to be suitable for commercial use (e.g. taxis) like their hybrid equivalents) and electric buses (which need to carefully plan charging strategies to maintain high fleet productivity). Beyond this, however, the effect of the extremely cold temperatures can be mitigated through driver behavioural adjustments and battery temperature management technologies to an extent sufficient to meet user needs.

EVs have been shown to be technologically feasible in countries with comparable climate extremes, with Canada and Norway (among others) having far higher rates of EV adoption. Learning from there shows that vehicle heat pumps, and battery and vehicle pre-heating can improve EV winter performance. Extreme cold can affect fast charger performance, with

Canada and Norway prioritising slow overnight charging (ideally in covered locations) to mitigate this alongside user behaviour (battery pre-heating). Mongolia's own experience is of the broad technological feasibility of EVs, while highlighting areas for enhancement.

Significant adoption of e-mobility outside of Ulaanbaatar is not currently feasible in techno-economic terms, considering extremely low population density and the importance of actual and perceived vehicle range and reliability to remote communities. However, charging infrastructure on major routes in the region around Ulaanbaatar would support EV uptake by Ulaanbaatar residents.

Environment: The environmental readiness of e-mobility is low to moderate in general. Mongolia's energy generation is the most carbon intensive in Asia (and is unlikely to fall in the short- to medium-term), at 733 g CO_2/kWh[2]. This reduces the decarbonisation impact of EVs. For instance, while an electric passenger car powered by the Mongolian grid produces around half the emissions of an HEV in Mongolia, it still emits around twice that of an EV which is powered by the German grid. Indeed, there are negligible environmental benefits for BEBs in Mongolia, even compared to ICE buses in Mongolia.

Ulaanbaatar's poor air quality, which is a high political priority, could offer an entry point for e-mobility to be promoted, given its potential to contribute to air quality improvement. EVs can still achieve localised benefits through cutting tail-pipe emissions. However, transport's contribution to air pollution is minor[15], and the prevalence of combined heat and power plants (CHPP) in urban areas for energy generation (including EV charging) makes the tailpipe benefits of EVs less clear cut. The city is currently pursuing other policies to address this challenge, including fuel/vehicle standards and modal shift.

There is limited policy focus upon decarbonisation in either road transport or energy sectors, making EV investment difficult to align with Mongolia's policy priorities. While e-mobility is not explicitly referenced in Mongolia's Nationally Determined Contributions (NDC), the Ministry of Environment and Tourism (MOET) has actively supported e-mobility in their role to support decarbonisation. A cross-government EV Working Group was also mandated in June 2023 by a Prime Ministerial Resolution. Despite this, there is no clear cross-government strategy, goals or targets, which frustrates stakeholders in translating their efforts into public policy outcomes (including decarbonisation).

Energy sector: The high carbon intensity of the Mongolian energy grid is a challenge for the role of e-mobility in decarbonising the transport sector. The single buyer energy model prevents the purchase of renewable energy (RE) through the grid, so operators/individuals cannot reduce the emissions of their EVs through their energy supplier. The challenges in Mongolia's renewable energy sector, together with predicted demand

[2] Statista. (2024, August 1). Electricity sector carbon intensity APAC *2022, by country*. https://www.statista.com/statistics/1299708/apac-carbon-intensity-power-sector-by-country/

growth, make further grid decarbonisation unlikely in the short- to medium-term without renewed focus.

At distribution network level, underinvestment in energy distribution in Ulaanbaatar (relative to the city's rapid growth), limited data availability on substation capacity, and unclear coordination and protocols on grid connections may frustrate EV charging point roll-out.

Urban mobility: The urban mobility readiness of e-mobility in Ulaanbaatar is low across vehicle segments. Ulaanbaatar's transport policy is currently focused on sustainable urban mobility, shifting journeys to more efficient modes and reducing the distance travelled for citizens to access services. Current policies include number plate restrictions and public transport investment which, while reducing carbon emissions, are driven by goals to address the city's stifling congestion, drive economic efficiency and improve liveability. In this context, e-mobility is unlikely to have comparable impact, although there may be a role for BEBs where they can support modal shift (e.g. if accompanied by bus priority measures and low carbon energy).

Segment based

Table ES-1 below provides a summary of the readiness of different vehicle segments in the Mongolian context, the full version of which can be found in *Conclusions on segment-level EV readiness* in the main report.

Table ES-1: High level summary of vehicle market readiness appraisal

	Private Automobiles			Commercial			Urban Buses[3]			
	Mass Market	Mid-range	New	Urban Taxi	Private Hire	Vans	1. BAU	2. Bus Priority	3. Green Energy	4. Ops 2&3
Market Readiness	4	8	12	10	10	12	11	13	10	11
	Low	Mod	Very High	High	High	Very High	Very High	Very High	High	Very High
Policy Support	4	4	4	6	5	8	3	5	8	10
	Low	Low	Low	Mod	Low-Mod	High	Low	Low-Mod	High	Very High
Overall Readiness	8	12	16	16	15	20	14	18	18	21
Low/ Moderate/ High	Low	Low-Mod	Mod	Mod	Mod	High	Mod	Mod-High	Mod-High	High

Based on the segment level EV readiness assessment, the key opportunity areas are:

- **Private automobiles:** These have high commercial readiness (in newer and mid-range vehicles). While private EVs are generally supported relative to ICEVs in their environmental impact, care needs to be taken for this not to conflict with other

[3] Options refer to different assumptions around operating conditions and energy source for charging

sustainable mobility initiatives, such as mode shift to public transport, which offer greater impact and support other policy goals.

- **Light commercial vehicles:** Urban taxis and light freight vans have a high market readiness, and support decarbonisation and urban air quality improvement. The key outstanding challenge is the lack of a suitable business model in an often-fragmented market. Plans for increased regulation of taxis and ride-hailing services in Ulaanbaatar may provide an opportunity in this segment.
- **Urban buses:** With the current bus operating model, there is no case for further electric buses, which increase operator cost and have GHG emissions similar to the EURO V diesel fleet. However, a strong policy case can be made for electrification where electric buses are charged with renewable energy and as part of bus priority measures to improve fleet productivity and promote public transport use. With improved productivity and business model reform, e-buses can be implemented at a similar lifetime cost to the recent new EURO V diesel vehicles.

Key considerations for policymakers

Strategic commitment to e-mobility development

E-Mobility and decarbonisation: E-mobility is primarily a tool to support goals of transport decarbonisation. Yet Mongolia's overall commitment to decarbonisation is limited, and there is no stated ambition for e-mobility. Without e-mobility being integrated with a cross-sectoral mandate for decarbonisation, EVs are likely to remain on the fringe of public policy.

Coordinated e-mobility delivery: There is much positive work in Mongolia's e-mobility field across the Government. However, these efforts do not appear to be well coordinated between sectors (transport, energy, environment) or actors (central government, city government and private sector). This potentially results in the duplication of efforts, gaps in market development, and inefficiencies in investments contributing to transport decarbonisation. Public charging infrastructure in Ulaanbaatar is a good example of this. Managing the EV transition will require a strong coordination, delivery, and monitoring function.

Objectives based EV transition: E-mobility is a market-based transition, which will be driven by the decisions of EV consumers and vehicle supply of markets including Japan, Korea, and China. The scope for policymakers is therefore to set outcome-focused policy actions to shape the path of this transition, to maximise the benefits and to mitigate the challenges. While e-mobility is a transport intervention, the agreed targets and policies will need joint ownership across all of government and, in particular, by the energy sector, which will need to take a solutions-focused role to aligning demand challenges with adequate charging point availability.

Transport sector key opportunities

Private automobiles: Private EVs should be supported since they reduce GHG emissions and other air pollutants, although not at the expense of higher priority goals, such as modal shift, which are the key focus for public investment. Key enablers for private EVs include:

- A more coordinated and purposeful approach to EV charging, including development of a private sector managed charging point network and enabling charging solutions for apartment residents (particularly overnight charging).
- There is no strong rationale for public subsidies on private automobiles, although 'nudges' have been shown to be helpful (e.g. green plate exemptions) and others can be explored in the Roadmap.
- Winter-appropriate technologies and behaviours are necessary to address the extreme cold temperatures, the approach to which should consider standards, engagement with manufacturers, and consumer/user education elements.

Piloting commercial segments: Catalysing urban taxis and light freight vehicles (vans) is a high-readiness and potentially low-cost action. The priority here is for support to develop a suitable business model and catalyse roll-out. Programmes to support these sectors may not require large financial investment but will require commitment and technical resource to coordinate and take forward. Further recommendations will be made in the roadmap.

Urban buses: Implementation of further BEBs is not recommended under the model as currently deployed. However, there is an opportunity for them to support public policy in sustainable mobility, as part of bus priority schemes where charged using green energy. This will include reforms to operational aspects and business model (investment, financing and contracting) aspects. Practical recommendations will be developed in the roadmap.

Energy sector considerations

The energy sector represents a current challenge to EV deployment.

Grid connections: In terms of grid connections, the current grid connection process through UBEDN should be expedited, with a solutions-focused approach taken to the deployment of charging infrastructure. This includes greater transparency around distribution network capacity, as well as grid connection approvals and timelines to enable CPOs and EV fleet operators to have certainty around charging infrastructure timelines. The EV transition will over time increase energy grid demand. Options to manage this include peak shifting (e.g. smart charging, EV tariffs) and/or coordinated planning for EV demand, as part of distribution network capacity planning.

Green EV charging: In terms of grid carbon intensity, the key challenge relates to charging for larger EVs (principally BEBs), for which the only current option is charging via a micro-grid solution. While this is a feasible option in the short-term and for large charging infrastructure, in the long-term the grid will need to become less carbon intensive for EVs to lower their indirect emissions, given the overwhelming majority of the vehicle fleet are private automobiles (for which local RE generation is less suited).

Wider grid decarbonisation: In the long-term, decarbonisation of EV charging should mirror a wider decarbonisation of the energy grid carbon, particularly considering the large anticipated demand growth. While this is a much broader policy agenda than solely to support e-mobility, it is clear that Mongolia has enormous RE potential that can be unlocked through focus on a stable long-term investment environment for RE, reforms to energy sector economic governance to allow RE to be funded by users (and not contribute to a system deficit in the current single buyer model), and to identify priority transmission infrastructure to unlock RE development locations. Further options will be developed in D2.

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List of acronyms

AC	Alternating Current
ADB	Asian Development Bank
AUES	Altai Uliastai Energy System
BESS	Battery Energy Storage System
BEVs	Battery Electric Vehicles
BMS	Battery Management System
BRT	Bus Rapid Transit
CAPEX	Capital Expenditure
CES	Central Energy System
CEVs	Clean Energy Vehicles
CHPP	Combined Heat and Power Plants
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CMS	Central Management System
CPS	Charging Protection System
CSF	Catalysed Soot Filter
DC	Direct Current
DD	Dangerous Defects
DNO	Distribution Network Operator
DPF	Diesel Particulate Filter
DSO	Distribution System Operator
EES	Eastern Energy System
EPR	Extended Producer Responsibility
ERC	Energy Regulatory Commission
EV	Electric Vehicle
EVAM	EV Association of Mongolia
EVSE	Electric Vehicle Supply Equipment
FCEVs	Fuel Cell electric Vehicles
FIT	Feed-in Tariffs
FMCG	Fast-Moving Consumer Goods
GAP	Government Action Plans
GHGs	Greenhouse Gases
GoM	Government of Mongolia
GPF	Gasoline Particulate Filter
GWh	Gigawatt Hour
HC	Hydrocarbons
HEV	Hybrid Electric Vehicles
Hz	Hertz
HGVs	Heavy Goods Vehicles
ICE	Internal Combustion Engine
ICEV	Internal Combustion Engine Vehicles
IEA	International Energy Agency
IK	Impact Protection
IP	Ingress Protection

ITF	International Transport Forum
JICA	Japanese International Cooperation Agency
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt hour
kWp	Kilowatt peak
LGV	Light Goods Vehicle
LHD	Left-Hand Drive
LNT	Lean NOx Trap
LPG	Liquified Petroleum Gas
LRT	Light Rail Transit
MaD	Major Defects
MiD	Minor Defects
MOE	Ministry of Energy
MOET	Ministry of Environment and Tourism
MRT	Metro Rapid Transit
MRTD	Ministry of Road and Transport Development
MUB	Municipality of Ulaanbaatar
MW	Megawatt
NAVC	National Automotive Vehicle Centre
NDC	National Dispatching Center
NENC	National Electricity Network Company
NOx	Nitrogen Oxides
NRTC	National Road Transport Centre
NSO	National Statistics Office
O2	Oxygen
OCPP	Open Charge Point Protocol
ODTS	On-Demand Transit Service
OEM	Original Equipment Manufacturer
OPEX	Operating Expenditure
PHEVs	Plug-in Electric vehicles
PM	Particulate Matter
PTA	Public Transport Agency
PTD	Public Transport Department
PPAs	Power Purchase Agreements
PV	Photovoltaic
REC	Renewable Energy Credits
RES	Renewable Energy Sources
RHD	Right-Hand Drive
SAIDI	System Average Interruption Duration Index
SCR	Selective Catalytic Reduction
SES	Southern Energy System
TA	Technical Assistance
TCO	Total Cost of Ownership
UB	Ulaanbaatar

UBEDN	Ulaanbaatar Electricity Distribution Network Company
USD	US Dollar
USUTP	Ulaanbaatar Sustainable Urban Transport Programme
VAT	Value Added Tax
VTA	Vehicle Type Approval
WES	Western Energy System

1. Introduction

Global and local policy drivers for e-mobility

1.1 E-mobility is an important tool in the global decarbonisation of the transport sector, and at local level offers extensive co-benefits including improved air quality, health, energy security and opportunities to develop new national industries across the value chain. While high capital costs have to date seen the transition to electric vehicles (EVs) driven by public sector support, technological advancement and falling battery prices mean that e-mobility is increasingly a private-sector led transition, with governments taking a market shaping role through regulation and coordination of market actors.

1.2 The effectiveness of EVs in mitigating greenhouse gasses (GHGs) is heavily dependent upon the carbon intensity of electricity generation. This is a challenge for Mongolia, where carbon intensive coal-based electricity accounted for 89 percent of generation in 2019. Furthermore, compared to the gradually declining global coal consumption, coal consumption in Mongolia is projected to grow[4]. This projected growth may offset the global effort to mitigate climate change and limit global GHG emissions. To ensure that the local air quality and health benefits of EVs do not further contribute to GHG emissions, it will be essential to explore the energy mix used in Mongolia for EV charging, considering how e-mobility can support renewable energy development and unlock climate finance opportunities.

Scope of this study

1.3 This Technical Assistance (TA), *Study and Recommendation for Application of E-Mobility in Mongolia*, seeks to support the World Bank, Government of Mongolia, and Municipality of Ulaanbaatar in the development and shaping of the Mongolian EV transition. This TA consists of two components, for which this report constitutes the first. These are:

- **E-Mobility Readiness Assessment:** This provides an exploratory assessment of the Mongolian transport and energy sector, seeking to understand the current state of EV deployment, the economic/technical readiness of EVs in the Mongolian context, and strategic opportunities and challenges to their wider adoption as a tool for transport decarbonisation.

[4] Hans et al. (2020). *The Mongolian electricity sector in the context of international climate mitigation efforts*. https://newclimate.org/sites/default/files/2020/03/Decarbonization_Pathways_Mongolia.pdf

- **E-Mobility Roadmap:** Taking the findings from the E-Mobility Readiness Assessment, the roadmap will develop scenarios for e-mobility growth in high readiness sectors, analyse the potential impact, and identify the necessary policies, incentives, and investments required to deliver these in a way which supports Mongolia's decarbonisation efforts and other policy goals. It also provides recommendations for urban bus business model reform, required to support EV deployment in this key sector or urban policy in Ulaanbaatar.

Structure of the remainder of this report

1.4 The remainder of this report is structured as follows:

- **Chapter 2: Mongolia's transport sector context** provides an overview of the transport sector in Mongolia as relevant to e-mobility including vehicle fleet analysis, vehicle market characteristics, and overview of public transport and commercial vehicle sectors.
- **Chapter 3: Policy agendas related to e-mobility** outlines the key policy agendas in the e-mobility arena across transport, environment and environment sectors.
- **Chapter 4: E-mobility market and deployment experience** outlines the current experience of Mongolia in the deployment of e-mobility.
- **Chapter 5: Mongolia's electricity sector context** provides an overview of the structure and characteristics of the electricity sector in Mongolia, including the energy grid and generation, energy use, and economic governance arrangements.
- **Chapter 6: Analysis of opportunities and constraints to e-mobility development** provides detailed analysis of different readiness factors for e-mobility. This includes technology suitability, Total Cost of Ownership (TCO) modelling, grid impacts, GHG emissions, and subsidy levels.
- **Chapter 7: E-Mobility Readiness Assessment** provides a rigorous multi-criteria assessment of the readiness of different vehicle segments in the Mongolian context, based on the information and analysis of the first six chapters.
- **Chapter 8: Vision for e-mobility development** outlines a recommended approach to take forward into the roadmap development. It considers the potential role of e-mobility in addressing key policies goals in Mongolia in a wider context, and proposes an approach to support growth of high readiness segments.

2. Mongolia's transport sector context

Overview

2.1 Mongolia's transport sector is shaped by the vast expanse of its geography and sparse population on one hand, and the challenges of its dense, rapidly growing capital city, Ulaanbaatar, on the other. This presents a dichotomy of transport contexts.

Urban transport

2.2 Nearly 75% of the population lives in or around a major city with 45% of the population (1.34 million people) residing in Ulaanbaatar, the country's capital city. Rapid urbanisation over the last few decades has increased the demand for and created strain on the urban transport network. For instance, car registrations doubled in the decade to 2021 (from 389,000 to 775,000)[5]. The rise in vehicles has seen traffic congestion and pollution have become increasingly serious challenges to productivity and quality of life.

2.3 Responding to these growth challenges, Ulaanbaatar has initiated a reform of the public transport sector since 2015 and made several proposals to develop mass transit schemes (including Bus Rapid Transit (BRT), Light Rail Transit (LRT) and Metro) and has designated dedicated bus lanes for public transport (although these are not always enforced). This work is ongoing, with the support from development partners including the World Bank supported Ulaanbaatar Sustainable Urban Transport Programme (USUTP), as part of a vision of a more sustainable transport system for Ulaanbaatar. E-mobility forms an important part of this vision.

Rural and interurban transport

2.4 Mongolia is the second largest landlocked country in the world with an area of over 1.5 million square km. This creates high transit costs and unreliable logistics chains, further aggravated by a sparse road network which is vulnerable to extreme weather events such as flooding and landslides, which make roads impassable for long periods especially in the more remote regions[6].

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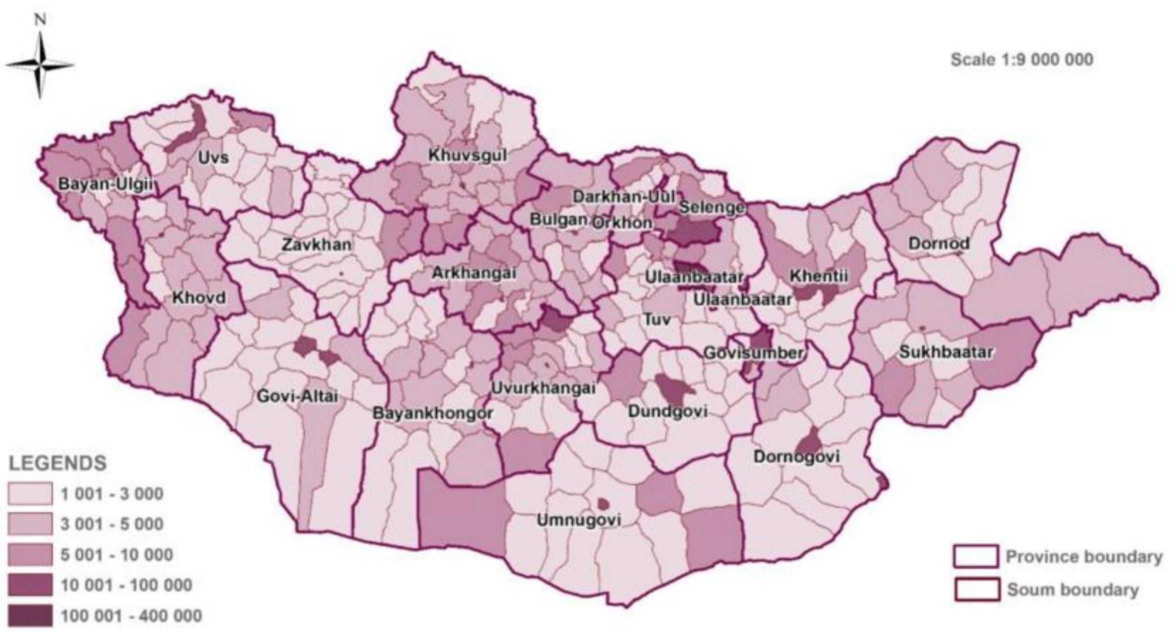
[5] National Statistics Office. (2024). *NUMBER OF REGISTERED VEHICLES , by age, by region, aimags and the Capital, by year* [Dataset]. https://www.1212.mn/en/statistic/statcate/573059/table-view/DT_NSO_1200_013V4

[6] International Federation of Red Cross And Red Crescent Societies (IRFC). (2021, February 2). *Mongolia: Flash Floods - Final Report (Operation n° MDRMN012) - Mongolia*. ReliefWeb. https://reliefweb.int/report/mongolia/mongolia-flash-floods-final-report-operation-n-mdrmn012

2.5 Development of the road network is therefore a particular priority, and a challenge given the size of the country and the severe weather it experiences. Out of Mongolia's 111,943 km road network, only 10,242 km are paved[7], with poor quality infrastructure most prevalent in rural areas. Low population density outside Ulaanbaatar (highlighted below in Figure 2-1) increases the costs of transport infrastructure investment and maintenance, as well as reducing the efficiency of service provision. This also applies to the e-mobility ecosystem, considering electricity grids, charging stations and maintenance services, while exacerbating range anxiety concerns.

Figure 2-1: Population density in Mongolia



Source: Bat-Orgil, Turmandakh. (2021). Single-Phase Power Generation System for Depopulated Area. 10.13140/RG.2.2.21045.40163.

Vehicle fleet characteristics

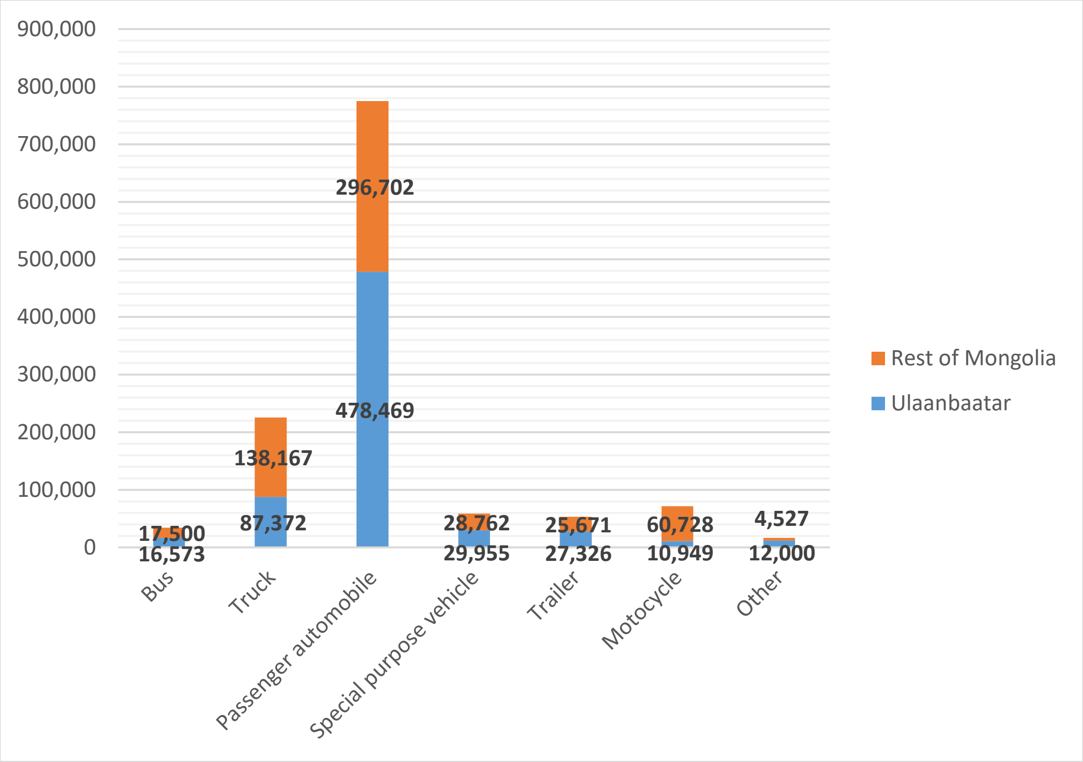
2.6 Vehicle fleet data at the national and Ulaanbaatar levels were obtained from the Mongolian National Statistics Office (NSO) and were available for the decade up to and including 2021. These are based upon annual vehicle registration data which, while it may not include all scrapped vehicles in the fleet, is the most accurate available and considered sufficiently detailed to give a valid indication of scale.

[7] Asian Development Bank. (2023, September 12). *ADB to support construction of road network in Western Mongolia*. https://www.adb.org/news/adb-support-construction-road-network-western-mongolia

Mongolia's national vehicle fleet

2.7 The make-up of the Mongolian vehicle fleet is shown in Figure 2-2. Passenger automobiles make up the largest transportation sector by far in Mongolia, with 775,000 vehicles in 2021 (over three times as many cars as the next largest transport segment: trucks/heavy goods vehicles (HGVs)). Motorcycles are a relatively limited sector, with less than 10% of the number of cars, and over 80% of motorcycles in areas outside of Ulaanbaatar. Almost two thirds (62%) of car registrations in Mongolia are in Ulaanbaatar, where motorisation rates are almost double that of outside of the capital (30 cars for every 100 people in Ulaanbaatar compared to 17 cars per 100 people outside).

Figure 2-2: Total number of registered vehicles 2021, by type and area (stacked)



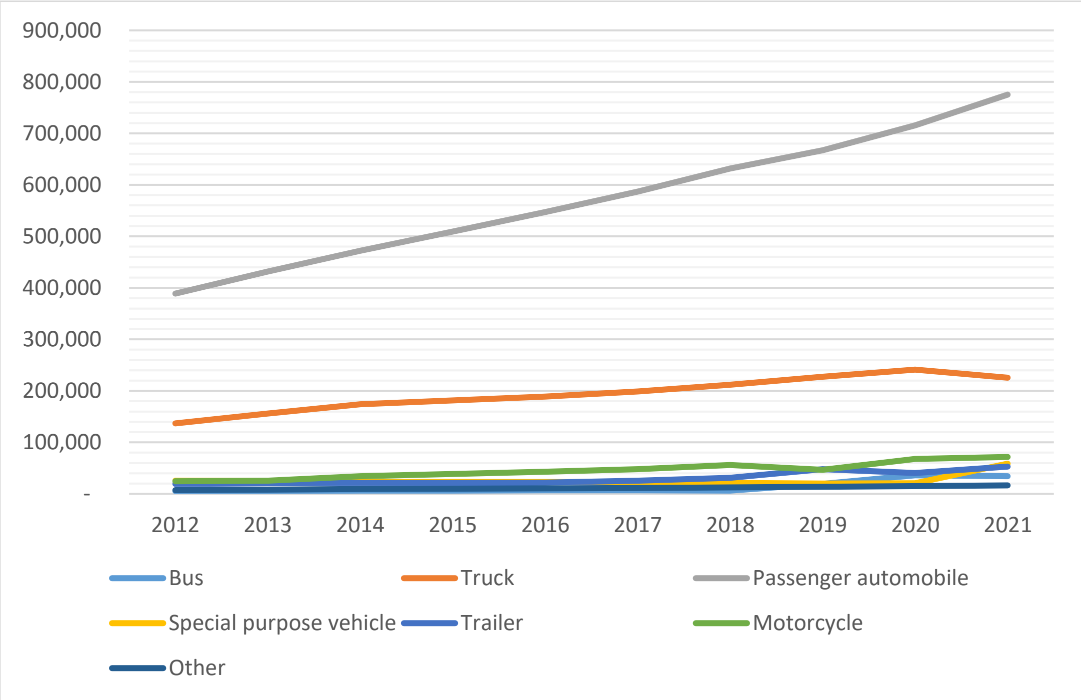
Source: National Statistics Office of Mongolia

Overview of vehicle fleet growth

2.8 Vehicle registrations have risen at a relatively constant pace over the last 10 years (2012-2021), with an increase in around 40,000 cars per year, resulting in an increase in the overall motorisation rate from 14 cars per 100 citizens to 23 cars per 100 citizens. Freight vehicle registrations have increased by about two thirds in the same period, while motorcycles have almost tripled, albeit from a low base (from 25,000 to 72,000).

2.9 NSO data shows an increase in over six times the number of registered buses in 2021 as compared to 2012 (from 5,600 to 34,000), with major increases in 2019 and again in 2020. The reason for this sharp rise in registrations is change in classifications of vans, which were reclassified under "buses" from 2019 after a database system update, according to the National Road Transport Centre (NRTC). Buses are procured and distributed by the Public Transport Department (PTD) of Municipality of Ulaanbaatar (MUB). However, there have not been bus fleet renewals on the scale suggested in 2019 and 2020 by this data.

Figure 2-3: Evolution of registered vehicles in Mongolia, by type (2012-2021)



Source: National Statistics Office of Mongolia

2.10 The NSO data shows that the majority of all vehicles registered in Mongolia were registered within the capital for the decade up to and including 2021, and that this was the case for most vehicle types in 2021. Motorcycles and trucks were the only vehicle types with more vehicles registered outside of Ulaanbaatar, with the former typically used in agriculture (animal herding) and the latter tending to be used for industries such as mining, being mostly located outside of the capital.

Overview of vehicle fleet age

2.11 Mongolia is notable for a very old vehicle fleet, with 79% of vehicles aged 10 years or older and 11% aged 7-9 years in 2023[5]. This has broadly been the case for over a decade according to the NSO, with a slight temporary increase reflecting import restrictions and economic effects of the pandemic. At the other end of the scale, less than 5% of vehicles are under three years old, a proportion reaching as low as 2% in 2016-7.

2.12 There are a number of reasons behind Mongolia's ageing fleet, which ultimately relate to cost sensitivity of vehicle purchase and relaxed regulatory regime in terms of vehicle import age, emissions and safety standards. This is important in the context of EVs, as they are generally more expensive than their Internal Combustion Engine Vehicle (ICEV) counterparts and the second-hand market for EVs is currently limited. Both of these issues are discussed in detail elsewhere in the report.

2.13 The age makeup of the vehicle fleet in Mongolia in 2021 was similar to that of Ulaanbaatar and this was the case for the previous ten years to 2012. This continues to be the case in 2023, according to the National Automotive Vehicle Centre (NAVC).

Table 2-1: Age of vehicles in Mongolia and Ulaanbaatar in 2021

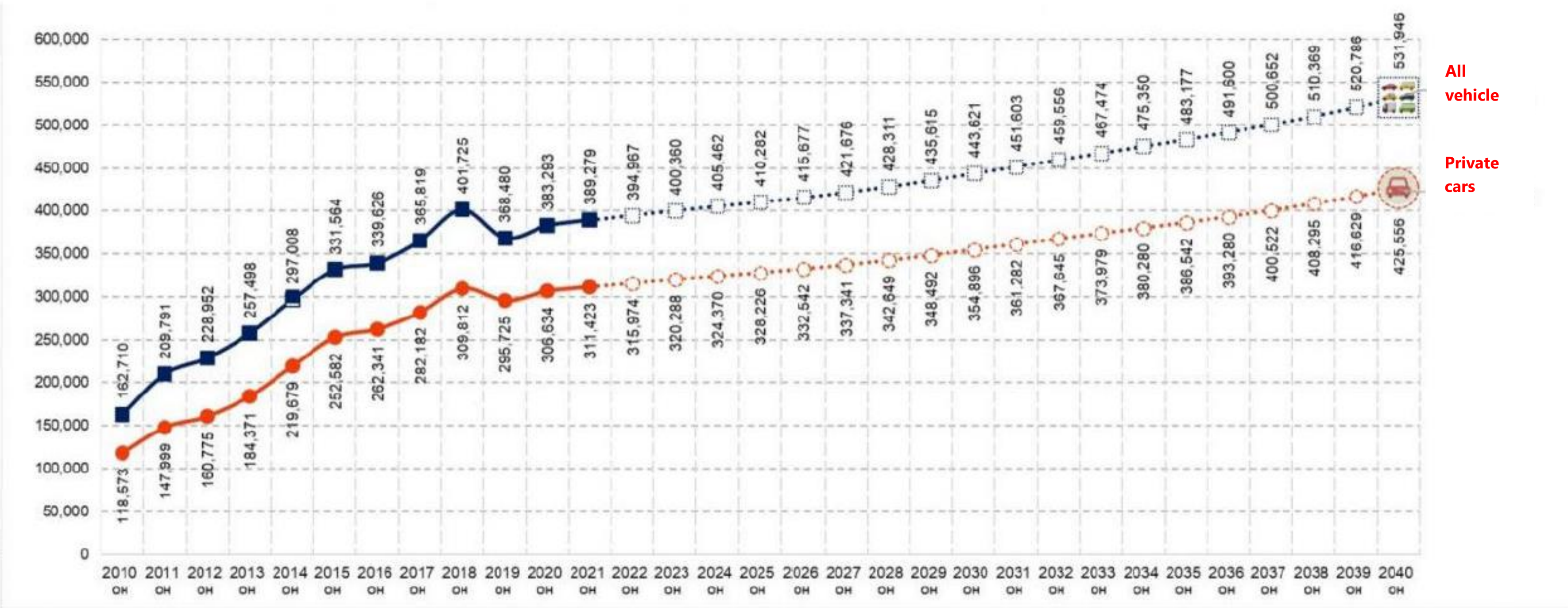
	Mongolia		Ulaanbaatar	
Age of vehicles	**Number of vehicles**	**% of vehicles**	**Number of vehicles**	**% of vehicles**
0-3 years	47,172	4%	22,831	3%
4-6 years	40,671	3%	20,207	3%
7-9 years	143,657	12%	95,315	14%
10+ years	1,003,207	81%	524,291	79%

Source: National Statistics Office of Mongolia

Future vehicle market projections

2.14 In assessing future transport trajectory for the city, the Ulaanbaatar 2040 Development Masterplan acknowledges that the overall private automobile market is reaching saturation point, with rapid motorisation seeing Ulaanbaatar reaching 0.7 vehicles per household in 2020. The expected vehicle trajectory is expected therefore to stabilise in the period to 2030 and 2040, as shown in Figure 2-4. It anticipates 355,000 private automobiles to 2030 (426,000 to 2040), and a total vehicle fleet of 444,000 to 2030 (and 532,000 to 2040), up from 311,000 and 390,000 respectively in 2020.

Figure 2-4: Vehicle stock growth trajectory from Ulaanbaatar 2040 Development masterplan.

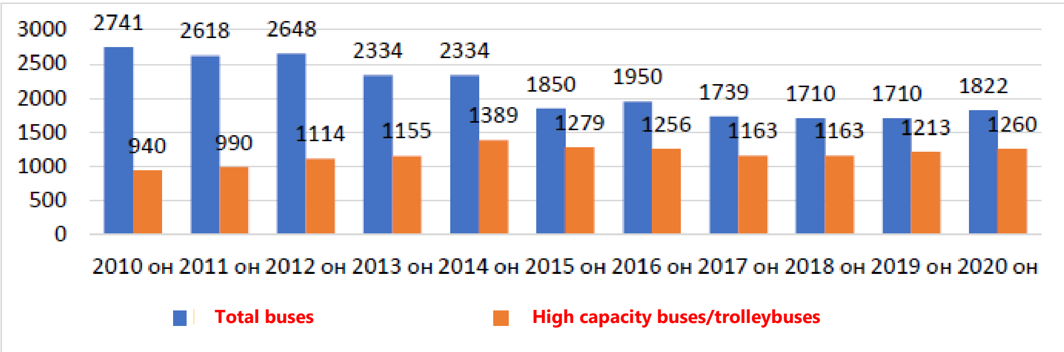


Source: Ulaanbaatar 2040 Development Masterplan

Public transport vehicle trends and future trajectories

2.15 As outlined in the Ulaanbaatar 2040 Development Masterplan (and 2.58.), the city has adopted a strategy towards sustainable mobility oriented around public transport, but definition of a stable policy and implementation challenges in various mass transit proposals make long-term forecasting a challenge. Figure 2-5 shows the trends in the period to 2020 in terms of the urban bus fleet, with a policy focus on phasing out minibuses from the urban fleet and move towards large (12m+ urban buses), as described on paragraph 2.58. Future bus fleet numbers will depend upon future policy decisions and implementation, particularly the relative focus between rail-based mass transit and bus improvements, together with the political appetite for driving mode shift (e.g. bus lane enforcement and road space reallocation).

Figure 2-5: Trajectory of urban buses in Ulaanbaatar (2010-2020)



Source: Ulaanbaatar 2040 Development Masterplan

Vehicle market

Country of origin

2.16 Mongolia does not have its own vehicle manufacturing industry, meaning that all the national vehicle fleet is imported. A summary of import sources can be found in Table 2-2.

2.17 **Small passenger vehicles (cars, motorcycles)** are overwhelmingly imported from Japan (92%), with small numbers from South Korea (2%) and a similar (but growing) number from China (2%). While China has the most advanced EV manufacturing industry, in the Mongolian case the growth in vehicles imports from China is more likely to result from ICE vehicle imports, particularly the liberalisation of the Chinese market for used vehicle exports (since 2019), as well as the general development of the Chinese vehicle manufacturing sector.

2.18 Of the overall private vehicle market, 95% are used vehicles, due to the demand for less expensive vehicles (explored in more depth in relation to import taxes and duties). Japan has an abundance of used vehicles, due to their strict emission standards and rigorous testing regime for older vehicles (three years and above) which promotes rapid turnaround and disincentivises used vehicles on the domestic market. Mongolia's permissive regulatory framework for right hand drive vehicles (despite its right lane driving rules) has allowed vehicles to be imported from Japan despite safety concerns.

2.19 Japan has a relatively small market of battery electric vehicles (BEVs) at the time of writing. This means there is unlikely to be a significant supply of used BEVs from Japan for some time. This represents a potential supply constraint and may require Mongolia to pivot to alternative markets with more advanced BEV adoption, e.g. China, to promote BEVs in the short-medium term. This is discussed further in the Barriers and Opportunities section below.

2.20 **Large passenger vehicles (buses, minibuses)** are predominantly imported from South Korea (55%), followed by Japan (23%) and the Russian Federation (7%). In recent years, there has also been an increase in imports from China (rising from 1% in 2020 to 14% in 2022). While the cause for this is likely as for small passenger vehicles, the scale of Chinese market growth in this segment is much greater since Chinese vehicles do not compete with low cost RHD vehicles from Japan.

2.21 **Freight vehicles** (trucks) are predominantly imported from South Korea (47%), China (29%) and Japan (18%). These proportions were relatively consistent in the five years to 2022.

Table 2-2: Vehicle fleets by country of import (Source: National Statistics Office of Mongolia)

	2018		2019		2020		2021		2022	
Vehicle type	**Number of vehicles**	**% of vehicles**	**Number of vehicles**	**% of vehicles**	**Number of vehicles**	**% of vehicles**	**Number of vehicles**	**% of vehicles**	**Number of vehicles**	**% of vehicles**
Large passenger vehicles (buses, minibuses)	**1,363**		**1,543**		**1,359**		**1,095**		**1,082**	
South Korea	930	68%	1,031	67%	806	59%	508	46%	596	55%
China	31	2%	30	2%	20	1%	74	7%	156	14%
Russian Federation	198	15%	274	18%	274	20%	235	21%	74	7%
Japan	185	14%	175	11%	239	18%	267	24%	246	23%
Others	19	1%	33	2%	20	1%	11	1%	10	1%
Small passenger vehicles (cars, motorcycles)	**64,039**		**69,472**		**53,087**		**55,238**		**65,612**	
South Korea	2,096	3%	1,295	2%	840	2%	876	2%	1,094	2%
China	127	0%	54	0%	128	0%	239	0%	1,550	2%
Russian Federation	228	0%	539	1%	226	0%	141	0%	100	0%
Japan	59,918	94%	65,372	94%	49,779	94%	52,014	94%	60,160	92%
Others	1,670	3%	2,217	3%	2,198	4%	2,021	4%	2,708	4%
Freight vehicles	**22,256**		**23,050**		**20,982**		**26,526**		**22,369**	
South Korea	10,720	48%	13,021	56%	10,585	50%	10,661	40%	10,571	47%
China	6,140	28%	3,742	16%	4,100	20%	7,904	30%	6,529	29%
Russian Federation	242	1%	206	1%	255	1%	530	2%	146	1%
Japan	3,931	18%	4,439	19%	4,795	23%	5,463	21%	4,005	18%
Others	1,223	5%	1,642	7%	1,247	6%	1,968	7%	1,118	5%

Vehicle age on import

2.22 The Mongolian vehicle market is dominated by the importation of used vehicles (approximately 95% of the private vehicle market). Whilst 27% of vehicles imported in the first half of 2023 were no more than three years old[8], it is estimated less than 5% of vehicle imports are new, according to a major vehicle importer (in the absence of official data). By contrast, over two thirds (68%) of vehicles imported in the first six months of 2023 were at least 7 years old.

2.23 Given that there are currently very few electric vehicles of a comparable to the typical Mongolian import age profile (globally, and particularly in Japan), scarcity means that a comparable 'mass market' EV segment is unlikely to develop in the near term. Even for those which are imported, access to financing is likely to be a challenge in lower income segments, with the capital cost of electric vehicles tending to be higher (while offset by lower energy costs). At and age of 7+ years, battery's range would also have deteriorated significantly.

Table 2-3: Vehicle imports in the first six months of 2023 by age

Age on import	Ulaanbaatar		Mongolia	
0-3 years	9,360	24%	13,793	27%
4-6 years	2,065	5%	2,816	5%
7-9 years	13,755	35%	16,532	32%
10+ years	14,479	37%	18,840	36%
Total	**39,659**		**51,981**	

Source: National Automotive Vehicle Centre (2023)

Driving side

2.24 Mongolian vehicle imports continue to be dominated by right-hand drive vehicles (i.e., vehicles designed to drive on the opposite side to Mongolian traffic), representing 68% of all vehicles imported to Mongolia in the first half of 2023[8]. Mongolia's permissive regulatory regime to this (and policy debate related to it) is primarily an issue of road

[8] National Automotive Vehicle Centre. (2023). *Vehicle Import Data* [Dataset].

safety but opens the market to low-cost imports from Japan (with low EV penetration) and reduces attractiveness of markets with a greater quantity of used EVs.

Vehicle engine size

2.25 The split of engine size of Mongolia's imported vehicles reflects the high proportion of its imports from affluent nations, with relatively large passenger vehicles, and its requirement for heavy machinery vehicles for its industries, such as mining.

2.26 In the first half of 2023, a relatively small proportion (19%) of imported vehicles had 1,500 cc or smaller engines (generally found in hatchbacks, other small cars, and motorbikes). Over half (51%) of imported vehicles had an engine size of 1,501-2,500 cc (generally associated with sedans, other larger cars, and light goods vehicles (LGVs)), reflecting the desire for larger vehicles which can handle Mongolia's harsh winters and poor-quality roads outside of Ulaanbaatar.

2.27 A substantial proportion (12%) of imported vehicles had very large engines (over 4,500 cc), generally associated with HGVs, heavy machinery vehicles, and some powerful 4x4s and LGVs.

Table 2-4: Engine size of imported vehicles in the first six months of 2023

Engine size	Ulaanbaatar		Mongolia	
<=1500 cc	6,055	17%	8,741	19%
1501-2500 cc	19,299	54%	23,641	51%
2501-3500 cc	5,556	15%	6,667	15%
3501-4500 cc	1,161	3%	1,380	3%
>4500 cc	3,775	11%	5,507	12%
Total	**35,846**		**45,936**	

Source: National Automotive Vehicle Centre (2023)

Fuel type

2.28 Over half (52%) of Mongolia's imported vehicles in the first half of 2023 were hybrid electric vehicles (HEVs), reflecting their relatively low capital cost and user costs (low maintenance costs and high fuel efficiency), particularly given the lower excise rates applied to hybrids compared to ICEVs. This is discussed in further detail in the next section. Hybrids are also more reliable in the extreme winter temperatures (compared to their ICEV counterparts).

2.29 The high proportion of hybrid vehicles means that a large-scale shift to BEVs would not bring about the same level of air pollution and GHG emissions reductions as it would if the national vehicle fleet was predominantly ICEVs. This is an important consideration when assessing the potential benefits BEVs could bring to Mongolia.

2.30 Diesel vehicles represented a quarter (24%) of imports, which is likely skewed by freight and heavy machinery vehicles. A similar proportion of imports were petrol imports (23%), with only 1.0% of imports compressed natural gas (CNG)-powered and just 0.3% BEVs, highlighting the embryonic nature of the BEV market in Mongolia in 2023.

2.31 The distribution of vehicle imports across drivetrains was similar for Ulaanbaatar to that of Mongolia, albeit with a slightly greater proportion of newly imported diesel vehicles registered outside of Ulaanbaatar (24%), which again likely points to the greater proportion of freight and heavy machinery vehicles.

Table 2-5: Drivetrain of imported vehicles

Drivetrain	Ulaanbaatar		Mongolia	
Petrol	8,196	23%	10,873	23%
Diesel	7,219	20%	11,043	24%
Electric	148	0.4%	157	0.3%
CNG	328	0.9%	486	1.0%
Hybrid	20,419	56%	24,016	52%
Total	**36,310**		**46,575**	

Source: National Automotive Vehicle Centre (2023)

Supply chain of vehicles in Mongolia

New vehicles

2.32 As noted above, the new vehicle market represents a minority of vehicle imports in Mongolia, estimated at less than 5% of vehicles by a major vehicle importer in Mongolia (in the absence of official data). These are predominantly higher end private cars, alongside commercial vehicles. New vehicles are predominantly sold through national vehicle distributors that are formally registered companies in Mongolia who represent specific international vehicle brands. For example, this study interviewed MSM Group who represent and distribute personal and commercial (light and heavy) vehicles for BYD, Ford, Jeep, Mercedes-Benz, FUSO and RAM. Their insights to the Mongolian EV market can be found in "New vehicle market and supply chain". Other business groups act as distributors for other brands, including Jaguar-Land Rover, Toyota, BASF and others.

2.33 In the new vehicle segment, vehicles are generally imported based on client demand, with distributors managing the import process, offering after sales service and maintenance, and being responsible on the part of the original equipment manufacturer (OEM) for vehicle warranties.

Used vehicles

2.34 The used vehicle segment, representing the majority of imports and vehicle transactions, is a much more diverse sector. Importers include small enterprises (typically 30-50 vehicles per years) and medium importers ranging up to approximately 100 vehicles per month. Specifically in the case of Toyota Prius, there is also a used vehicle mass wholesale sector, with individual entities importing up to 2,000-4,000 vehicles per year.

2.35 There is a diversity of business models for vehicle import, ranging from individuals operating without a formal company registration (often securing sales through informal or word-of-mouth contact) to large formal businesses with professionalised marketing and sales teams. Importers tend to purchase vehicles in batches at physical mass auctions in Japan, although online purchase and import is increasing as a business model for some smaller importers.

Vehicle import process

2.36 As outlined in Country of origin, most of Mongolia's personal vehicles are imported from Japan. This requires a multi-step process with various actors:

- Vehicles are bought (online) from auctions in Japan.
- Mongolian logistics companies then transfer the vehicles from the auction site to the nearest Japanese seaport.
- From there, the vehicles are shipped to Tianjin port (in China) in containers that can hold 4-5 cars. It takes about two months to process the vehicles at Tianjin.

- Containers are then transported by train from Tianjin to Zamiin Uud (a Mongolian town on the border with China). It then takes about 5 days to pass border customs.
- From Zamiin Uud to Ulaanbaatar, it takes two additional days by train.

2.37 The logistics costs for each container shipment from Japan to China (usually carrying several vehicles) costs approximately $4,000. The following rail shipment from Tianjin to Zamiin Ude then costs around $700, excluding tax. And the rail shipment from Zamiin Ude to Ulaanbaatar costs around $300, including tax. Assuming each container carries four cars, this adds up to around $1,250 per vehicle (plus tax).

2.38 Import costs from Japan are, therefore, a major consideration for Mongolian consumers. The relatively low capital costs of second-hand ICEVs and hybrids from Japan (due to their abundance resulting from low local demand and limited export markets), currently balances their import costs relative to countries with lower logistics costs but a more competitive local used vehicle market.

2.39 In terms of EVs, China is the largest producer and consumer of EVs globally[9], meaning it will be the first country to have a significant second-hand EV market. The reduced import costs will also allow Mongolian consumers to spend more on vehicles, however it is likely that national and international demand (and therefore prices) for these left-hand drive vehicles will be greater than currently prevalent right-hand drive vehicles from Japan. More opportunities are likely, however, to exist in other segments (e.g. trucks, motorcycles, buses) where this market distortion does not apply.

Vehicle import taxes and duties

2.40 In Mongolia, the taxation system for vehicle imports and purchases involves three distinct components: Import tax, Excise tax, and Value Added Tax (VAT). These taxes play an important role in determining the overall EV cost and financial implications associated with bringing vehicles into the country.

2.41 **Import tax/duty** is levied on the importation of vehicles into the country. This tax is calculated as a fixed percentage of the vehicle's value. In Mongolia for car segment, it is set at **5% of the total value of the vehicle cost** (i.e. both ICEVs and EV).

2.42 **Excise tax** levied on vehicle imports is subject to variation based on the technology of the vehicle, engine capacity (applicable for ICEVs and HEVs[10]) and the number of years

[9] Jaeger, J. (n.d.). *These countries are adopting electric vehicles the fastest*. World Resources Institute. https://www.wri.org/insights/countries-adopting-electric-vehicles-fastest#:~:text=China%20is%20by%20far%20the,rest%20of%20the%20world%20combined
[10] Hybrid Electric Vehicles (HEVs)

that have passed since its production. The excise rate for ICEVs, HEVs and EVs is given in Table 2-6, Table 2-7 and Table 2-8 respectively. The rate is higher the older the vehicle is and the larger the volume of the engine is (only applicable to ICEVs and HEVs). The rates for an EV are the same as those for an HEV with a maximum engine volume of 1,500 cm^3.

Table 2-6: Excise Tax Rate (USD) - ICE

No.	Volume of engine cylinder (cm^3)	Period following the production year (in years)			
		0-3 years	4-6 years	7-9 years	10 years and over
1	1,500 and below	500	1,000	2,000	6,000
2	1,501-2,500	1,500	2,000	3,000	7,000
3	2,501-3,500	2,000	2,500	4,000	8,000
4	3,501-4,500	4,500	5,000	6,500	10,500
5	Over 4,501	7,000	7,500	9,000	13,000

Table 2-7: Excise Tax Rate (USD) - Hybrid

No.	Volume of engine cylinder (cm^3)	Period following the production year (in years)			
		0-3 years	4-6 years	7-9 years	10 years and over
1	1,500 and below	109	232	486	1,450
2	1,501-2,500	334	464	725	1,697
3	2,501-3,500	442	580	972	1,936
4	3,501-4,500	993	1,160	1,573	2,538
5	Over 4,501	2,060	3,944	5,677	9,566

Table 2-8: Excise Tax Rate (USD) - EV

No.	Volume of engine cylinder (cm^3)	Period following the production year (in years)			
		0-3 years	4-6 years	7-9 years	10 years and over
1	1,5000 and below	109	232	486	1,450

2.43 **Value Added Tax (VAT**) is a tax imposed on the value added at each stage of the production and distribution chain of goods and services. In Mongolia, VAT is applicable to the sale of most goods and services, including vehicles. It is a tax levied on the increase in value of the product at each stage of production or distribution. For vehicles, the VAT is calculated as:

Value added tax (VAT) =10% of the [Vehicle Value + Import Duty + Excise Tax]

2.44 Table 2-9 is a summary table of import taxation costs for typical mass market and luxury cars, by fuel type. In summary, in terms of excise rates, consumers are highly incentivised to purchase HEVs or EVs over ICEV equivalents and are incentivised to import smaller engines and newer vehicles in all cases. Consumers are also incentivised to import EVs over HEVs for most engine sizes, but not as strongly, and there is no difference in incentives between EVs and HEVs with 1,500 cm^3 and below engines.

Table 2-9: Import taxation costs as a proportion of total purchase costs for mass market and luxury cars by fuel type

Vehicle segment	Input	ICEV	Hybrid	EV
Mass Market Car (Used) And Commercial Taxi (Car)	Model	Toyota Corolla	Toyota Prius 20	Nissan Leaf (with 40 kWh battery capacity)
	Purchase cost (USD)	7,600 Vehicle cost: 4,702 (62%) Custom Duty: 225 (3%) Excise Duty: 2000 (26%) VAT: 673 (9%)	7,390 Vehicle cost: 3,550 (48%) Custom Duty: 168 (2%) Excise Duty: 1697 (23%) VAT: 521 (7%) Battery cost: 1452 (20%)	19,532 Vehicle cost: 11,000 (56%) Custom Duty: 540 (3%) Excise Duty: 232 (1%) VAT: 1157 (6%) Battery cost: 6600 (34%)
New Car segment And Premium Taxi Car segment	Model	Mercedes Benz C class	-	BYD Han (With 88 kWh battery capacity)
	Purchase cost (USD)	52,000 (86%) Vehicle cost: 44,630 Excise Duty: 500 (1%) VAT: 4670 (9%) Custom Duty: 2200 (4%)	-	69,000 Vehicle cost: 42,850 (62%) Excise Duty: 109 (0.2%) VAT: 4939 (7%) Custom Duty: 6428 (9%) Battery cost: 14,520 (21%)

Urban transport in Ulaanbaatar

2.45 This section outlines the urban transport context in Ulaanbaatar. In the context of rapid economic, population and vehicle fleet growth (described above), it outlines the current status of the public transport sector, bus fleet, air quality impacts and congestion. It finishes with an overview of current urban transport policy direction towards sustainable urban mobility, focused upon modal shift.

Public transport in Ulaanbaatar

2.46 Ulaanbaatar's bus network comprises 107 routes operated by 18 bus companies (16 private and two public). Since the implementation of institutional reforms in 2015/6 (under the Smart Bus Initiative), each route is contracted by the PTD, who set the fares, minimum level of service provision, and performance incentives with these contracts. PTD is also responsible for system-wide revenue risk, which has led to a high structural financial deficit (see Financial performance of urban transport network). The PTD is the regulatory body overseeing and contracting both public and private operators, shaping the legal framework to achieve the MUB's public transport objectives.

2.47 The two public bus operators are organised by PTD, which is responsible for ensuring the two public operators meet the minimum service requirements of their contracts. Buses operating from Bus Park 1 and Bus Park 2 are controlled by one public operator, whilst buses from Bus Park 3 are controlled by another. Therefore, the PTA performs an implementation role, while the PTD performs a regulatory role.

2.48 Ulaanbaatar's bus fleet is primarily (90%) composed of 12 m single-deck buses, with small proportions of trolleybuses, articulated buses and double-deck buses making up the rest. The fleet includes several types of battery electric bus (BEB) of different brands (Jinlong, Skywell) and sizes (double deck, 12m) introduced as pilots ahead of wider scale-up. There are no officially registered paratransit microbuses, as they have been phased out by the PTD. However, there are informal operators unofficially continuing to provide these services and proposals being developed by the Ulaanbaatar Sustainable Urban Transport Program (USUTP) for on-demand transport services which may incorporate minibuses.

Bus fleet characteristics and numbers

2.49 Table 2-10 provides a summary of the Ulaanbaatar's bus fleet characteristics.

Table 2-10: Summary statistics of bus fleet

Data	Comment/Context
• 1,323 buses in total • 1,190 diesel buses • 55 BEV buses (both single & double deck) • 32 trolley buses • 46 natural gas buses • 507 12m EURO V buses procured Q1 2024 • Average age – 10.5 years (as of June 2023)	Aging fleet but there have been attempts to upgrade in recent years – 363 new buses were bought in 2022 (including 47 BEVs), and a further 507 new buses were procured in Q1 of 2024. The regulation prohibiting the age of buses to be greater than 12 years was temporarily extended in 2021 by City Council Resolution in response to the COVID-19 pandemic.

Financial performance of urban transport network

2.50 Resolving the financial pressures upon the urban public transport network in Ulaanbaatar is a major policy agenda for MUB. The financial challenge is complex and multi-faceted with slow bus speeds and weak contractual incentives contributing to a high system cost, low fleet productivity, and lower ridership (and therefore revenues). Together with low passenger fares (on the revenue side) the size of the public transport subsidy requirement is increasingly unsustainable.

2.51 In relation to e-bus transition, the impact of low bus financial productivity and a constrained funding environment creates a challenging financing environment for e-bus investment (which is capital intensive). While addressing the wider financial challenge is the subject of separate studies, it will be important for the development of an e-bus business model which minimises the financial implications upon MUB while maximising fleet productivity.

Air quality

2.52 Ulaanbaatar is one of most polluted capital cities in the world. In 2019, the city's PM2.5 level was higher than World Health Organization (WHO) safe level for seven months of the year. While the worst of this air pollution relates to electricity production (including thermal power stations and the Combined Heat and Power Plants (CHPPs) located within the city boundaries, which provide heating during the extreme cold of the winter months) and burning of coal in ger areas for heating and cooking, the transport sector contributes significantly to important pollutants (e.g., approximately 20-30% of annual average PM10 emissions)[11]. While 70% of CO_2 emissions are attributable to light duty vehicles, some 70% of PM is attributable to heavy duty vehicles[12].

2.53 The air quality impact of Ulaanbaatar's transport sector is driven by a number of factors:

- The age of the city's vehicle fleet. There is currently no mandated maximum vehicle operating age under the national framework (with the exception of public buses and taxis, with 10- and 12-years maximum ages respectively) and nor is there a limit on vehicle age upon import. Consequently, 74% of the fleet registered in Ulaanbaatar was over 10 years old and over 94% older than 7 years (National Statistics Office, 2020).
- Emissions standards. Lower (EURO II) fuel standards contribute to poor air quality, while existing Mongolian National Standards (MNS) for vehicles (equivalent to EURO II/III) facilitate the (reportedly) widespread practice of removal of catalytic converters upon import since these are not required under current standards.
- Rapid motorisation and congestion also drive air pollution through vehicle density and intensity of usage

2.54 For the private vehicle market, the extent of this air pollution impact is to some extent offset by the rapid uptake of hybrid vehicles in Mongolia, which have been popular in the market given their low fuel consumption (particularly in congested Ulaanbaatar) and (primarily) reliability in the extreme winter cold.

Congestion

2.55 Ulaanbaatar has experienced rapid population and spatial growth in the past 20 years, with the city's population having increased from 780,000 in 2001 to 1.45 million in 2019, an 87 percent increase. Population growth has been accommodated both in low-density settlements (lacking adequate access to the basic services including formal public transport) and in high density satellite areas which, while offering higher quality of housing, tend to be located further away from employment and commercial activities.

2.56 While the city has experienced high population growth, this has been outpaced by the growth in the city's private vehicle fleet which has doubled in just 10 years (to 2021).

[11] Dugerjav, G. (2023). *Decarbonization of Public city Transport in Ulaanbaatar, Mongolia*. https://www.itf-oecd.org/sites/default/files/itf-sipa_mng_dissemination_s2_p2_0.pdf , and World Bank. (2020). *Ulaanbaatar Sustainable Urban Transport Project (P174007) - Project Information Document (PID)*.

[12] Bayasgalan, B., & Matsumoto, T. (2017). Estimation and prediction of road traffic emissions in Ulaanbaatar. *Journal of Japan Society of Civil Engineers Ser G (Environmental Research)*, *73*(5), I_183-I_190. https://doi.org/10.2208/jscejer.73.i_183

The causes for increased motorisation and car ownership are complex, however key factors include the low cost of imports from Japan (due to the permissive regulatory regime), and the old vehicle fleet and cycle of decline for the city's public transport system.

2.57 Consequently, Ulaanbaatar is now among the most heavily congested cities in the world, with the average road user/road vehicle driver losing 2.5 hours per day due to congestion and average traffic speed in main streets in the region of 8-12 km/h[13]. Congestion is a high priority on the public policy agenda, with the National Government Minister for Ulaanbaatar also Chairing a National Committee for Reducing Traffic Congestion in Ulaanbaatar. Some key initiatives here have included number plate-based circulation restrictions (one day per week; for which EVs are exempt), while longer terms plans exist for mass transit and sustainable mobility interventions.

Sustainable urban mobility

2.58 The transition to e-mobility needs to be seen in the context of a wider policy agenda of sustainable urban mobility, as outlined in the transport section of the Ulaanbaatar 2040 Development Masterplan. There is an increasing appreciation among policymakers that addressing congestion and its impacts (city functioning, quality of life, economic growth, air pollution) requires not only technology shifts and additional infrastructure, but also to catalyse modal shift.

2.59 Ulaanbaatar has investigated a number of transport-related proposals, including rapid transit studies (BRT, LRT and MRT) and road construction projects funded by donor banks. These include long-term Asian Development Bank (ADB) assistance towards implementation of BRT Figure 2-6 shows the scope of these as of 2017[14], with a 2023 commission for development of the Peace Avenue alignment) for and the Japanese International Cooperation Agency (JICA). As part of the latter, a new road infrastructure investment project concentrated at south of Peace of Avenue has entered its early stages of development.

2.60 Whilst the city has vision and ambition towards sustainable urban mobility, the challenges of rapid growth, low density expansion, sprawling land use, a sparse road network and sectoral coordination has presented challenges to shifting policy into

[13] Dugerjav, G. (2023). *Decarbonization of Public city Transport in Ulaanbaatar, Mongolia*. https://www.itf-oecd.org/sites/default/files/itf-sipa_mng_dissemination_s2_p2_0.pdf
[14] *Ulaanbaatar Projects*. (n.d.). https://www.fareast.mobi/en/projects/Ulaanbaatar

significant improvement of public transport services[15]. An efficient, high quality public transport network providing mobility to Ulaanbaatar's residents is a key requirement to make the city's mobility sustainable, alongside supporting measures such as institutional strengthening, efficient road space use, and promotion of non-motorised transport. With much of Ulaanbaatar's bus fleet requiring renewal, new electric buses could provide both a comfortable, attractive service, although their environmental credentials are marginal compared to ICE buses (explored in more depth later in this report).

2.61 However, one policy which has been successfully implemented is a restriction on traffic using a number plate system. The policy has taken different forms over recent years[16], but essentially the policy has restricted vehicles' access to downtown Ulaanbaatar based on the last digit of their number plate[17]. For instance, odd numbers being allowed on alternate days, with even numbers allowed on the intervening days[18]. EVs are fully exempt from these restrictions, and are denoted by green number plates, to avoid them being fined by number plate detection cameras or traffic officers[19].

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[15] The World Bank. (2021). Ulaanbaatar Sustainable Urban Transport Project (P174007). In *Project Information Document (PID)* (Report No. PIDA31171; Appraisal Stage, pp. 1–17). https://documents1.worldbank.org/curated/en/708891618997774951/pdf/Project-Information-Document-Ulaanbaatar-Sustainable-Urban-Transport-Project-P174007.pdf

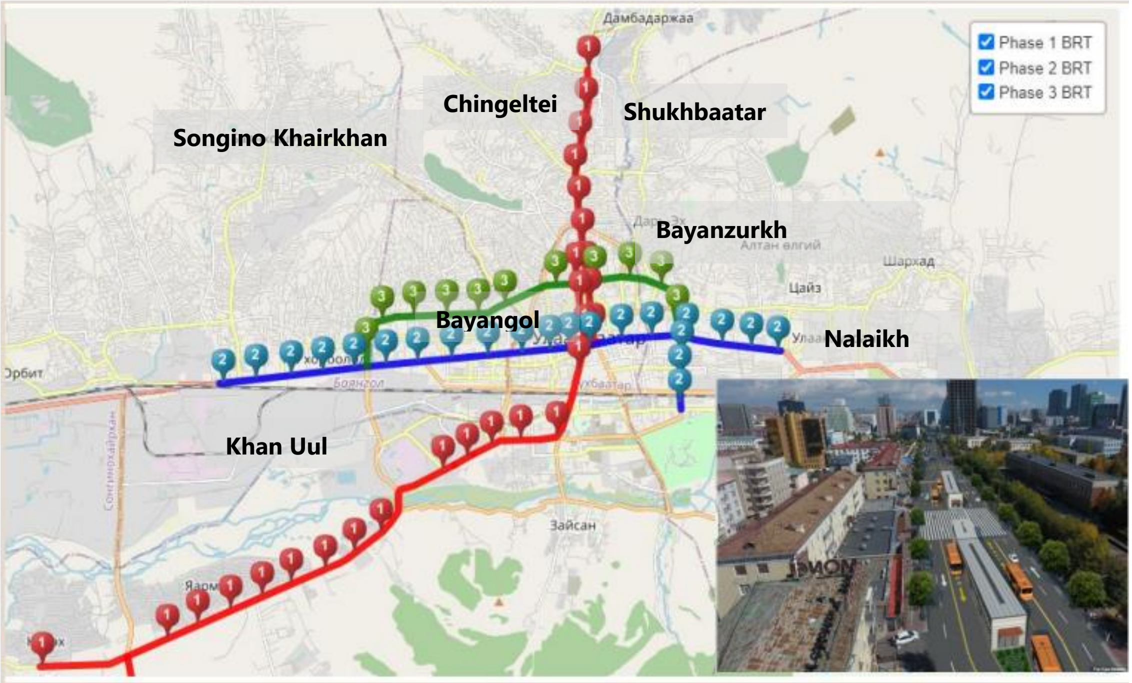
[16] Odontuya, A. (2016). *Common traffic rules of UB*. gogo.mn. https://mongolia.gogo.mn/r/152456

[17] Tumurbaatar, D. (2022). *Temporary driving restriction reduces traffic congestion by 40%*. PressReader. https://www.pressreader.com/mongolia/the-ub-post/20220902/281496460103936

[18] U.S. DEPARTMENT of STATE — BUREAU of CONSULAR AFFAIRS. (n.d.). https://travel.state.gov/content/travel/en/international-travel/International-Travel-Country-Information-Pages/Mongolia.html

[19] Dulguun, B. (2017). *Electric cars exempted from driving restrictions and road tax*. PressReader. https://www.pressreader.com/mongolia/the-ub-post/20170823/281479276535996

Figure 2-6: BRT planned corridors[14]



2.62 There are also a few days a year where no vehicles are allowed into the city centre, including Car-Free Day, which promotes active travel amongst Ulaanbaatar residents, usually held in May[20]. The Ulaanbaatar Marathon is often held on this day.

2.63 Ulaanbaatar is also receiving assistance from the World Bank in developing a more comprehensive framework for sustainable urban mobility through the USUTP. This project comprises three main components[21]:

- Integrating key transport corridors to improve efficiency.
- Improving the quality, reliability, accessibility, and integration of the public transport system.
- Institutional capacity building through strategies, tools, and methodologies in transport infrastructure planning, management, and service provision, to ensure the long-term ability of the MUB to develop a comprehensive and effective institutional framework for sustainable urban mobility.

[20] *Car-Free Day promotes risk-free, healthy city*. (2019). www.theubposts.com. https://www.theubposts.com/a/11688#:~:text=The%20annual%20Car%2DFree%20Day,the%20third%20week%20of%20May.
[21] *Development Projects : Ulaanbaatar Sustainable Urban Transport Project - P174007*. (n.d.). World Bank. https://projects.worldbank.org/en/projects-operations/project-detail/P174007

Buses outside of Ulaanbaatar

Interurban buses

2.64 Generally, interurban buses are coaches (such as the Hyundai Universe) operated by small private companies, typically with a fleet of 1-10 coaches. These coaches can transport approximately 45 passengers. The vehicles are usually imported as used vehicles.

2.65 The private operators operate under a fully commercial business model, and report to the National Automotive Vehicle Centre but are ultimately regulated by the Ministry of Road Development and Transportation.

Intraurban buses

2.66 Most cities and towns outside of Ulaanbaatar do not operate bus services with 12-meter buses due to their small population. Therefore, collective transport tends to take the form of fixed-route shared taxis. Most of these services are privately (informally) operated, and there is limited regulation of their services.

2.67 Darkhan, Mongolia's third largest city with a population of 150,000[22], has announced that in late 2023 it will be introducing a new fleet of 20 modern Skywell e-buses purchased by the local government[23].

Other vehicle segments

Taxis

2.68 Taxi services can be found in all Mongolian towns and cities. The majority of these vehicles are operated informally, often by individual drivers and usually unregulated. Many of these services are provided through ride-hailing apps, such as UBCab (the largest and principal platform in Ulaanbaatar). There is no accurate data on the volumes or characteristics of the informal taxi fleet as a whole, however UBCab report that there are around 40,000 vehicles registered with their platform alone (the vast majority in Ulaanbaatar). The vehicles in the informal sector tend to align with the general fleet in being relatively old sedan cars and predominantly HEV technology (making them economical to operate on high daily mileage, particularly in heavy traffic).

[22] Wikipedia contributors. (2024, May 24). *Darkhan (city)*. Wikipedia. https://en.wikipedia.org/wiki/Darkhan_(city)
[23] *Darkhan State Registration Department*. (2023). Link

2.69 In Ulaanbaatar, there are 10 officially licensed taxi companies operating 615 vehicles, (according to the PTD). Two thirds of these vehicles are Liquified Petroleum Gas (LPG)-fuelled, with the remainder currently running on gasoline[24]. Publicly licensed taxis are imported from South Korea, where taxis have predominantly been LPG-fuelled for over a decade[25]. There is no regulation in South Korea enforcing taxis to run on LPG but the fuel is significantly cheaper than gasoline, as the government incentivises its use to lower NOx emissions in the sector with lower tax rates than petroleum and diesel[26]. Taxis from South Korea are also preferred for their left-hand drive, which is the correct side for Mongolia. LPG is readily available at fuel stations across Mongolia. Despite the reduced NOx benefits offered by LPG, it should be noted that the licensed taxi fleet in Ulaanbaatar is ageing, with almost half aged 10 years or older[24], meaning many of their engines will be less efficient, somewhat negating these benefits.

Light freight vehicles

2.70 According to the Ulaanbaatar 2040 Development Masterplan[27], approximately 80% of freight arriving in Mongolia arrives to Ulaanbaatar (principally by rail), and 70% is destined for locations within the city and its environs. While some of this cargo (particularly coal) is delivered directly to its ultimate destination (power plants), the remainder is distributed through the national registered truck fleet (55% registered in Ulaanbaatar), and vans (which since 2021 are registered separately under buses).

2.71 While heavy freight is not considered in this study due to the early state of technology development and implementation barriers, light freight vehicle (van) EV technology is globally maturing and widely available. Vans are predominantly used in Mongolia for last mile logistics and lighter freight, such as urban deliveries, courier and parcel services. The Development Masterplan outlines a need for increased focus on shifting urban freight deliveries to smaller vehicles to mitigate the impacts of heavy trucks (particularly in the city's commercial core).

[24] MUB PTD. (2023). Response to study team's data request.
[25] Kyung-don, J. (2013, January 20). *Taxi industry slugs it out over which fuel to use.* https://koreajoongangdaily.joins.com/2013/01/20/socialAffairs/Taxi-industry-slugs-it-out-over-which-fuel-to-use/2965784.html
[26] OECD. (2019). Taxing Energy Use 2019: Country Note – Korea. In *Taxing Energy Use 2019.* https://www.oecd.org/content/dam/oecd/en/topics/policy-sub-issues/carbon-pricing-and-energy-taxes/taxing-energy-use-korea.pdf
[27] Transport Volume, Page 113

3. Policy agendas related to e-mobility

3.1 This section outlines the current transport policy agenda as related to e-mobility, considering the overall policy environment for decarbonisation and the wider policy agenda.

Decarbonisation of the transport sector

3.2 Mongolia does not have a detailed national transportation strategy. Overall national level policy direction is outlined in the National Vision 2050 document[28] and an immediate pipeline of priority projects, investments and policy actions then outlined in four-year Government Action Plans (GAP) aligning with parliamentary periods. GAP interventions tend to be heavily focused on infrastructure improvement, likely reflecting Mongolia's remote geography and strategic location which places a high strategic priority on enabling long-distance road and rail (predominantly freight) corridors to support economic growth and integration.

3.3 The Vision 2050 document does not make explicit reference to e-mobility (which remains in its infancy in Mongolia), however does provide the policy basis to "reduce GHG emissions…in transport" as a short-term priority, with increasing emphasis on GHG reduction in subsequent stages (2031-40 and 2041-50).

3.4 The current GAP (2020-2024) includes an objective to "Develop environmentally friendly, accessible, sustainable, and safe transportation services that meet the demand". Under this objective, the electrification of public transport in Ulaanbaatar and creation of EV and natural gas charging stations is included, alongside passenger transport terminals and rail-based logistics hubs.

National environmental policy agenda

Air quality and GHG emission reduction policy

3.5 The Ministry of Environment and Tourism's (MOET) Sustainable Development Goals (SDGs) & Climate Change Policy division is responsible for coordinating policymaking related to Mongolia's Nationally Determined Contributions (NDCs) and other environmental sustainability goals.

3.6 Mongolia's revised NDC was submitted in October 2020 and sets out the country's aim to mitigate its GHG emissions by 22.7% by 2030 compared to the business-as-usual

[28] State Great Hural. (n.d.). VISION-2050" LONG-TERM DEVELOPMENT POLICY OF MONGOLIA. In *Annex 1 to Resolution 52, 2020*. https://cabinet.gov.mn/wp-content/uploads/2050_VISION_LONG-TERM-DEVELOPMENT-POLICY.pdf

scenario. Its key components include the production of energy, transportation, construction, industry, agriculture, industrial processes, and waste.

3.7 Planned actions within the transportation sector include switching to Euro V fuel standards, switching coal transportation from auto to rail transportation, and switching the heating of passenger trains to electric heating. There is no reference to e-mobility.

3.8 MOET takes an active role in supporting efforts towards improved urban air quality, particularly in Ulaanbaatar (see below section). These efforts focus on the promotion of policies to line ministries. In terms of e-mobility, MOET is promoting this through programmes, policy reform, awareness campaigns, and market development (including supporting the establishment of the EV Association of Mongolia). As the owner of Mongolia's NDCs, it is strongly supportive of implementation of EURO V fuels both to reduce air pollution and as an indirect incentive to EV adoption.

Battery recycling

3.9 Given the high proportion of used vehicles in the Mongolian fleet, vehicle waste management is a significant policy area. A report produced for the MRTD by local consultancy SICA identified that the HEV fleet (at 2019) produced an annual total of 38.43 tons of high-voltage battery waste. Recycling of these batteries poses a major challenge in Mongolia. No facilities exist locally, and overseas recycling is frustrated by the challenge of re-export of life-expired vehicles across the border to China. Considering that the battery of a BEV (e.g., Nissan Leaf) is 10 times larger than a hybrid vehicle (e.g., Prius), MRTD is conscious of the urgency of addressing this challenge within EV policy.

Ulaanbaatar City policy agenda

UB 2040 Masterplan

3.10 There is no direct reference to e-mobility in Ulaanbaatar's 2040 Masterplan, through which the existing traffic conditions were studied regarding the street network, traffic organisation, road facilities, cargo, rail, public transport, active travel, and air.

3.11 The following aims related to transport were proposed:

- Citizens should be able to use public transport services quickly and conveniently and parking needs should be regulated to reduce traffic intensity and congestion.
- Ulaanbaatar should implement its own tax policy in the special economic zone to help solve the issues faced by citizens including air pollution, public transport, congestion, and the living environment.

- Regulations should be placed on used cars such as banning cars over a certain age.

Wider considerations

3.12 E-mobility should be seen in the context of Ulaanbaatar's congestion and air quality challenges and policy goals for a shift towards sustainable urban mobility. Key considerations include:

- Air pollution benefits from EV transition should factor in the relative impact of HEV segments relative to ICEV dominated sectors (e.g., buses and light vans), and the benefits of different use cases (e.g. high use commercial vs light use personal)
- Support for efforts towards addressing congestion, ensuring that promotion of transport electrification does not lead to additional motorisation (either in fleet size or total vehicle mileage)
- Wider support for sustainable urban mobility goals, including e-mobility in the context of prioritisation of public transport and active mobility within a framework of 'Avoid-Shift-Improve' (e.g. through green corridors).

E-mobility policy coordination

3.13 Mongolia has been quick to adapt to the arrival of EVs over the last two years, with different national and Ulaanbaatar-level actors taking actions to support the creation of an e-mobility ecosystem and to promote EVs. There is not yet a single national strategy or roadmap which aligns e-mobility with national policy objectives, or which coordinates actions to support deployment of EVs in a way which supports these objectives.

E-mobility policy stakeholders

3.14 The list of key stakeholders engaged through this study is shown below, with transport/mobility aspects considered first (from a transport, energy, and municipal perspective) followed by the energy sector (policy, economic regulation, and transmission).

Table 2-4: Public stakeholders interviewed for this assessment

Transport	Environment	Energy	Municipality

Ministry of Roads and Transport Development	Ministry of Environment and Tourism	Ulaanbaatar Energy Distribution Network Company	Public Transport Department (PTD)
		Energy Regulatory Commission	Project Management Office of World Bank Ulaanbaatar Sustainable Urban Transport Program (USUTP)
		Ministry of Energy	Public Bus Company
		National Dispatching Centre	

3.15 From a transport-sector perspective, the key stakeholders in policy development related to e-mobility are:

- **Ministry of Road and Transport Development (MRTD),** specifically its Transport Policy and Incentives Division. The MRTD is responsible for the overall transport sector in the country. It is supportive of EV deployment in Mongolia based on the potential to mitigate vehicle emissions and air pollution and has actively supported policy, regulatory, and fiscal initiatives to promote them.
- **Ministry of Environment and Tourism (MOET),** specifically its SDG and Climate Change Policy Division. MOET is responsible for policy to mitigate the environmental impacts of Mongolia's transport sector, including GHGs, air pollution, and vehicle waste management. It is strongly supportive of EV deployment, also promoting policy, regulatory, and fiscal incentives to promote EVs. It has also coordinated EV ecosystem development activities through EV fairs and recent coordination with local EV suppliers for them to form the EV Association of Mongolia (EVAM) to voice private sector ecosystem needs.
- **Municipality of Ulaanbaatar (MUB)**. Engagement with MUB has been through the PTD and the city's Ulaanbaatar Sustainable Urban Transport Programme (USUTP) which is working with the World Bank to coordinate urban mobility policy and investments. The city has taken various initiatives to support EVs in the city, including ongoing investment in a fleet of e-buses and deployment of EV chargers, as part of their parking remit.
- **Ministry of Energy (MOE).** The Energy Policy Department in MOE is responsible for the development of energy policy in Mongolia and supporting the legislative, regulatory, and programme actions for its delivery. MOE considers areas including energy security, decarbonisation, and economic aspects. It is also responsible at

policy level for ensuring that the electricity system in Mongolia is contributing to wider energy policy and meets long term capacity needs.

- **Government of Mongolia (GoM),** specifically the Customs General Administration. It sets the import excise tax rates for vehicles by type, engine size and age, and are therefore influential in determining the price competitiveness of EVs in the Mongolian market.

3.16 It should be noted that public-private partnerships can be implemented by MUB, the Government of Mongolia, Ministries and International organizations.

E-Mobility policy coordination

3.17 Prime Ministerial Resolution 108 (dated 12th June 2023) mandates the creation of a cross-governmental EV Working Group at ministerial level. The Working Group will be responsible for "studying in detail the issues of increasing the use of electric vehicles of a certain motor capacity, and providing management and organisation for presenting, approving, and implementing solutions". It is not clear if the resolution has yet been implemented, or the agenda, or contents of discussions arising from it.

3.18 According to the Resolution, the Working Group is to be chaired by the Minister of MRTD, also including Minister for Ulaanbaatar[29]; Minister of Environment and Tourism; Minister of Mining and Heavy Industry; Governor of Ulaanbaatar; State Secretary for the Ministry of Foreign Affairs; State Secretary of the MOE; and State Secretary of the Ministry of Economy and Development.

E-mobility goals and ambitions

3.19 Mongolia does not have any formal targets for the number of EV's deployed, however the MRTD has a working estimate of 30,000 EVs in operation by 2030 based on current policy and plans[30]. While this would represent a 70% annualised rate of fleet growth (based on the 700 vehicles in circulation as of June 2023, this would still only result in 4% of the overall vehicle fleet in Mongolia as EVs (7% of Ulaanbaatar if focused here).

3.20 In March 2023, the OECD's International Transport Forum (ITF) conducted a multi-stakeholder scenario development and validation workshop on the topic of transport decarbonisation for Ulaanbaatar[31]. Local experts were asked to propose contextually appropriate future targets for different transport interventions, including the transition

[29] Dual role also includes Head of the National Committee to Reduce Traffic Congestion in Ulaanbaatar
[30] Ministry of Foreign Affairs - EV adoption presentation
[31] Workshop proceedings are available here: SIPA-T Mongolia Repository | ITF (itf-oecd.org)

to EVs for both 2030 and 2050. Considering the Baseline Scenario (business as usual), stakeholders anticipated that EVs will represent 0.14% of the car fleet and 50% of the bus fleet by 2030 and 16% of the car fleet and 70% of the bus fleet by 2050. This increases up to 2.3% and 50% respectively in the 2030 Climate Ambition Scenario and 50% and 100% for 2050. The projections and targets are shown in Table 3-1.

Table 3-1: Key OECD-ITF Sustainable Urban Mobility Scenarios to 2030 and 2050

Area	Measure	Baseline Projection		Climate Ambition Target	
		2030	2050	2030	2050
Vehicle Tech.	Share of private car fleet that is electric (%)	0.14	16	2.3	50
	Share of bus fleet that is electric (%)	50	70	50	100
Infrastructure Expansion	LRT Network (km)	39	100	39	150
	Cable Car Network (km)	23.1	20	23.1	50
	Bus Network (km)	4100	4100	4100	4100
	Bike Network (km)	815.7	1600	815.7	2400
	Pedestrian Network (km)	734.6	1400	900	2600
Public Transport	Bus Speed (% increase from current speeds)	5	10	5	Up to 20
	Bus Priority (% of network)	22	30	60	100
	Public Transport Promotion (% reduction in cost of trips)	25	30	36	80
Shared Transport	Shared Bikes and Scooters (# of vehicles deployed)	1400	3000	2800	6000
	Car Occupancy Rate (% increase from current level)	5	10	5	10
	Parking (% of space in the city centre with parking access restrictions)	5	10	30	70

EV policy actions at national level

3.21 At national level, MRTD and MOET have been working on the development and implementation of transport sector policies to support e-mobility. While many necessary and positive steps have been taken, current promotion of the technology is not clearly aligned to specific goals/targets (e.g. decarbonisation, air quality) nor is it clearly coordinated among responsible/impacted agencies. Key initiatives are included in Table 3-2 below.

Table 3-2: National level policy actions

Policy / Programme	Responsible	Status
Development of EV and Charging Standards	MRTD	EV Standards approved and applicable since August 1, 2018, through MNS 6728:2018. EV Charging Standards approved and applicable since 2019, through MNS 6758: 2019 Further review in Technical & Regulatory Barriers section.
Regulation to reduce customs taxes on EV imports by 50% (vis-à-vis ICEV)	MRTD	Government Regulation issued 2021, but not yet implemented by customs authority.
Implementation of green number plates for EVs	MRTD/NSO	Regulation approved and implemented. EVs now operating with green plates, offering benefits in Ulaanbaatar[32].
Implementation of chargers outside of Ulaanbaatar along main roads	MRTD	10 implemented, 25 more planned Prime Ministerial Order issued; not yet implemented; Status unclear.
Conversion of public official vehicle fleet to EV	MRTD	Paused, reportedly due to unwillingness of international suppliers of chosen vehicles to offer in country technical support /maintenance services.
Awareness – EV Fair	MOET	An EV fair was held in Ulaanbaatar in June 2023 to raise public awareness and support market development by local suppliers.
Facilitating creation of EVAM.	MOET	MOET facilitated the creation of EVAM. Formation was agreed in June 2023 as an industry association to represent the needs of ecosystem stakeholders. EVAM was reportedly to be chaired by Leaf Centre with membership of 15 other companies.

Future national government priorities for roadmap development

3.22 Engagement with MRTD and MOET has identified a wide range of proposals and focus areas for future development to support the development of the EV sector. Based on

[32] Implementation of green number plates allows for implementation of policies directed at promoting EVs (in a context without effective automated number plate recognition-based enforcement and reliant on visual identification and social enforcement). This currently primarily relates to exemption from circulation restrictions in Ulaanbaatar.

interviews and subsequent follow-up of the consultant team, these initiatives are understood not to have moved beyond early conceptual status. Some of the areas raised for EV market development include:

Ministry of Roads and Transport Development

3.23 MRTD has been supporting the wider Government of Mongolia in the development of overarching government policy and strategy. Notwithstanding any further policy development (within the framework of the Prime Ministerial Resolution), an indication of MRTD's EV priorities include:

- Identifying mechanisms to connecting EV charging facilities to the energy network within the framework of public-private partnership.
- Identifying mechanisms for incorporation of renewable energy sources (RES) within EV charging systems.
- Programmes to incentivise private sector implementation of public EV charging stations (e.g., in private parking lots).
- Transition of the government vehicle fleet to EVs.
- Further restrictions on ICE commercial vehicles from driving in Ulaanbaatar.
- EV tax exemptions (including vehicle registration fees and road use tax).
- Fiscal incentives to EV operation, such as 100% exemption from parking fees.
- Providing financial support to start-up entrepreneurs in the EV field.
- Research and innovation in the field of battery recycling.

Ministry of Environment and Tourism

3.24 With its more cross-government scope, MOET has identified priorities in terms of supporting market development and addressing barriers to user acceptance:

- Promotion of supercharging along highways (every 200km on major highways).
- Regulations/requirements for EV charging facilities in residential and commercial buildings.
- Development of National Standards on EV Charging.
- Consideration of parking-based incentives for EVs.
- Fiscal incentives for EV purchase (capital costs).
- Tightening regulatory standards on ICEVs to reduce TCO differential (e.g., Increase fuel standards to EURO V).

EV policy actions at Ulaanbaatar level

3.25 Municipality of Ulaanbaatar has also taken actions to support the development of e-mobility. These are outlined below in Table 3-3, and include a major commitment to electrification of public transport and the deployment of EV chargers across the city (initially through its own investment, alongside development of a public-private partnership model for deployment in privately operated car parking lots). Building on the opportunities from the passing of green licence plate standards, EVs have also been exempted from circulation restrictions. This has increased the attractiveness of EVs for commercial fleets (e.g., see APU case study above). While many of these actions as positive, they have not been implemented within the framework of a clearly defined set of objectives or strategy.

Table 3-3: Ulaanbaatar level EV policy actions

Policy / Programme	Responsible	Status
Exemption of EVs from Ulaanbaatar circulation restrictions	MUB	Implemented. Green licence plate vehicles are exempted from 1 day per week circulation ban (which applies to HEV and ICEV).
Implementation of e-buses on urban routes	MUB (PTD)	Pilots of two brands of e-buses as described above. PTD report 156 additional e-buses on order.
Implementation of public EV chargers in Ulaanbaatar (22)	MUB	Completed
Ordinance for the implementation of EV charging in 25 public car parks	MUB	Ordinance Approved / Implementation Pending
Accepting approach to e-scooter implementation	MUB	Implemented

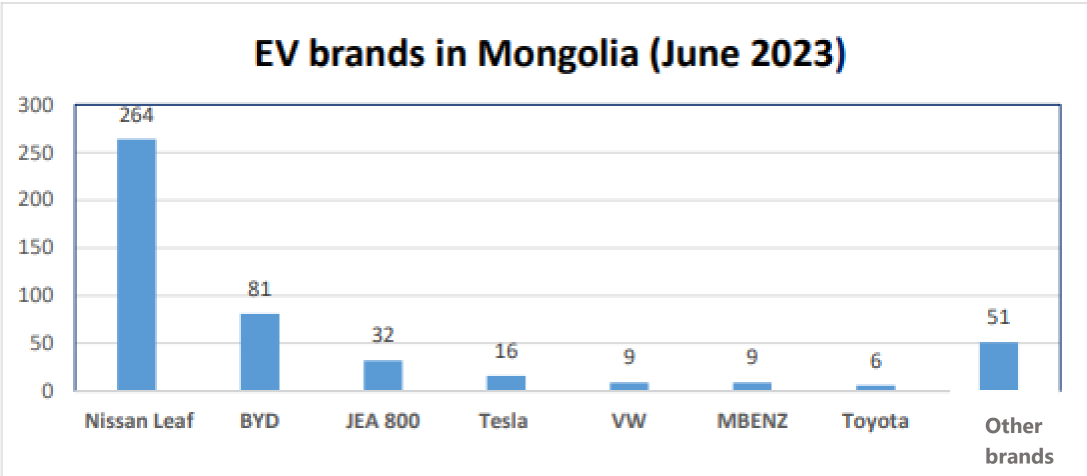
4. E-mobility market and deployment experience

EV deployment overview

4.1 This section outlines the current position and existing experience of Mongolia in the EV market, considering implementation models, supply chain, and experience across segments. As of December 2023, 1,061 EVs were in operation in Mongolia[33]. While this represents only 0.1% of the vehicle fleet, it represents growth of 243% since 2020[34]. All of these are private cars, with the exception of 32 Trolleybuses (JEA 800) and 55 Battery Electric Buses (included on the right-hand column under "Other brands").

4.2 Engagement with stakeholders found a generally supportive approach to EVs. Key drivers for government policy stakeholders include the air quality agenda (particularly in Ulaanbaatar) and energy security (as outlined above). Retailers reported that the low energy cost (and therefore operating cost) is a key selling point, while positive experience of hybrid technology in the Mongolian climate reduces (to an extent) technology anxiety. E-mobility does, however, remain a relatively new concept, despite rapid growth and increased prominence over the last two years.

Figure 4-1: EVs registered in Mongolia



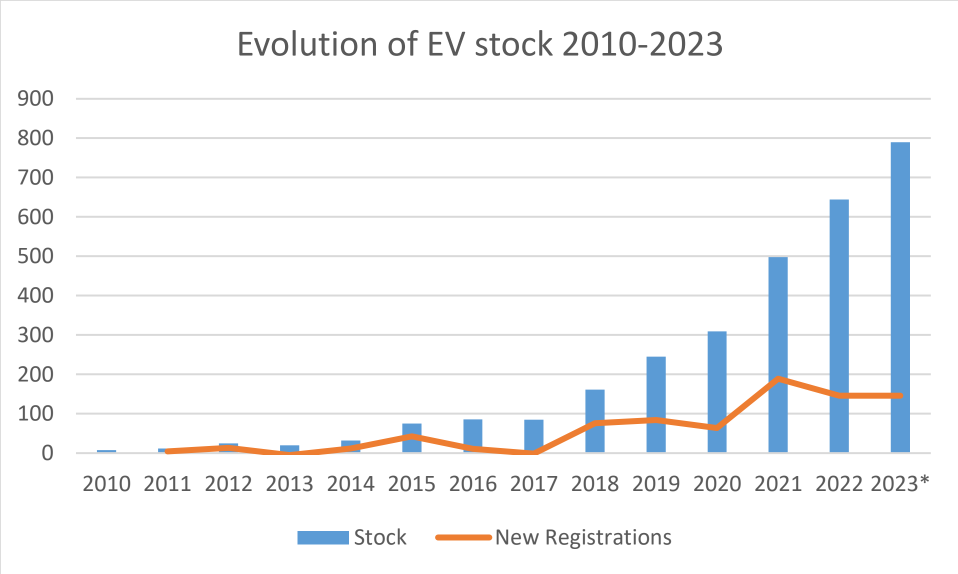
Source: Mongolian Ministry of Foreign Affairs

[33] MRTD. (2024). Increase the use of electric cars, electricity on the establishment of car charging centers. Mongolian Ministry of Road and Transport Development.
[34] Mongolian Ministry of Foreign Affairs. (2024). *Vehicle Data* [Dataset].

Trajectory of EV deployment in Mongolia

4.3 The trajectory of EV growth in Mongolia is shown in Figure 4-2 below. Average EV stock growth over five years has been of 38%, with MRTD reporting that the sector has particularly developed since 2021. At the same time, it should be noted that the sector remains very small, representing 0.1% of the 775,000 vehicles registered in the country.

Figure 4-2: EVs registered in Mongolia[35]



Battery electric buses

Background

4.4 As the largest and most developed public transport system in Mongolia, electric bus investment has focussed almost exclusively on the capital city. As part of the city's journey towards higher air quality and a more sustainable transport system, Ulaanbaatar's PTA wishes to significantly increase its deployment of e-buses in the city fleet by 2050. The Agency has deployed a number of different e-bus models in the city as part of recent procurements for fleet renewal. These include a pilot of 8 Jinlong 12m e-buses (red) and a further 45 Skywell e-buses (12m buses and double deckers). The details of these are outlined in Table 4-1 below. The buses are charged through fast chargers located at bus depots and are equipped with diesel heating to mitigate the impact of the extremely cold winter months upon bus performance.

[35] 2010-2020 based on National Auto Vehicle Centre data sets, updated with 2021 and 2023 figures as reported through secondary sources.

4.5 Outside of the capital, there is only one city investing in e-buses. Darkhan has announced that in late 2023 it will be introducing a new fleet of over 20 Skywell 12m e-buses. There are currently no other significant urban bus systems in Mongolia, meaning that the majority of e-bus potential is focused on these cities.

Implementation model and procurement

4.6 E-buses in Ulaanbaatar have been implemented using the existing public transport investment and operational model, with conventional public procurement (tendered through local importers). E-buses procured to date have been allocated to the two public operators (who make up 2 of the 18 network operators and 30% of the fleet[15] under the PTD). The terms of this allocation (e.g. transfer of ownership or leasing) have not been shared, however it is understood to be on the same terms and process as for ICE buses.

4.7 E-bus ranges vary by model and route, but in general have a range of 150km in summer months, with a reduction of 25% in the winter (although this reduction varied by source consulted) due to a combined impact of battery performance and increased route congestion (as the e-buses operate along Peace Avenue, Ulaanbaatar's busiest corridor). Considering the operating hours of the fleet in Ulaanbaatar, the e-bus range is insufficient for a full day's duty cycle, necessitating the buses returning to the depot for charging (once per day in summer, twice in winter – charging occurs during the middle of the day). This is managed operationally through the removal of the vehicle from service for one duty cycle per charging (potentially 90 minutes) providing the driver with time to return to depot, recharge (30 mins) and return to the start point. This removal from service tends to happen during the middle of the day, reducing service frequency and in-service kilometres (and therefore fleet productivity), however minimising impact on peak user demand (and potentially total fleet size impacts).

4.8 The bus operating contract for Ulaanbaatar is based on a rate paid per hour of bus operation in line with performance. This covers operating costs, with vehicle capital cost provided (*de facto*) by the public sector. The hourly rate has been adjusted to reflect the lower e-bus operating cost profile for e-bus operators. It appears they are not compensated for the time spent charging (the additional cost to the operator may, for example, offset the reduced energy costs compared to ICE).

4.9 Charging infrastructure is installed at the depots with one fast charger provided per four buses. In the case of the Yinlong buses, one 350kW charger with 2 connections was provided directly by the OEM and installed by the operator at the depot site. The existing trolleybus fleet of Zorchigch Teever Negtgel (PTD operator) means that installation built upon the electrical engineering expertise of this department. Regarding e-bus charging, the specification for the 240kw charger is displayed in Appendix 1.

Operating experience and plans

4.10 Engagement both with the PTD and operator found satisfaction with the performance of the e-bus technology, with limited adjustments required to accommodate operation and maintenance. Operating costs (to the operator) were reported (on site visit) to be much lower than for traditional ICE buses on account of the low energy tariff (further details can be found in the Total Cost of Ownership section). Nevertheless, three challenges were identified which would need to be assessed, particularly prior to private operator implementation:

- E-bus charging strategies, which see buses returning to the depot one or more times per day during operational hours. This impacts upon operational productivity, both in terms of reducing capital investment productivity but also associated human resources.
- Deployment of e-buses to date has been through public operators, who also operate a fleet of trolleybuses. The technology learning curve has therefore been less steep than it may be in the future for private operators (who operate only ICE vehicles).

4.11 The 2023 fleet renewal tender included provision for 156 new battery electric buses (as part of an overall purchase of 800 buses). The procurement for this renewal package was not successful, and the replacement tender resulted in the purchase of 507 Yutong EURO V diesel buses, and no electric buses. While there is still a requirement for further bus fleet renewal in the short-medium term, it is not known if this is expected to include further BEB procurement.

Table 4-1: E-buses currently deployed in Ulaanbaatar

Manufacturer	Nanjing Golden Dragon			Yinlong Dolphin Group
				
Operator	Zorchigch Teever Negtgel 1 (PTA)			Zorchigch Teever Negtgel 2 (PTA)
Bus length	12 m			
Fleet size	37 + 8	10	160	8
Cost (each)	588,000,000 ₮ 170,000 USD	777,000,000 ₮ 220,000 USD	625,000,000 ₮ 180,000 USD	620,000,000 ₮ 180,000 USD
Range of full charge	200 km	400 km	-	200 km
Battery capacity	250 kWh	322 kWh	250 kWh	210 kWh
Charger capacity	240 kW			
Heated by diesel?	Yes			
Cost per charger	76,842,000 ₮			

Trolleybuses

Operation and experience

4.12 In addition to Battery Electric Buses, it is important to note that Mongolia has operated electric trolleybuses in Ulaanbaatar since 1987, with overhead catenary infrastructure designed for a fleet of 150 buses (see Figure 4-3). As the fleet has aged, buses have been taken out of service at a faster rate than they have been replaced. However, there are still 42 trolleybuses still in operation along two routes operated by the PTA. The original ZiU-9 type vehicle is the mainstay of the city's trolleybus system, although in 2007 they were joined by several Hyundai Aero City 540 vehicles which were converted from diesel power[36].

Future deployment

4.13 There are no current plans to expand the trolleybus system in the city due to issues with the existing infrastructure (ageing catenary infrastructure and trolley buses which frequently disconnect from the catenary, leaving buses stranded), according to engagement with UBEDN. The existence of the network does, however, have potential benefits in terms of:

- Experience in the maintenance and operation of EV typologies (held by the Public Bus Operator 1).
- Experience of the Public Bus Operator in electrical engineering and its relation to vehicle operations.
- Existence of overhead catenary with the potential for use by hybrid (battery equipped) trolleybuses.

Figure 4-3: Ulaanbaatar Trolleybus

[36] *Wikiwand - Trolleybuses in Ulaanbaatar*. (n.d.). Wikiwand. https://www.wikiwand.com/en/Trolleybuses_in_Ulan_Bator

Personal EVs

4.14 As shown in Figure 4-1, the majority of the EVs in operation in Mongolia are private vehicles. Nissan Leafs have been the most prevalent model in Mongolia (similar to other markets in the region such as Kazakhstan). While a breakdown of the EV age profile has not been provided, anecdotally they are understood to predominantly be second hand imports from Japan. The other significant brand is BYD (from neighbouring China) and other luxury brands including Tesla and Mercedes-Benz (understood to be imported new or almost new).

4.15 This section provides an overview of the experience of used and new EVs as personal cars in Mongolia, based on primary stakeholder engagement and subsequent data sourced as part of this assessment.

New vehicle market and supply chain

4.16 There are new vehicle distributors for BYD, Mercedes, and GD already established in Mongolia, with Hyundai reported to be setting up distribution next year. OEMs are providing an ~8-year warranty on new EV purchases, with distributors providing routine maintenance and servicing.

4.17 MSM Group observes that, in the new vehicle segment, EVs have represented as much as 45% of total sales in the last 12 months (in the context of a very small new vehicle segment in Mongolia). Low operating costs and EV freedom of road use (ICEVs and hybrids are not allowed to operate inside Ulaanbaatar on 1 day per week as part of congestion regulation) are seen as the main benefits to EV owners. Furthermore, Ulaanbaatar is a compact city in a very remote location, with limited destinations in a routine driving distance. As a result, there is limited day-to-day usage range anxiety for city driving. At the same time, there is a strong culture of travelling to the countryside, and on occasional long journeys, for which EVs may be more challenging.

4.18 Financing is available for new EVs in Mongolia, with subsidised financing through the Green Climate Fund and Mongolia Green Financing Corporation via commercial banks. This makes annualised interest rates approximately 4-5% lower than for ICEVs.

Second hand market and supply chain

4.19 In the second-hand market, Nissan Leaf has been the main EV brand, imported from Japan under the same market incentives (supply of used vehicles with limited Japanese or international market) as is the case for Japanese hybrid and ICEVs, alongside significantly reduced excise tax for EVs. The capital investment cost for a Nissan Leaf (compared to an equivalent hybrid Prius) would be approximately 30-40% higher in the local market, despite units being sold for as little as 15,000,000 MNT (US$4,500). This extra expenditure would be recouped in saved costs on excise tax when compared to importing an ICEV. However, the savings would not recoup the extra capital expenditure when compared to most hybrids.

EV financing

4.20 Financing is available for both new and used EV imports both through commercial banks and other financial services providers. Commercial banks offer specific EV loan schemes with concessional rates using financing from the Green Climate Fund[37] via the Mongolia Green Financing Corporation. These offer interest rates 4-5% lower than typical ICEV or hybrid financing (14-15% annually). Financing for used EV exists, with Leaf Centre quoting rates in a range of 3% for up to 50m MNT (US$14,000) and 14% beyond that. These tend, however, to have a more limited loan duration (no greater than two years).

Operating experience and trends

4.21 Higher range EVs have had a positive entry to the market. Advertising and user experience highlights the low operating costs while claimed ranges of 450km in urban traffic are sufficient for destinations in the region around Ulaanbaatar. Given the remote geography of Mongolia there are relatively few intercity/long distance journeys, and so EV range covers the vast majority of trips. The prevalence of dedicated parking spaces in modern apartments blocks in the city enables the installation of captive overnight home charging points. While energy demand for individual (or even several) EV home chargers can be accommodated by existing apartment block grid connections, as EV penetration increase, the cumulative impact may result in pressures at building and substation level.

4.22 More mass market EV options, particularly the Nissan Leaf, have had a more mixed market response based upon consultations with the Leaf Centre[38]. Older Nissan Leafs have often suffered from poor range, as low as 75km in the extreme winter temperatures. As a result, Leaf Centre (responsible for 65% of EV imports) has ceased their importation and instead promotes the Chinese-made BAIC EU5 as the entry-level

[37] The Green Climate Fund (GCF) – a critical element of the historic Paris Agreement - is the world's largest climate fund, mandated to support developing countries raise and realize their Nationally Determined Contributions (NDC) ambitions towards low-emissions, climate-resilient pathways. (Green Climate Fund, n.d.)
[38] Leaf Centre is an independent local importer not formally affiliated to Nissan

second-hand sedan EV (a three-year-old version of which costs approximately $19,000) and offers a range of up to 400km.

Public charging infrastructure

4.23 There have been various initiatives for the deployment of public charging infrastructure in Ulaanbaatar (and potentially outside). These can be broadly categorised as:

4.24 Public sector led charging stations: MUB has delivered 25 charging stations around the city. Furthermore, an ordinance has been signed to provide EV charging facilities in 71 public commercial car parks around Ulaanbaatar through private operators (see Figure 4-4). This has not, as of June 2023, been implemented.

4.25 Commercial charging stations: Various businesses have deployed public charging infrastructure in the city. These include:

- For-profit charging interests (e.g., PetroVIS) seeking to develop an EV charging business model.
- 'Affinity' charging stations for businesses seeking to attract clients to their businesses and for market positioning (e.g., Emart; see case study).
- EV retailers seeking to support the development of the EV market. For example, Leaf Centre is planning to deploy 8 rapid chargers in the areas around the capital (within a 250km radius) at which customers will be able to charge vehicles for free for two years.

Figure 4-4: Locations of parking lots in MUB's mandate for future EV charger deployment

Deployment case studies

4.26 This section illustrates some of other examples of private-sector led EV and infrastructure deployment in the Mongolian context, covering charging infrastructure, e-vans, and e-scooters It is intended to provide qualitative insights on the level of development of the e-mobility ecosystem in Mongolia, current initiatives and deployment experience.

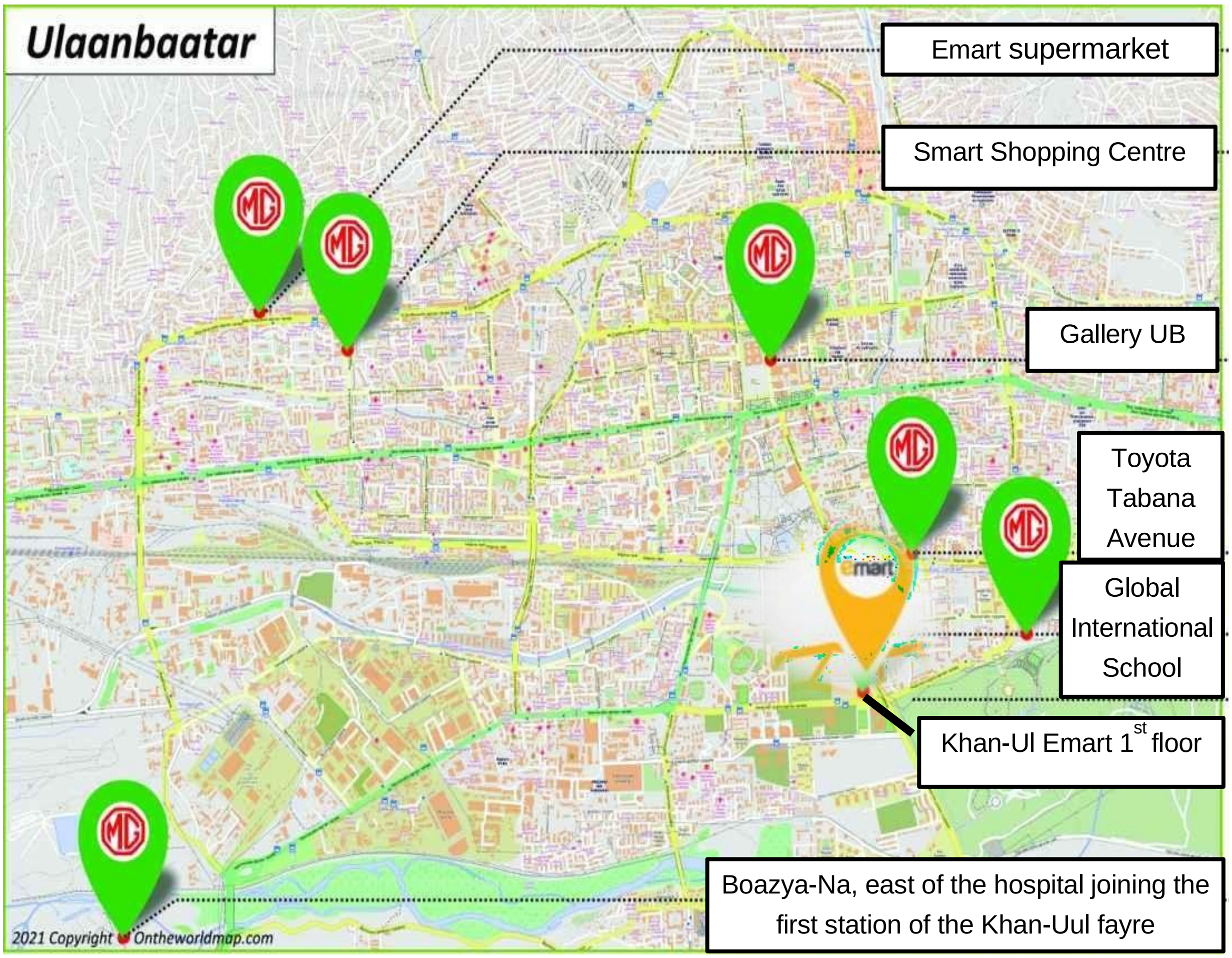
Case study: Commercial charging infrastructure

4.27 Emart is a South Korean supermarket chain which has recently expanded its operations to Mongolia. It has installed EV chargers at two locations in Ulaanbaatar, as shown in Figure 4-5, as part of Global Motors' (Mongolia's distributor of MG Motors vehicles and chargers) deployment of seven EV chargers across the city[39].

4.28 This is part of a branding strategy looking to position Emart as a more sustainable choice to its competitors, and also in anticipation of growing demand for EV charging from its customers in the coming years and as a way of establishing itself in this new market.

[39] Ochirjamaa, B. (2020). *Global Motors averts plan to install 20 EV charger*. https://www.pressreader.com/mongolia/the-ub-post/20200608/281565177991064

Figure 4-5: Locations of Global Motors' chargers



Source: Emart

Implementation approach and operation

4.29 Chargers at six of Global Motors' locations use regular 20kW chargers, whilst the Khan-Ul Emart hosts a fast, 60kW charger, which can charge two cars simultaneously.

Emart's 60 kW charger

- **Model** – SETEC Power 60kW
- **Total cost of installation** (inc. price of charging unit) – 23,928 USD (82,553,900 ₮)
- **Estimated cost of electricity /month** – 57.97 USD (200,000 ₮)

4.30 The business model that Global Motors uses for EV charging is based upon smart cards. Customers wishing to use the SETEC chargers are required to acquire a SETEC EV charger card, with at least 2.90 USD (10,000 ₮) loaded to their card. The energy cost at these stations is 0.06 USD (200 ₮) per kWh to charge an EV (only marginally above the energy tariff from the distribution network).

4.31 Global Motors had originally planned to install chargers in twenty locations when they began introducing EV chargers to Ulaanbaatar, but the company has paused its rollout, citing slow business and a lack of customers at its current locations (Figure 4-5).

Case study: Light freight vehicles use

4.32 Mongolia's largest brewer and beverage manufacturer, APU (Absolute, Pure, Unique), has purchased two light cargo vans (with five larger BEV freight vehicles ordered), which are being deployed for last-mile distribution of wine-to-wine stores within Ulaanbaatar city centre from APU's warehouse. Interviewed as part of data collection for this study, APU has stated that the e-van initiative was intended to reduce overall fuel cost and consumption and increase fleet productivity (not being subject to weekly circulation restrictions). While positive about the project experience when interviewed, it is too early to conclude the extent to which these objectives have been realised.

4.33 The vans also provide a marketing opportunity around APU's corporate social and environmental responsibility commitment.

APU's pilot BEV vans

- **Model** – BYD T3
- **Fleet size** – 2
- **Load capacity** – 800 kg
- **Cost** – 123 million ₮ (approx. US$ 35,400) per vehicle
- **Range** – in practice, 200 km in congestion, 250 km with light congestion (significantly less in winter)

Implementation model

4.34 The vehicles were purchased outright by APU from MSM automotive; they are owned and operated independently by the company (no third-party freight company is involved). The chargers for the e-vans were installed free of charge by BYD, connecting to the existing warehouse power supply. Typically, charging commences once the vehicles have returned from their final delivery (around 20:00-21:00). There is no scheduled charging overnight to charge at times of lower demand, but the chargers do cut off the electricity supply to the vehicles once they are fully charged.

Figure 4-6: A BYD T3

Source: Vanzey Pte Ltd

Operating experience and future plans

4.35 Overall performance of the vehicles has been within the daily range requirement of the vehicles for city use. APU has found that the range of their vehicles tends to be 200 km ordinarily (when negotiating heavy congestion), and 250 km if operating in light congestion (compared to an OEM stated range of 300km). Given the e-vans have only been operating since June 2023 their winter performance is not yet known, however it is expected that the range will reduce significantly. Depending on the extent of the range reduction, this may require modifications to be made to the fleet's delivery operations (i.e. incorporating time for charging during the day).

4.36 The company plans to expand its existing fleet of freight vehicles with BEVs. This is driven not only by the company's desire to be seen as an industry-leader in social and environmental responsibility, but also because it has found that EVs are more comfortable for their drivers, whilst producing less air and noise pollution in their warehouse.

4.37 A company spokesperson reported that tax exemptions for EVs (particularly for business purposes) would accelerate the company's EV adoption, although it is not clear whether this means that EVs are currently financially unviable without tax exemptions or that this would make already viable EVs more attractive.

Case study: E-Scooters

4.38 The multinational e-scooter rental platform JET Sharing has been operating in Ulaanbaatar since May 2023 under a franchise agreement to a local owner. The company also began operating in Erdenet, Mongolia's third city, in August 2023[40]. However, information is limited on this city's operation, so this chapter focuses on Ulaanbaatar.

4.39 JET Sharing is relatively new, having only launched in 2021 in Almaty, and typically operates in countries in Central Asia and Eastern Europe.

JET e-scooters in Ulaanbaatar

- **Fleet** – 700 scooters introduced at the start of the trial
    - Fleet of 3,000 planned for the city
- **Operational season** – 1st May to 1st November
- **Tariff** – 600 ₮ (US$ 0.17) + 250 ₮ (US$ 0.07) per minute, or 14,100 ₮ (US$ 14.09) for 1 hour[1]
- **Operational cost** – approx. 25 million ₮ (US$ 7,250) per month

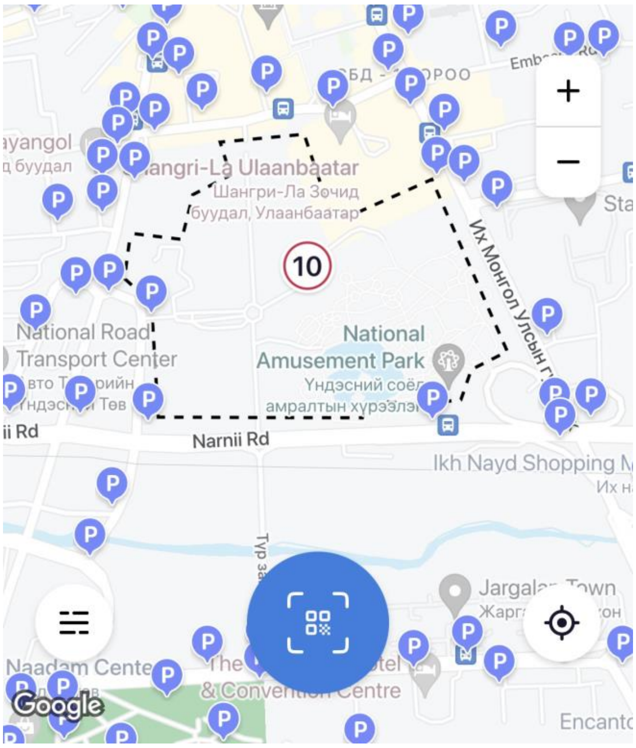
Implementation model

4.40 The initial pilot has seen JET deploying 700 of the scooters within an operational area which extends from Sapporo Interchange in the West to Officer mini-district in the East, and 100 Ail bus stop in the North to Zaisan Hill in the South (see Figure 4-7). The scooters have a range of up to 70km per full charge[41], according to the manufacturer (assuming a 75kg load, operating at an average speed of 16km/h in a 25°C environment), and have a maximum speed of 25km/h. However, the scooters are limited to 10km/h and cannot be parked in the city centre.

[40] JET. (2023). *JET*. https://www.facebook.com/p/%D0%AD%D1%80%D0%B4%D1%8D%D0%BD%D1%8D%D1%82-Jet-100064705747525/?paipv=0&eav=AfYYYuyxp9O6sz1NmNaWF1QbHC_pvOVytHUC5fOcxS2_RkuZbj4N1BCBovHuQyqN6H8&_rdr

[41] Segway-Ninebot. (n.d.). *MAX G2 e*. United Kingdom - English. https://uk-en.segway.com/products/ninebot-kickscooter-max-g2e-powered-by-segway

Figure 4-7: 10km/h speed limit and parking-free zone



Source: JET Scooter app (2023)

4.41 The e-scooters are only intended to be operational during the warmer months (May through October) to avoid battery life issues caused by extremely low temperatures in winter, when there is also lower demand for micro mobility and poor user safety due to the harsh conditions.

4.42 JET Sharing employ 50 staff in Ulaanbaatar who collect e-scooters for recharging in 25 small, flat-bed, diesel trucks (Kia Bongos and Hyundai Porters). Most of these staff are part-time and are not paid over winter, whilst there is no need for the e-scooters to be collected. The vehicles are taken to one of two existing charging facilities (one in Khanuul District and one in Sukhbaatar District), which also acts as a depot over winter. This is the only procedure used by the company for recharging the e-scooters; they do not swap batteries remotely. The operating model for Ulaanbaatar is estimated to cost approximately 25 million ₮ (US$ 7,250) per month.

4.43 Whilst the MUB has not actively facilitated or procured for the introduction of the e-scooter network, it has passively been supportive by not imposing restrictions or blockages to JET Scooter’s introduction and operation.

Figure 4-8: Ulaanbaatar JET e-scooter operational area

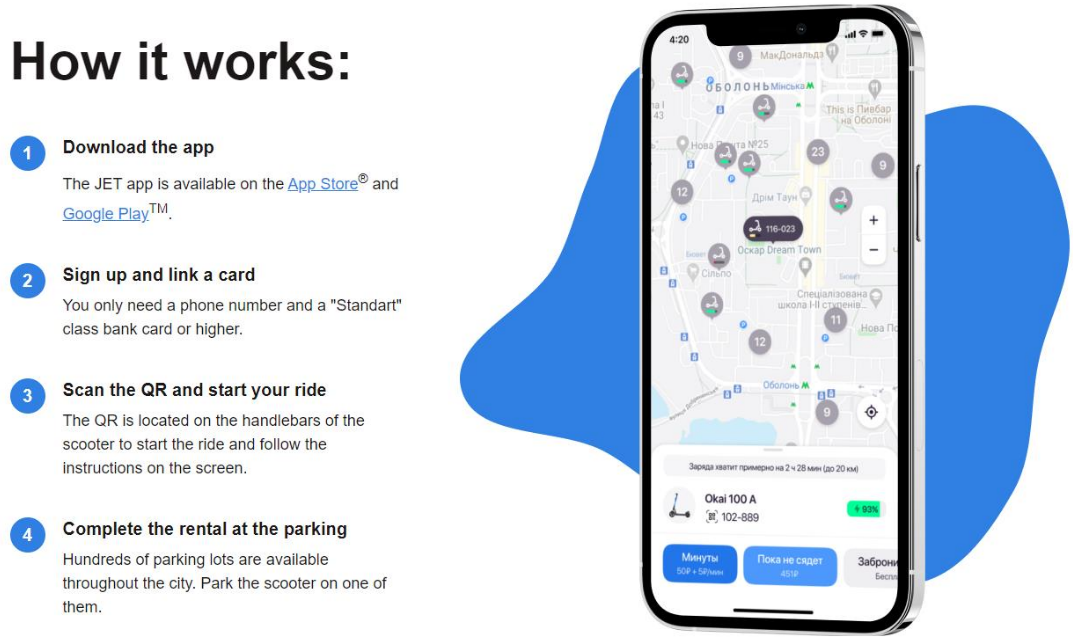
Source: JET Scooter app (2023)

Customer interface

4.44 Customers can access the NINEBOT2022 e-scooters using the JET Scooter app, which also provides the location of available e-scooters and parking spots around the city, as well as storing money in an e-wallet. Users must deposit a minimum of 4,000 ₮ (US$1.16 in 2023) in the e-wallet to hire an e-scooter. This provides the user with a ride of up to 18 minutes.

4.45 The fare is currently 600 ₮ + 250 ₮ per minute (US$ 0.17 + US$ 0.07), although this is an entry level pricing and there are plans for this to be increased over time. This is relatively expensive compared to bus fares in the city, which are a flat rate of 500 ₮ (US$0.14). However, when compared with purchasing a private e-scooter or using a taxi, the JET Scooter platform is an affordable alternative. Its attractiveness may also lie in offering an escape from Ulaanbaatar's heavy traffic, with car and bus speeds falling to average speeds of 5-10km/h in peak times in central areas.

Figure 4-9: JET Scooter app



Source: JET Scooter app (2023)

Operating experience

4.46 While anecdotally well utilised, JET's operation in Ulaanbaatar is not currently profitable, however return on investment is planned to be reached in 2-3 years. The operation does not receive financial support from Government.

4.47 The JET Scooter operation has encountered many of the issues common to e-scooter sharing platforms around the world, including reports of stealing, breaking, intentionally damaging, and improper use of equipment. Use of (and parking) of e-scooters on pavements has also been reported.

4.48 There are a number of additional issues which are more specific to Ulaanbaatar. From an operational perspective, the capital's particularly heavy congestion makes collection and recharging challenging. Meanwhile, the city is lacking in appropriate infrastructure for e-scooters to be ridden safely and efficiently.

4.49 For the future deployment of this EV technology, MUB could better accommodate the adoption of e-scooters with better infrastructure, such as smooth pedestrian footways, better provision of cycle lanes, dedicated e-scooter parking bays, and dropped kerbs and ramps.

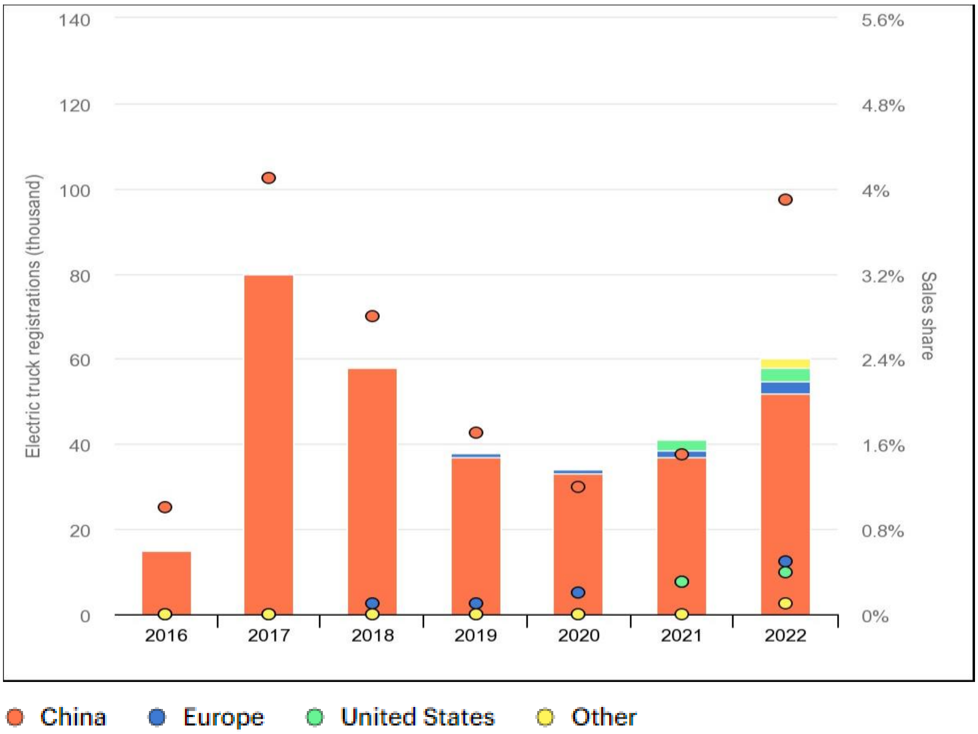
Readiness of other sectors

4.50 Recognising Mongolia as a frontier country for EV adoption, this study has focused on the most established EV vehicle segments and use cases for detailed analysis. A focus was also made on urban transportation, recognising the unique context of Mongolia as having a single large urban centre beyond which the population is extremely dispersed. As such, the following sectors were eliminated at strategic level:

Heavy freight vehicles

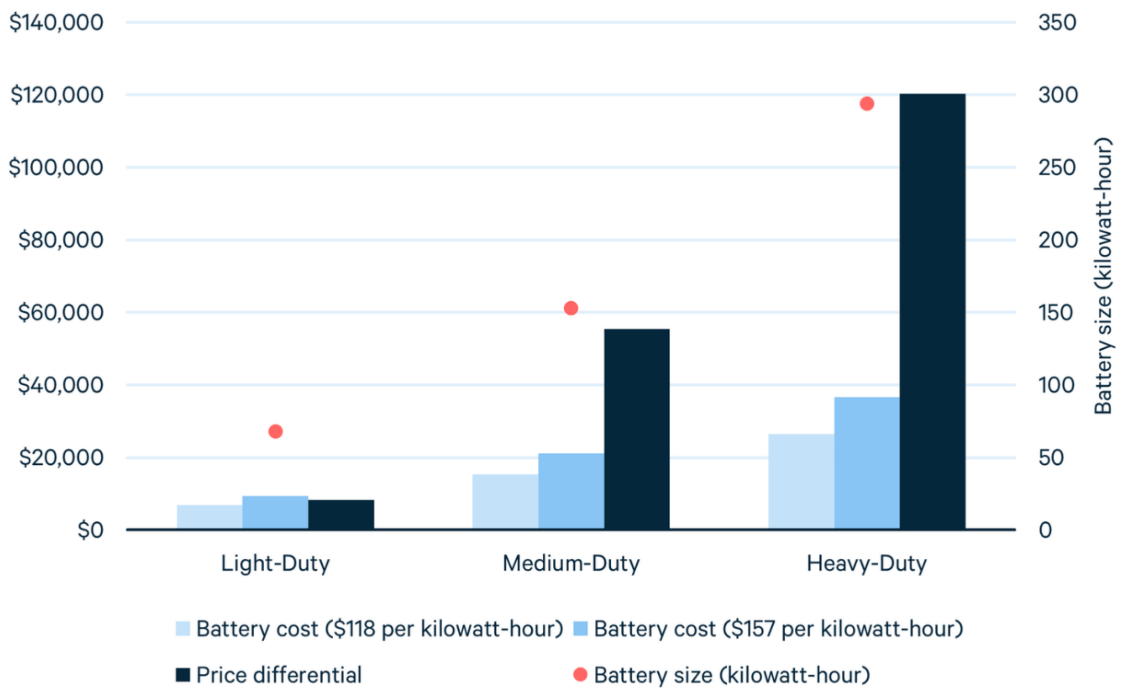
4.51 One of the 'hard to abate' transport sectors, heavy freight (particularly long distance) electrification remains in an early stage of development, and without a clear future trajectory (between different electrification technologies and hydrogen fuel cells). Globally representing 1.2% of sales (most of which in China) (Figure 4-10), electrification of Mongolia's heavy freight sector would imply navigating an extremely high TCO differential and EV battery costs (see Figure 4-11) driven by battery prices per kilowatt-hour. Additionally, it would require provision of superchargers (1MW) along major highways which, in a context as remote as Mongolia, would provide a costly and logistically challenging exercise for the energy grid. This emphasises the disproportional expense of heavy trucks compared to lighter-duty vehicles.

Figure 4-10: Electric truck registrations and sales shares by region, 2015-2021



Source: IEA, (2023)

Figure 4-11: Price differential and battery cost across vehicle type



Source: Resources[42]

Cycles and Motorcycles

4.52 While motorcycles have been a popular sector to electrify in much of Asia, in the context of Mongolia motorcycles are predominantly a mode for rural use (e.g., for animal herding) in often remote locations which are off-grid (e.g., Gers using off-grid solar). No electric motorcycles have been registered to date, as their engine capacity is below the capacity at which registration is required. However, it is well known that light electric off-road motorcycles (also known as Surrons – a common e-bike brand) have been imported into the country since 2019[43]. They are popular for their ability to handle Mongolia's variety of road qualities and for off-roading in the countryside, although they are also popular for driving around urban areas.

4.53 These electric off-road motorcycles typically cost between US$3,000-4,000 new but are also available for less as second-hand vehicles. They are usually charged at home by owners and have an effective cruise range.

[42] *Why are electric truck prices so high?* (n.d.). Resources for the Future. https://www.resources.org/common-resources/why-are-electric-truck-prices-so-high/

[43] Б.Анхтуяа. (2022, June 21). *Reckless teens riding electric dirt bikes cause crashes on roads - News.MN*. News.MN - the Source of News. https://news.mn/en/797627/

4.54 Combined with a small overall market size, focus on reliability and dispersed maintenance and servicing sector, this technology has not been taken forward for further analysis.

4.55 Besides Surrons, cycling has a very minor mode share in Ulaanbaatar and Mongolia more widely, with available data suggesting a rate of 0.63% of journeys (which may in fact already include Surrons)[44]. Key challenges here include infrastructure quality, road safety, air quality and climate extremes. While there may be some scope for e-bikes within a shared framework similar to the JET e-scooters (particularly in the context of wider sustainable urban mobility reforms), it is not considered a major opportunity area for e-mobility in the current state of transport development.

Readiness of Mongolian e-mobility sector summary

4.56 The examples above show that an active e-mobility ecosystem has been organically developing over the last few years in Mongolia.

4.57 This has been a joint effort across the public and private sectors. The MUB has been actively updating its bus fleet with BEVs and implementing supporting infrastructure, alongside some public electric charging facilities across the city for personal EV use. The Government of Mongolia also offers reduced excise duty rates for BEV imports. However, the private sector has been driving much of the early growth of the sector. For instance, early adopters of EVs for freight vehicles have done so with minimal government support.

4.58 The e-mobility market in Mongolia is in its early stages (even in comparison to a relatively fledgling market globally) but is following similar patterns of adoption as more developed markets. EVs are currently low in number but growing in both the public and private sectors, and shared micro-mobility options are available in the capital. Much can be learnt from more developed e-mobility markets to prepare a roadmap for further adoption in Mongolia.

[44] Eldev-Ochir, E. & Asian Infrastructure Research Institute. (2023). *ASSESSMENT OF URBAN MOBILITY: ULAANBAATAR*. https://www.itf-oecd.org/sites/default/files/itf-sipa_mng_dissemination_s3_p3_0.pdf

5. Mongolia's energy sector context

Sector overview

5.1 The electricity sector in Mongolia comprises several state-owned entities responsible for regulation, generation, transmission, and distribution of electricity. These entities operate under the framework of the "Single-Buyer Model", where a single wholesale buyer of electricity can choose from a number of different generators, with retail monopolies to consumers based on regionally determined distribution networks (which also act as retailers).

5.2 The key stakeholders involved in the sector include:

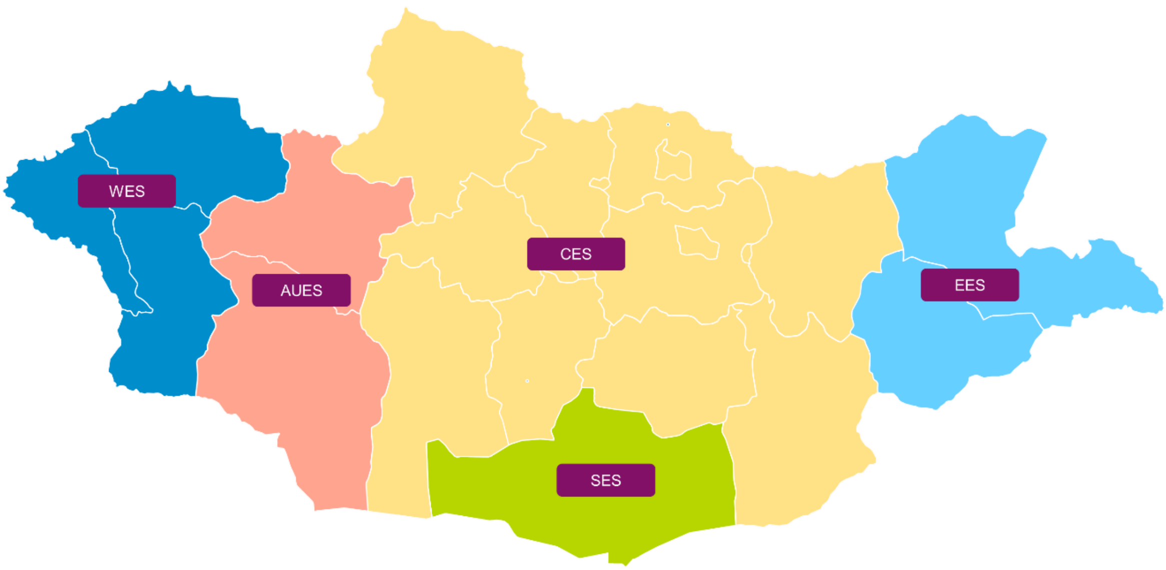
- Ministry of Energy (MOE): The MOE is responsible for the development of policy and legislation in the overall energy sector in Mongolia, in line with government policy, including Vision 2050 and four-year plans, and evolving national priorities.
- Electricity Regulatory Commission (ERC): The ERC is the authority that oversees the electricity sector system operators (including for generation, transmission, distribution, and supply of energy). It is responsible for coordinating economic and technical regulation of the sector and its enforcement. Its purview includes energy pricing and tariffs (to consumers, and between system operators), licensing of energy projects, energy conservation, and consumer regulations.
- National Power Transmission Grid (NPTG): NPTG serves as the Transmission System Operator (TSO) for the national grid.
- National Dispatch Center (NDC): The NDC is the national power system operator and the owner of the existing electricity management system. It is responsible for the control and management of the country's energy grid and power generation facilities.
- Regional distribution network companies. For example, in Ulaanbaatar, this function is performed by Ulaanbaatar Electricity Distribution Network company (UBEDN): UBEDN functions as the Distribution System Operator (DSO) for the electricity grid in Ulaanbaatar city (which is responsible for the most consumption in the country). These distribution network companies are responsible for the supply to consumers and energy billing.
- Energy Generation Companies: Thermal power plants are state owned companies, and renewables are private including through foreign investment (e.g., Japan Development Fund has funded solar).

Energy grid overview

5.3 Mongolia’s electricity grid is managed by multiple transmission and distribution companies. This national grid compromises of five regional energy systems which are:

- Central Energy System (CES)
- Western Energy System (WES)
- Altai Uliastai Energy System (AUES)
- Eastern Energy System (EES)
- Southern Energy System (SES).

Figure 5-1: Mongolia's regional energy systems

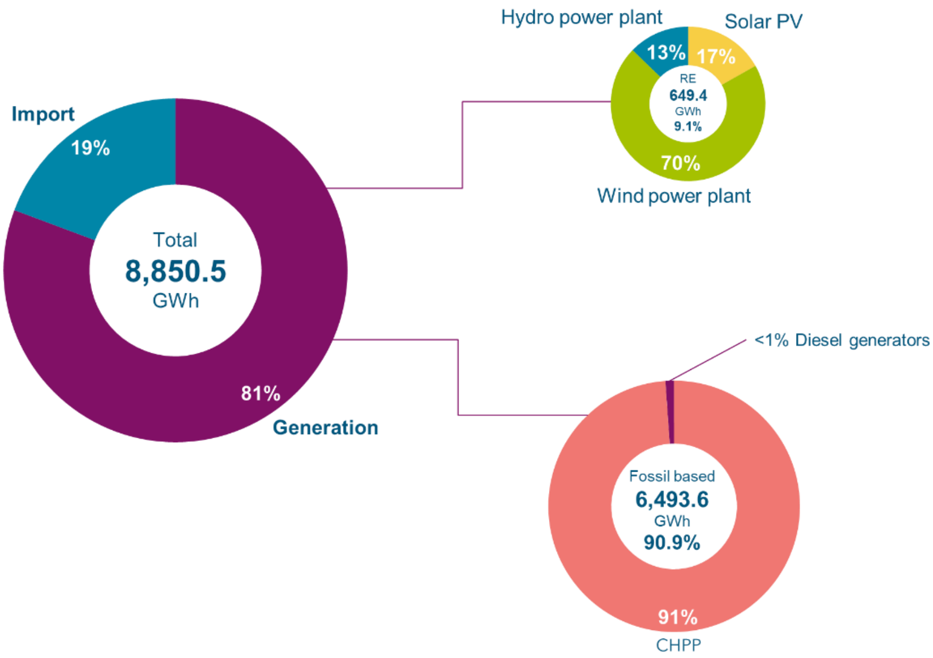


Energy generation

5.4 Mongolia’s generation system consists of nine thermal power plants, three wind power plants, five solar power plants, and three hydropower plants. Most of Mongolia's electricity supply comes from coal-fired Combined Heat and Power Plants (CHPPs). In 2022, approximately 80.7% (8,850 GWh) of the country's electricity was generated domestically (of which 90.9% (6,493 GWh)) originated from nine CHPPs and the remaining 9.1% (649 GWh) from renewables including wind, solar, and hydro power. Approximately a fifth of energy generation (ca. 1,682 GWh) was imported, predominantly from Russia. Figure 5-2 shows the generation sources for domestic production.

5.5 Most of the electricity and heat consumption in Mongolia takes place within the CES, which partially relies on the Russian grid for frequency and load balancing support. Due to higher electricity prices, the import is restricted at 100 MW under normal conditions, although during the peak demand period at night in winter, it reaches up to 180 MWs.

Figure 5-2: Mongolia's electricity generation sources[45]



Transmission and distribution

5.6 In terms of capacity, Mongolia's transmission network comprises of around 80 substations, which are distributed across the country at three voltage levels: 110 kV (3609 km of lines), 220 kV (1956 km of lines) and 330 kV (250 km) and is primarily concentrated around the capital city of Ulaanbaatar. They are shown in Figure 5-3 and Appendix 3.

5.7 Electricity in Ulaanbaatar is distributed at 50 Hz throughout the city using various voltage levels. High voltage transmission consisting of 330kV, 220 kV and 110 kV. Medium voltage distribution on 35 kV, 15 kV, 10 kV and 6 kV, along with low voltage distribution overhead lines and underground cables. The most common connections available to consumers are low voltage 230V single phased or 400V three phased[46]. The city grid is shown in Figure 5-4 and Appendix 4.

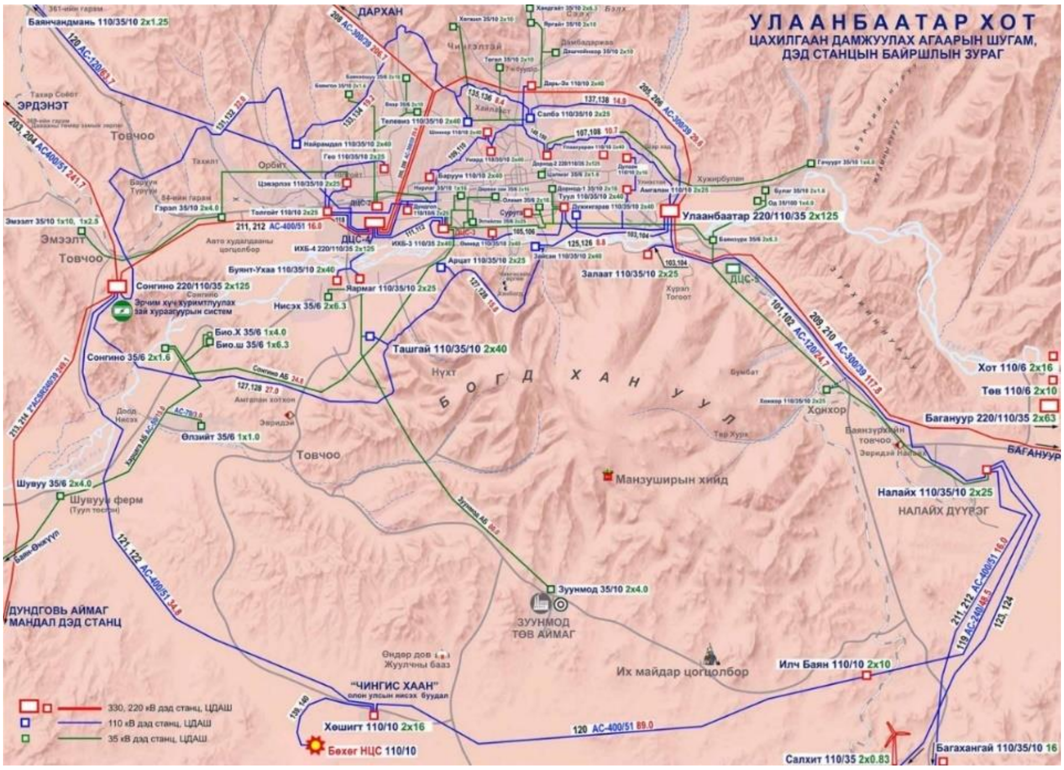
5.8 Within Ulaanbaatar, four out of the nine CHPPs are situated in the vicinity of the city centre. Based on our engagement with energy stakeholders in Ulaanbaatar, the distribution network is experiencing major pressures through rapid urban growth and

[45] Energy Regulatory Commission. (2021). Statistics on energy performance Mongolia [Dataset].
[46] Typically, residential consumers receive electricity through a single-phase supply, whereas commercial and industrial consumers commonly receive a three-phase power supply.

expansion, together with aging infrastructure in both generation and distribution systems.

Figure 5-3: Map of Mongolia's energy system[47]

Figure 5-4: Transmission and distribution grid around Ulaanbaatar[48]



[47] Ministry of Energy. (2021a). Mongolia’s transmission map.
[48] Ministry of Energy. (2021b). Ulaanbaatar’s distribution map.

Mongolia's electricity use settings

5.9 Around 90% of the electricity use in Mongolia occurs in the CES, which includes Ulaanbaatar. Two thirds of energy consumption occur in non-residential settings (public and commercial/industrial), with residential use split between 21% in Ger districts, and 12% at apartments. This highlights both the substantial usage by individual industrial consumers and comparatively higher energy consumption by users within Ger Districts. Non-residential customers represent 8% of the total connections, the other 92% are residential customers with 43% being in apartments and 49% in Ger districts[49].

[49] In Mongolia, GER districts, also known as "Ger Areas," refer to informal settlements or neighborhoods primarily characterised by traditional Mongolian gers (nomadic tents) used as dwellings. These areas typically lack formal urban planning and infrastructure, including basic services like water supply, sanitation, and electricity. The ger areas lacking electricity commonly uses coal-burning stoves for cooking, worsening the air pollution in these areas.

Figure 5-5: Location of Ger areas in Ulaanbaatar

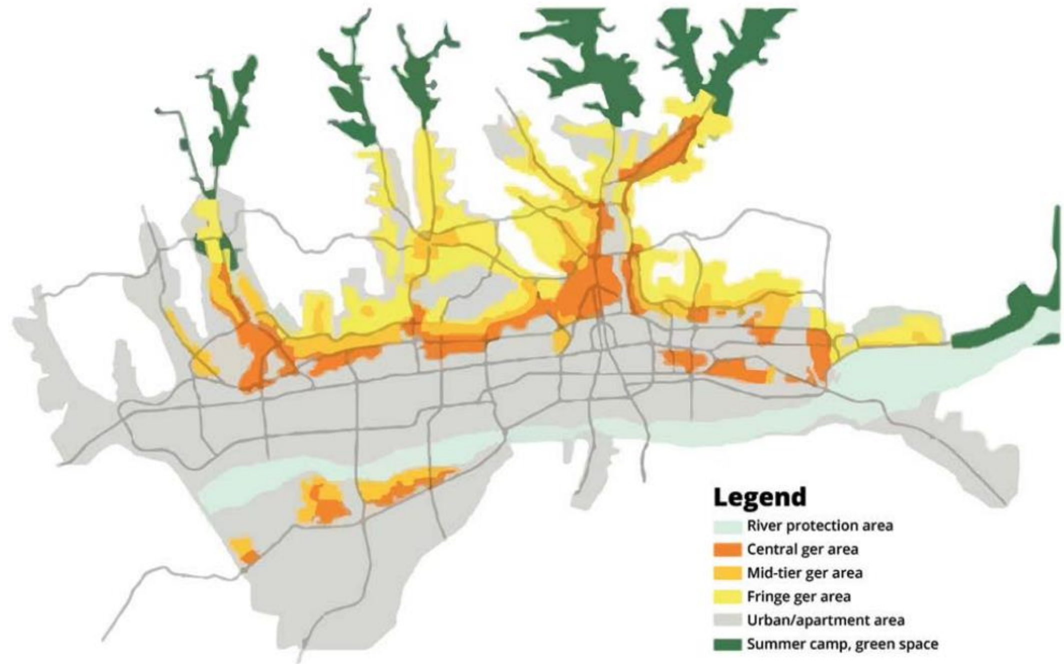
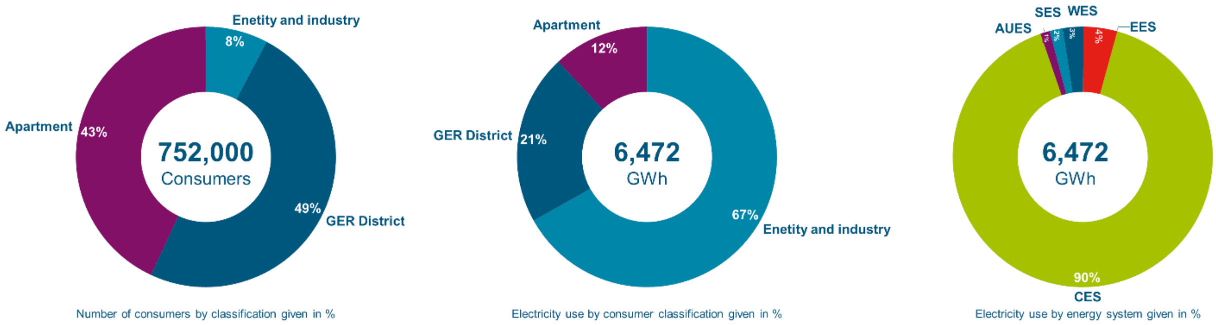


Figure 5-6: Mongolia's electricity uses by consumer classification[45]



Demand patterns

5.10 The daily power demand curve for Mongolia follows a typical pattern for Asian countries, with relatively high background demand and flatter peaks[50]. Energy demand is however highly seasonal (considering the extreme climate) which has a significant impact on electricity consumption. Figure 5-7 illustrates the 24-hour load profile of the CES and an indication of the supplied generation. The difference between peak demand in the evening and the low load during off-peak hours directly correlates with

[50] Refers to the load profiles of India and China in "Future global electricity demand load curves, Victhalia Zapata Castillo, et al. (2022)"
Castillo, V. Z., De Boer, H., Muñoz, R. M., Gernaat, D. E., Benders, R., & Van Vuuren, D. (2022). Future global electricity demand load curves. *Energy*, *258*, 124741. https://doi.org/10.1016/j.energy.2022.124741

consumer types and their consumption patterns. During periods of high winter load, the daily difference between peak and low load can range from 24-35% of the peak demand.

5.11 Currently, the maximum peak during winter reaches in the CES approximately 1,361 MW at around 19:00 hours. To meet this, a maximum generation capacity of about 75-80% is generated from CHPPs, with additional generation coming from RES (principally wind) available at that time and the remaining imported from the Russian power system.

5.12 The ageing coal fired CHPPs are highly loaded during the peak demand in the winter, have low operational efficiency, and are not designed for high operational flexibility. If we zoom in on the CHPPs located in Ulaanbaatar (CHPP-2, CHPP-3, CHPP-4), most are experiencing demands above 90% of its rated capacity during winter load. This could be a potential concern for large scale EV deployment in Mongolia, since uncontrolled charging of EVs in other countries has been found to have disproportionate impact on peak energy demand under normal circumstances[51] (e.g., focused on home charging).

5.13 There is a notable misalignment of the input of domestically produced solar power, which comes during the afternoon shoulder period, and peak energy demand.

On the other hand, during the summer season, power demand decreases significantly in major cities in Mongolia as people tend to explore the countryside, and the central heating system is not in operation. Consequently, power demand reaches around 40-45% of the winter peak demand during low load, resulting in lower generation however still a minor power import from Russia[52]. This partial Russian import stems from the inability of the CHPP plants to efficiently adjust to load fluctuations.

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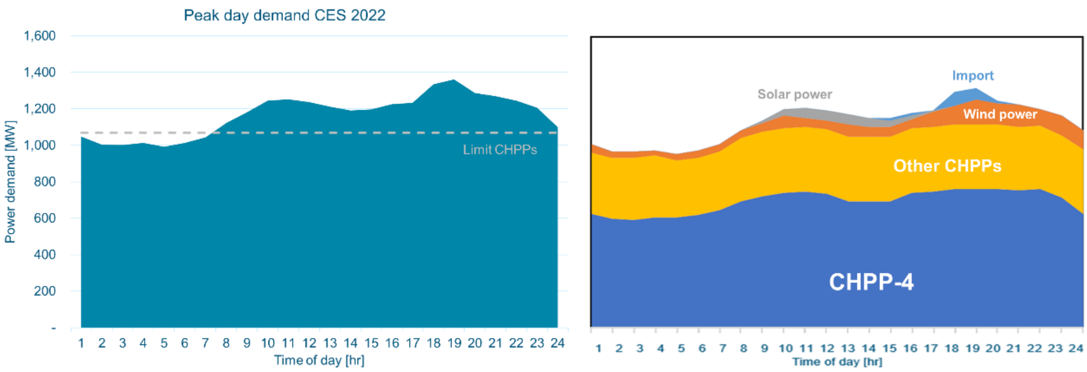
[51] Engel, H., Hensley, R., Knupfer, S., & Sahdev, S. (2018, August 8). *The potential impact of electric vehicles on global energy systems*. McKinsey & Company. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-potential-impact-of-electric-vehicles-on-global-energy-systems

[52] Cited in “Under-Frequency Load Shedding in Mongolia: Simulation Assessment Considering Inertia Scenarios”, National Dispatching Center Mongolia
Under-Frequency load shedding in Mongolia: Simulation assessment considering inertia scenarios. (2020, June 1). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/document/9152584

Figure 5-7: Power demand of the CES for a peak winter day in 2022



Economic governance in the Mongolian electricity system

5.14 The Mongolian energy system operates under a single buyer model, with economic management and regulation of the system and its components under the ERC. ERC has oversight of the participation of economic organisations in the market, prices and tariffs for energy services and inputs, and standards for consumer services. Within this model, tariffs are set for different components of the system, with tariffs to generators, transmission grid operators, distribution network operators (DNOs), and consumers.

5.15 The Mongolian energy sector is currently working on a programme of reform to the energy tariff system with a view to reducing the fiscal pressure posed by current energy subsidies and to promote investment in the sector. This report provides analysis of the current system and tariff levels.

Energy retail and end user tariffs

5.16 Sale of energy to consumers is by DNOs, with monopoly provision in their geographically defined zones (at rates determined in the Energy Code). For example, in Ulaanbaatar, the DNO and sole energy retailer is UBEDN.

5.17 At an aggregate level, Mongolia has some of the lowest end user electricity tariffs in Asia, as shown in Figure 5-8 below. Average rates are approximately US$0.06 for industrial users and US$0.05 for residential users. Residential rates are at almost half of those for the next lowest regional market (China) and a third of the rate of the Philippines.

5.18 End user tariffs vary by user type and generation, with residential and non-residential users offered single and time-of-use tariffs using smart metering. Single tariffs are outlined below in Table 5-1.

Figure 5-8: Mongolia's end user tariffs compared to several Asian countries

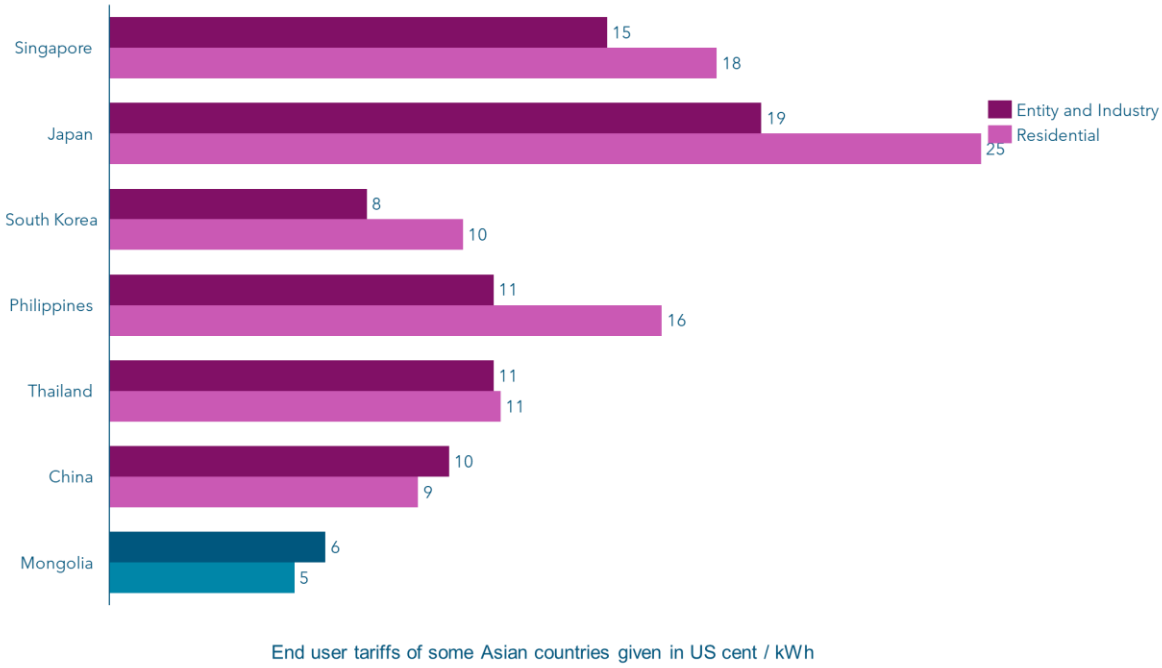


Table 5-1: Mongolia's single rate electricity tariffs (excl. VAT)

Consumer categories	Tariff (USD/kWh)
Residential	
Monthly consumption below 150 kWh	0.039
Monthly consumption above 150 kWh	0.045
Industrial	
Mining, processing industry	0.052
Other industries, business entities and organisations	0.048

5.19 Additionally, the following (monthly) capacity and connection fees exist:

- Renewable levy (0.0068 USD/kWh), included in the tariffs.
- Capacity tariff of the other industries 2.60 USD/kW/month.
- Capacity tariff for mining industries 7.24 USD/kW/month.
- Basic fee for residential consumers 0.57 USD/ month.

Time of Use tariffs using smart metering

5.20 The different time-of-use tariffs are shown in Table 5-2 below. While smart metering technology (for time-of-use tariffs) has variable coverage, there is relatively high coverage in Ulaanbaatar. Based on the data provided by UBEDN to the study team, there were approximately 3.1m billing months for the residential time-of-use tariff. When divided over 12 months, this would indicate that *at least* 250,000 households in Ulaanbaatar (approximately one third) have use of this technology (and potentially far more given the ease of switching between the two). Notably, the share of time-of-use billing was equally split between apartments and Ger areas which is broadly reflective of their prevalence as energy consumers. There is also an ongoing program of smart meter conversion, with UBEDN (as of 2022) planning to install 11,200 smart meters in Ulaanbaatar (1.5% of all connected consumers).

5.21 The Ulaanbaatar region has already implemented a time-of-use tariff policy in the past, with specific measures in place. As part of the 2017 air pollution action plan, the government introduced a zero-nighttime electricity policy for low income ger districts. This policy aims to incentivize a shift from coal to electric heating and cooking[53]. During the winter season, customers in these districts receive free monthly electricity usage up to 1,500 kWh during nighttime hours (between 21:00 and 6:00). According to the government, around US$5.8 million was subsidized in 2019 to 116,000 households in Ulaanbaatar and 22,000 in rural areas[54]. These collective measures led to a significant reduction in pollution by half in ger areas. Encouraged by the positive outcomes, the initiative expanded to include a 50% discount to households in aimag and soum centers, as well as urban settlement areas. In 2023, a budget of US$9.8 million was allocated to sustain and expand this initiative.

Table 5-2: Mongolia's time of use electricity tariffs (excl. VAT)

Consumer categories	Tariff (USD/kWh)	
Residential		
Shoulder *From 6 am until 9 pm*	0.040	
Off peak *From 9 pm until 6 am*	0.032	
Industrial		
	Mining	*Others*

[53] Asian Development Bank. (2023a, September 4). Ulaanbaatar Air Quality Improvement Program – Phase 2. https://www.adb.org/projects/53028-001/main#:~:text=ADB%20Releases%20%2460%20Million%20for,the%20Mongolian%20capital%20of%20Ulaanbaatar.
[54] Munkhzul, A. (2020). *Air pollution reportedly reduced by 49.6 percent*. MONTSAME News Agency. https://montsame.mn/en/read/211671

Shoulder *from 6 am until 5 pm*	0.049	0.047
Peak *from 5 pm until 10 pm*	0.086	0.071
Off peak *from 10 pm until 6 am*	0.029	0.032

Feed-in Tariffs (FIT)

5.22 Feed-in tariffs have been established in the Mongolian energy regulatory framework in order to promote renewable energy generation in Mongolia through meeting the additional generating costs of the industry relative to coal-based sources. The feed-in tariff system in Mongolia is characterised as follows:

Table 5-3: Mongolia feed-in tariffs

Renewable energy type	Tariff (USD/kWh)
Wind Energy	0.080 – 0.10
Solar PV	0.15 - 0.18
Hydropower up to 5 MW	0.05 – 0.06

5.23 The tariff prices are presented as ranges, allowing for flexibility in power purchase agreements (PPAs) and are granted for a fixed period of 10 years. This flexibility enables stakeholders to negotiate prices that align with the project's specific characteristics while having stability with long-term revenue predictability.

5.24 Stakeholder engagement with a private solar developer contracted by NDC (under the single buyer model) found that the contracting of existing RES supply in US dollars has resulted in financial losses to the energy system due to currency fluctuations. For example, a 12MW solar plant contracted in 2016 with at a rate of $0.15-$0.18/kWh has increased from 180MNT/kWh (in 2016) to 510 Tugrik/kWh as of January 2024.

Net-Metering

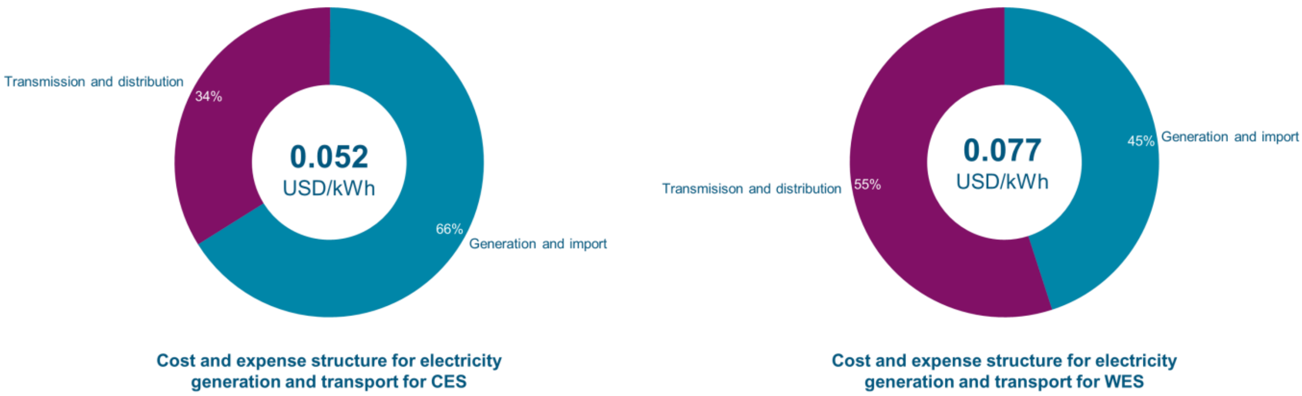
5.25 In addition to FITs, Mongolia has regulations in place for net-metering. Households and companies are now allowed to install solar PV systems and wind generators at their facilities, with excess electricity returned to the grid as credits towards energy used from the grid at other times. This encourages decentralised renewable energy generation and enables consumers to offset their energy bills.

5.26 The expenses associated with the development of renewable energy have substantially declined in recent years. To illustrate, the cost of wind energy projects has plummeted to less than 0.09 USD per kWh[55], rendering them more appealing. Likewise, the development costs for solar PV projects have now dipped below 0.12 USD per kWh[55]. These remarkable cost reductions highlight the continuous trend of renewable energy becoming progressively competitive in terms of cost, thereby making it a more attractive and sustainable choice for energy production.

Network cost base and subsidy

5.27 Extremely low energy user tariffs mean that the overall cost structure of the system is not met by the revenue generated through customer billing. Indeed, the tariff system meets only the short-run marginal cost, meaning an extensive part of the operating and the entire capital investment needs to be covered by subsidy[56]. This has resulted in a structural financial deficit within the energy system, currently balanced through subsidy. There is a regional variation to this challenge. For example (as shown in Figure 5-9), in the CES, characterised by higher population and grid density, the cost amounts to 0.052 USD per kWh, whereas the average consumer pays around 0.050 USD per kWh. This implies that nearly 5% of the electricity cost is covered by government subsidies. In contrast, in the WES, which covers a more extensive geographical area, the cost rises to 0.077 USD per kWh, while the end user tariff falls within the range of 0.037-0.053 USD per kWh resulting in a far higher rate of subsidy ranging from 30% to 50% per kWh.

Figure 5-9: Cost structure for electricity generation and transport in CES and WES

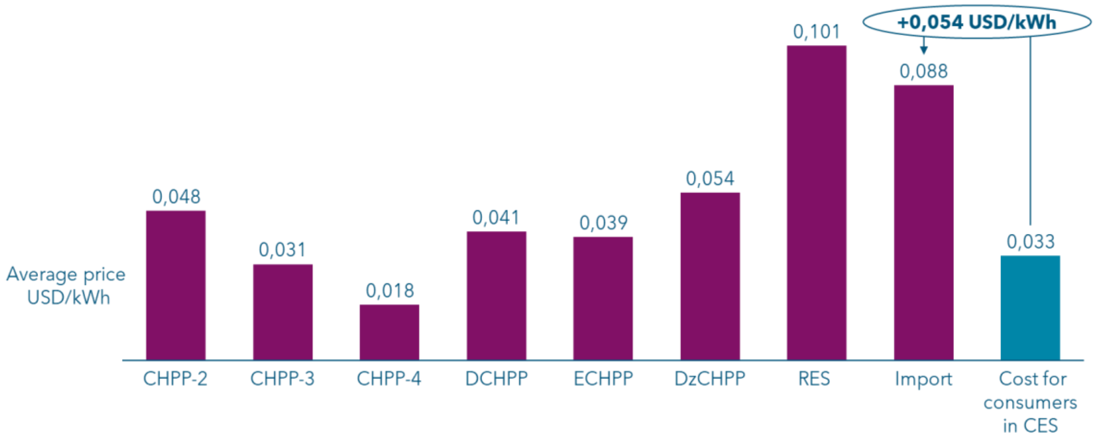


[55] Lkhagva, J. & Energy Regulatory Commission. (2019). *RENEWABLE ENERGY POLICY IN MONGOLIA Feed-in tariff to Auction*. https://events.development.asia/system/files/materials/2019/09/201909-renewable-energy-policy-mongolia-feed-tariff-auction-en-and-cn.pdf

[56] International Bank for Reconstruction and Development. (2020). *TRANSFORMING MONGOLIAN AGRICULTURE THROUGH GROWTH, RESILIENCE, AND COMPETITIVENESS*. International Bank for Reconstruction and Development / The World Bank. https://documents1.worldbank.org/curated/en/894991596007778450/pdf/Policy-Note-for-Mongolia.pdf

5.28 While regional cost variations are part of the picture, another major dynamic relates to generation source and the prices paid by the single purchaser (NDC) for energy generation. Mongolia's relatively low generating cost base (on account of thermal energy and coal industry) means that renewable energy feed-in tariffs for commercial renewables remain two to three times higher than existing CHPP generation. Meanwhile, imported generation of thermal energy to cover demand peaks (all year) and capacity gaps (particularly winter) make a heavy contribution to system cost. Both imports and RES therefore have a major impact upon subsidy requirements, and a strong bearing on current policy direction towards peak shaving (see next section).

Figure 5-10: Average single-buyer (NDC) purchase price per kWh by source for 2022[57]



5.29 As shown in Figure 5-10, consumers typically contribute approximately 0.033 USD/kWh[58] towards generation and import costs. However, the cost of generation to the NDC varies greatly by source, with some CHPP below this cost and RES and imports several times higher. In this economic context, assessing the subsidy impact of e-mobility upon the energy sector will depend upon the generation source used for the marginal energy demand. For example, home charging of personal EVs would typically take place in the evening peak time. At this time, marginal energy would be supplied from imports at a rate of 0.087 USD/kWh to NDC and thus imply a subsidy of 0.054 USD per kWh. Conversely, overnight charging demand would be more likely to be generated through national sources (e.g. CHPP) with a lower cost of generation and consequent impact upon the system financial deficit.

5.30 Additionally, the current on-grid renewable energy FIT regime sees RES being paid 0.10 USD/kWh. Where an increase in EVs is accompanied by additional on-grid RES within

[57] Energy Regulatory Comission. (2022). Data *gathered* by ERC [Dataset].
[58] Based on 66% of what the consumers in CES pay per kWh (174 MNT/kWh) in line with ERC data from 2022.

the current tariff and regulatory regime, the energy system (i.e., subsidy) impact would be approximately 0.066 USD/kWh.

Table 5-4: Annual contribution of various generation sources

Annual generation source contribution	
CHPP-4	46%
CHPP-3	12%
Darkhan CHPP	4%
Erdenet CHPP	4%
Other CHPP's	8%
RES	7%
Import	19%

Mongolia's (sustainable) energy policies and goals

5.31 MOE has various iteration of an energy roadmap however Table 5-5 gives an overview[59] of the plans proposed by the Mongolian government towards 2050. This shows that goals up to 2030 are concrete and from 2030 to 2050 these become less specific. The target of renewable energy sources (including nuclear) meeting 30% of energy need by 2030 is aligned with the Government of Mongolia's State Policy on Energy 2015-2030[60], however with RE penetration at 10% in 2024, high projected demand growth, and significant challenges being faced by the RE sector (as outlined in the remainder of this section) is unlikely to be realised by that timeframe.

Table 5-5: Overview of Vision 2050 Energy Goals

Horizon	Goals specific to energy	Action points
< 2023	Develop energy security and backup capacity Establish a foundation for the development of RES Strengthen regulation and improve legal environment.	Installed power capacity will be doubled Hydro power will represent at least 10% of installed power Backup capacity will increase to 10% of installed power. Develop foundation for renewable sector Enhance tariff system

[59] Based on Mongolia's sustainable development vision 2030 and Long-term development vision 2050. Ministry of Energy. (2017). *Energy sector of Mongolia, Policies and challenges*. https://eneken.ieej.or.jp/data/7391.pdf

[60] *Mongolia's clean Energy transition: a pathway to sustainable and inclusive development*. (n.d.). UNDP. https://www.undp.org/mongolia/blog/mongolias-clean-energy-transition-pathway-sustainable-and-inclusive-development

2024 – 2030	Export secondary energy Develop the renewable sector Establish and develop a national green financing system Promote environmentally friendly, efficient, clean technologies and efficient energy use.	Meet 100% of national energy demand from domestic supply and become an energy exporting country. Share of renewable need to reach 30% of installed power. State owned power and distribution companies will become public or privatized companies. Connect (export energy) with North-East Asian countries with high-capacity DC lines.
2030 - 2040	Become fully self-sufficient in energy production needs Make a transition towards export-oriented industries. Develop smart energy consumption and efficient generation Increase internal and external sources of climate green financing.	Establish and develop a national green financing system Promote environmentally friendly, efficient, clean technologies and efficient use. Reduce greenhouse gas emissions and increase carbon absorption in energy, agriculture, construction, transport, industry and waste management sectors.
2040 – 2050	Strengthen adaptation to climate change Improve sustainable energy generation and consumption.	Promote sustainable energy generation and smart consumption Implement measures for climate change mitigation.

Energy sector policy agendas relevant to e-mobility

5.32 This section outlines the policy and implementation interests of the Mongolian energy sector, focusing on the impacts of e-mobility upon energy capacity (grid and generation), energy subsidy, and energy security. While the MOE is the primary policymaker for the energy sector, this section reflects the perspectives across all interviewed stakeholders.

Meeting energy demand (particularly peak demand)

5.33 At a policy level, Mongolia's growing population results in growing demand for energy, and in terms of generation, Mongolia is not able to meet its own energy needs at peak times. Additional energy is purchased on international markets (from Russia) at a cost far above domestic production, the cost of which is borne by the public sector (through NDC, the Single Purchaser in the energy system). To this extent, the core focus of national energy policy is on managing overall demand and action to reduce (or minimise) peak electricity demand.

5.34 At energy grid (distribution) level, Ulaanbaatar faces ongoing challenges due to the rapid urban expansion and population growth there, which has placed a strain on UBEDN's grid infrastructure. While limited information is available on the condition of the distribution network, it was indicated that there are increasing capacity challenges and a need for asset renewal. Consequently, UBEDN's priority is to ensure that the integration of electric mobility occurs in a controlled manner and is concentrated in specific designated areas. This has different implications in terms of proliferation of individual EV users (at scale resulting in a cumulatively large impact on energy demand) and larger EV fleets (e.g., bus garages, which would need to secure grid strengthening).

5.35 Considering the distribution network capacity challenge, energy peaks remain an issue at distribution (and not just generation) level. Indeed, it was highlighted that shifting the demand for EVs to better align with available energy resources would effectively be a prerequisite for EV support in energy policy.

5.36 UBEDN has identified specific locations where the capacity for EV charging infrastructure can be effectively accommodated, however there is a reluctance to see the mass proliferation of EV charging infrastructure using existing local distribution infrastructure.

Managing energy subsidy

5.37 As shown above in Figure 5-7, imported energy is used to manage demand peaks in the Mongolian energy system, however its high purchase cost (to NDC) results in a system financial deficit and increases energy subsidy requirement (see Figure 5-10). In the current framework (in which a marginal unit of energy demand increase during peak would be from imports), peak-time EV charging demand would result in an increase in energy sector subsidy pressures.

5.38 As the economic regulator for the Mongolian energy system, ERC is engaged in a program of energy tariff reform, intended to increase revenue generation (and reduce subsidy), enable investment in the energy system, while protecting socially vulnerable groups. In this context, consideration will be needed for how to incentivise consumption shift outside of peak hours.

5.39 Our engagement found support for implementation of a tariff structure tailored specifically for EV charging, which would allow greater mitigation of the impact of EV charging on Mongolia's peak demand.

Renewables

5.40 MOE's perspective on renewable energy is shaped both by the cost of generation (see 5.24) and the fact that generation of renewable energy (particularly solar) does not align with the timing of anticipated EV demand peaks. As such, it considers that renewables do not effectively contribute to the key energy policy objective (meeting or managing peak demand) while also resulting in additional subsidy requirements for the energy system.

5.41 As a result, a 2019 amendment to the Renewable Energy Law has removed the ability of project developers to initiate their own projects, instead leaving specification and terms of future RES capacity to the public sector utilities. Engagement with energy sector stakeholders in January 2024 identified that current RES offer prices remain prohibitively high.

5.42 While energy policy is not currently focused on increasing renewable generation, it is supportive of solutions that effectively synchronise peak demand with energy production (including renewables) on a national scale. Consequently, technologies such as energy storage and hydroelectric power are appealing options for MOE and are being actively explored.

5.43 In the absence of energy source selection (e.g., wholesale or retail competition), there is support for self-sufficient EV charging solutions (i.e. solutions generating and/or storing their own energy) as a means to enhance the utilisation of renewable energy sources. Engagement with a private solar developer identified a sales cost of US$0.08-10/kWh for new off-grid solar generation.

Energy security

5.44 The reliance of Mongolia on energy imports from neighbouring countries has a financial (subsidy) and energy security impact. This drives a policy focus on expanding overall local generation capacity to meet demand, while minimising peak energy demand. At the same time, Mongolia imports all its gasoline and diesel, meaning that EV transition would be largely neutral in terms of energy security (and potentially supportive in the longer term as local generation expands).

6. Analysis of opportunities and constraints to e-mobility readiness

Introduction

6.1 Building on this contextual research, this section outlines the results of key areas of readiness analysis, covering technological, economic, supply, operation and policy aspects. This analysis covers e-mobility readiness in Mongolia in both general and market segment specific terms, and informs the overall readiness assessment conclusions. Key analysis includes:

- Suitability of EV technology in the Mongolian context, considering in particular the extreme winter climate and remote geography outside of Ulaanbaatar.
- Total Cost of Ownership (TCO) analysis of the economic competitiveness of e-mobility based on the Mongolian vehicle and energy market.
- Assessment of the potential impacts of e-mobility upon the Mongolian energy system, including energy demand, subsidy implications and GHG mitigation implications.
- Analysis of the operating model for e-buses in the Ulaanbaatar context and opportunities for business model optimisation to maximise deployment.
- Review of technical regulations relevant to EVs and opportunities for strengthening and adjustment.
- Other policy and strategic considerations relevant to prioritising e-mobility policy interventions and investments.

EV technology suitability in the Mongolian context

Climate

6.2 Extreme seasonal climate variations mean temperatures in Ulaanbaatar fall to as low as -40°C (more typically -20°C to -30°C) in the period from December to February[61]. The impact of extreme cold temperature upon EV performance is the subject of extensive technical studies and deployment experiences exists in Mongolia and other higher-

[61] *Ulan Bator Climate, Weather by month, Average Temperature (Mongolia) - Weather Spark*. (n.d.). Weather Spark. https://weatherspark.com/y/117604/Average-Weather-in-Ulan-Bator-Mongolia-Year-Round

penetration contexts such as Norway, Canada and areas of the USA. The key challenges fall into two categories:

- **Vehicle range:** Resulting from reduced battery performance and increased energy demand required for heating.
- **Vehicle charging performance:** Battery Management Systems of vehicles typically limit the charging rate of DC (fast) chargers to avoid detrimental effects on the battery cells[62][63]. This substantially increases the time taken for batteries to charge using fast charging stations.
- **Demand for public charging infrastructure and energy** (a secondary effect of the two points above) depending on local charging patterns, due to increased energy demand and reduced charger efficiency.

International evidence and experience

6.3 A growing range of evidence exists of the performance of EVs in extreme cold climates. Additionally, various case studies exist of high EV sales penetration in contexts of extremely cold winter climates. These include Norway (82% EV sales penetration in 2023[64]) and areas of the United States (e.g. Midwest region) and Canada (e.g. 20% of new cars in Quebec and 25% of new cars in British Columbia[65]).

Battery range

6.4 Global empirical data on these impacts (using data from 5.2m journeys) shows a temperature of -20°C reducing range to 50% of rated range[66]. Country-specific examples also exist from Norway and Kazakhstan, showing latest Yutong E12 buses achieving a range of 374km at -25°C in Astana, and power consumption of 1.56kWh/km in Kirkenes, Norway[67] at -33°C (equivalent to 189km on a full battery[68]).

[62] Bayram, I. S. & Department of Electronic and Electrical Engineering, University of Strathclyde. (2021). Impacts of Electric Vehicle Charging under Cold Weather on Power Networks. In *IEEE* (pp. 1–10) [Journal-article]. https://strathprints.strath.ac.uk/79154/1/Bayram_UPEC_2021_Impacts_of_electric_vehicle_charging_under_cold_weather_on_power_networks.pdf

[63] Motoaki, Y., Yi, W., & Salisbury, S. (2018). Empirical analysis of electric vehicle fast charging under cold temperatures. *Energy Policy*, *122*, 162–168. https://doi.org/10.1016/j.enpol.2018.07.036

[64] Klesty, V. & Reuters. (2024). *Tesla extends lead in Norway sales, EVs take 82% market share*. https://www.reuters.com/business/autos-transportation/tesla-extends-lead-norway-evs-take-record-82-market-share-2024-01-02/

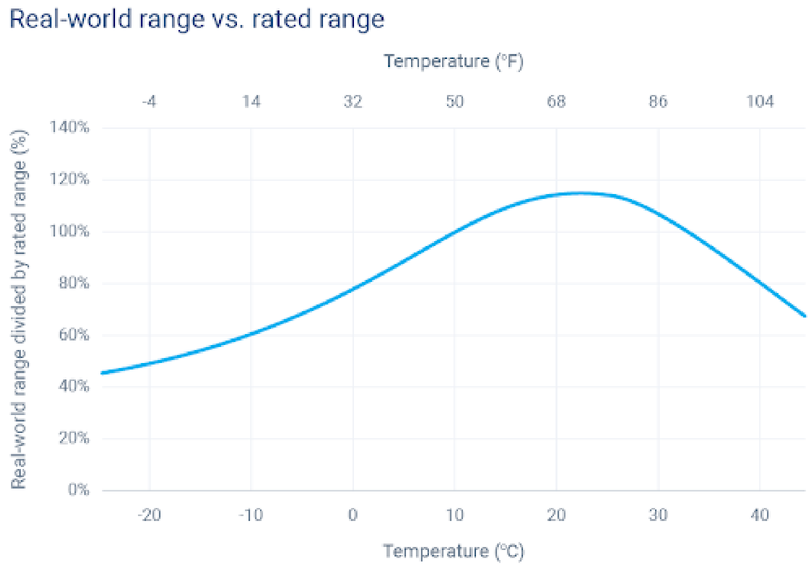
[65] Cecco, L. (2023, December 19). Canada to require all new cars to be zero-emission by 2035. *The Guardian*. https://www.theguardian.com/world/2023/dec/19/canada-car-emissions-automaker-electric-2035

[66] Argue, C. (2023, August 17). To what degree does temperature impact EV range? *Geotab*. https://www.geotab.com/uk/blog/ev-range/

[67] Editorial Staff. (2024, February 20). *Yutong U12 e-bus underwent testing in Norway and Kazakhstan, with dedicated technologies for cold climate*. Sustainable Bus. https://www.sustainable-bus.com/electric-bus/yutong-testing-norway-cold-climate-technologies/

[68] *Model E12 – Yutong Eurobus Scandinavian AB*. (n.d.). https://yutongeurobus.se/products/model-e12-2/#tab-id-2 – Battery capacity of 295 kWh

Figure 6-1: Real-world range of EV's according to ambient temperature[66]



6.5 Evidence and experience show that climates similar to that of Mongolia are not inherently an impediment to EV deployment, although planning for their deployment will need to overcome these considerations. Some examples of this are shown in Table 6-1, with brief explanations for each below.

Table 6-1: Key technologies and behaviours to address battery range issues of cold climates

Solution	Automobile	Bus	Commercial
Diesel heating		X	
Pre-heating vehicle before use	X	X	X
Heat pumps	X		X
Opportunity charging	X	X	X

- **Diesel heating** – As already seen in UB, diesel-powered heaters can be used in BEBs to reduce the energy demand on the battery. This does, however, significantly increase the BEBs' emissions and reduce the environmental case for them, which is the primary purpose for implementing BEBs. A separate power source for heaters in smaller vehicles is uncommon given the space requirements for this.
- **Pre-heating vehicle before use** – This tactic involves using an EV's heater to warm the cabin and battery up whilst stationary, ideally whilst plugged in to a

charger, for 15-20 minutes before driving. This not only reduces the requirement for heating whilst driving (which can significantly drain a battery in cold conditions), but also heats the battery, allowing it to deliver energy more efficiently[69].

- **Heat pumps** – Heat pumps extract heat from the outside air and transfer it inside the vehicle, making them more energy-efficient compared to traditional resistive heaters, such as Positive Temperature Coefficient (PTC) heaters, which directly convert electrical energy into heat using a blower.
- **Opportunity charging** – An extensive network of charging points placed strategically to service demand, for instance near employment hubs or at supermarket car parks, can help to alleviate range anxiety in extremely cold conditions. If drivers can be confident they can recharge their battery away from their home, they can make longer journeys and top up their battery if it drains faster than expected due to cold conditions.

Charging performance

6.6 Fast charging infrastructure is less efficient in extreme cold temperatures. Research result have shown that the efficiency of most commercial chargers reduces to 80-90% below -15°C and to 40-50% below -25°C. This is consistent with recent widely reported user experiences in the US Midwest during extreme cold weather in January 2024[70]. Meanwhile a study of over 4,000 Tesla Model 3s found that charging times were only nine minutes longer at -18°C than more temperate conditions[71]. Another challenge is that some vehicles initially reject fast charging input due to battery temperature. Various mechanisms exist to overcome this challenge as summarised in Table 6-2 with experience from Norway of the need for user education around battery 'preconditioning'[72] to warm the battery prior to fast charging. Norway has found that the promotion of overnight slow charging, including where possible in covered areas, can further address this issue.

[69] *Tips for using an EV in cold weather*. (n.d.). Connected Kerb. https://connectedkerb.com/stories-and-reports/tips-for-using-an-ev-in-cold-weather/
[70] Garsten, E. (2024, January 19). Perfect storm to blame for cold weather EV charging woes, study says. *Forbes*. https://www.forbes.com/sites/edgarsten/2024/01/19/perfect-storm-to-blame-for-cold-weather-ev-charging-woes-re-new-study/?sh=3678e09c3947
[71] Electric Autonomy Canada. (n.d.). *Electric Autonomy Canada*. https://electricautonomy.ca/
[72] Dnistran, I. (2024, January 19). Here's why Norway hasn't had trouble with winter EV charging. *InsideEVs*. https://insideevs.com/news/705338/norway-winter-ev-charging-no-trouble/

Table 6-2: Key technologies and behaviours to address charging issues of cold climate

Solution	Private Automobile	Bus	Light Commercial
Prioritise slow overnight charging	X	X	X
Battery pre-conditioning	X	X	X
Indoor vehicle storage	X	X	X

Overall demand upon charging infrastructure and energy

6.7 During winter months the demand on charging infrastructure and the energy grid will increase, as drivers combat the effects of the extreme cold on EV battery ranges. Nevertheless, given that home charging tends to be predominant in early stages and public charger utilisation rates low, this issue is unlikely to be a major issue in early phases and should be considered as part of wider charging infrastructure market development during later stages.

Local validation

6.8 The suitability and impact of Mongolia's extreme climate was validated in stakeholder discussions, which found real world experience of:

- **Light vehicles (cars, vans):** Reported reduction in range between 30% and 50% during the winter months. For newer vehicles with a higher rated range, this does not impact upon their suitability for primarily urban use (even in winter the range is significantly higher than a typical urban use) and given the early stage of EV use it is likely that improved user behaviours and practices can further reduce this range impact. One area of potential concern was that some older models of Nissan Leaf were limited in range to 75km in winter (a combination of climate performance, low battery capacity in entry level/older models, and degraded batteries in used vehicles), making them unsuitable for high intensity commercial use (e.g. taxis) and less attractive for individual use.

- **Urban buses:** A reduction of 25% in range for urban buses in winter compared to summer. While significant enough to impact on operational efficiency and design, it is lower than other vehicle types due to the retention of diesel heating. Heating is a major impact for urban buses in particular (given the frequency of door opening and closing). Operational experience included the requirement for an additional daily charge during the winter, reducing capital deployment and adding to the operator financial viability challenge. Options and precedent nevertheless exist to help mitigate these (e.g. on-route opportunity charging and in-motion charging) and are widely deployed in other extreme cold climates.
- **Motorcycles:** Climate extremes inform a very low share of motorcycles (see segment data in the E-Mobility Assessment) and relatively few electric bicycles (e.g. Surrons), which become unfeasible in the winter months as their users are exposed to the elements. This mode was therefore not considered.

Conclusion

6.9 Mongolian and international experience demonstrates that electric vehicle technology can be compatible with Mongolian climate conditions, subject to certain adjustments to vehicle technology, operation and user behaviours. It will be important to consider the vehicle hardware and behavioural adjustments necessary to maximise performance and functionality, and to consider the additional energy and (to a degree) charging infrastructure required. Experience from Norway, Canada and colder areas of the USA will be important to explore to support policy development.

Spatial population distribution

6.10 Population distribution in Mongolia means that outside of Ulaanbaatar, population and activity locations extremely dispersed. The Tov province which surrounds the capital has a population density of 1 person/km^2. Other than Ulaanbaatar, Mongolia has only three other population centres above 50,000 people, specifically:

- Moron (134,000, 775km from UB)
- Erdenet (107,000, 382km from UB)
- Darhan (75,000, 225km from UB)

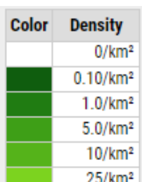
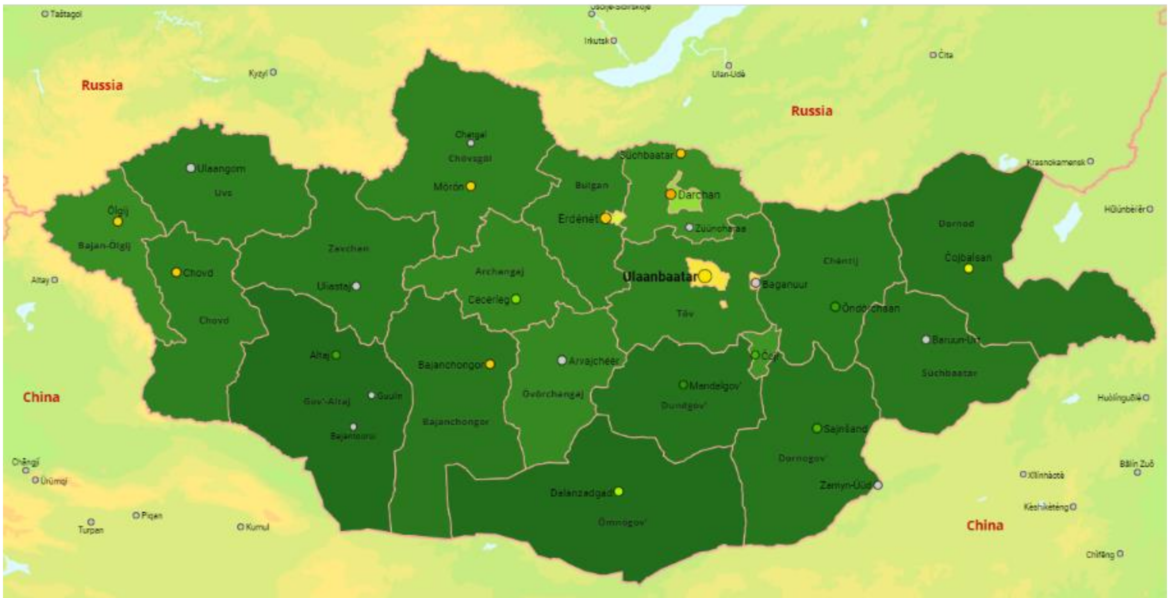


Figure 6-2: Population density of Mongolia[73]



6.11 Sparse population makes e-mobility economically and technically unfeasible for Mongolia outside of the capital (as validated during the January 2024 Mission Workshop). Conversely, for Ulaanbaatar, the implications of sparse population outside of the city mean that long distance journeys outside of Ulaanbaatar are relatively infrequent for private vehicle owners, although it is important to note that there is a strong culture of leisure and recreation in remote rural areas in the region surrounding the capital, which will be an important factor for the acceptability of EVs for urban residents.

6.12 In the current context, significant adoption of e-mobility outside of Ulaanbaatar is not likely to be feasible in techno-economic terms, considering the high investment costs and importance of actual and perceived vehicle range and technical reliability to remote communities. Therefore, UB should be prioritised for investments and early adoption measures.

Economic competitiveness of EVs in Mongolia

Overview

6.13 The creation of a market for EVs is dependent upon, among other things, the economic competitiveness of an EV compared to its ICE equivalent over its full lifetime,

[73] *Mongolia: Provinces, cities & urban settlements - population statistics, maps, charts, weather and web information*. (n.d.). https://www.citypopulation.de/en/mongolia/cities/

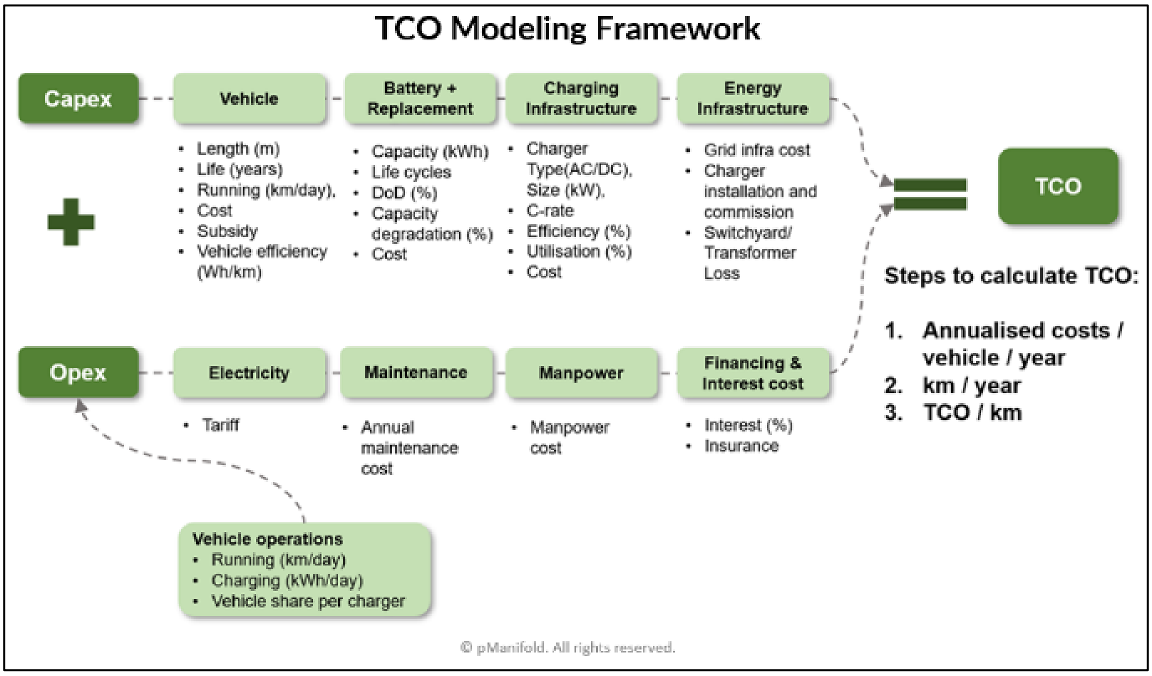
considering its capital investment cost (and financing cost) alongside operating cost including fuel, maintenance, and taxes. Global experience is for EVs to have a far higher capital expenditure (CAPEX) requirement (vehicle plus battery), partially offset against lower "fuel" (energy) costs and maintenance requirements. However, this dynamic – and its extent – varies greatly depending on market segments, use cases, operating conditions, and tax regimes.

6.14 In this section, a TCO model has been developed to compare the economic case for EV transition in the Mongolian context. The scenarios considered, focus on the principal vehicle segments identified in Chapter 2, specifically cars (considering both lower-mileage private use and higher intensity taxi use), light freight vehicles, and intra-urban buses.

Total Cost of Ownership (TCO) model

6.15 The TCO analysis helps to understand the different cost elements across the life cycle of vehicle including various capital costs, taxations, and operational costs. It offers more accurate assessment of the economic efficiency of an EV over an ICEV. The methodology framework used for the analysis is shown in Figure 6-3. All costs in the figure are included in the analysis.

Figure 6-3: TCO Framework



6.16 The different CAPEX and OPEX costs are annualised (i.e., adjusted to reflect a value on an annual basis) to arrive at total yearly cost, which is then used to derive TCO per km.

TCO scenarios

Private Cars

6.17 Private cars are the major vehicle segment in Mongolia, as described in Chapter 2. This segment is dominated by pre-owned (or used) vehicles comprising of 95% of the market, overwhelmingly of Japanese origin, with the new vehicle market remaining at below 5% and of a wider range of origins. Three sub-markets have been modelled:

- 'Mass market' used vehicles: This considers entry level used sedan cars which represent the vast majority of the Mongolian vehicle fleet (Toyota Corolla, Toyota Prius). ICE, hybrid, and EV models are considered. The inclusion of HEVs reflects the strong prevalence of these vehicles (particularly Toyota Prius) in this segment.
- Mid-market used vehicles: This considers higher end used cars, which represent a smaller subset. Again, ICE, hybrid and EV models are considered, reflecting the high prevalence of hybrid vehicles in this segment.
- New vehicles: This is a small vehicle segment in Mongolia (less than 5%), but one in which EVs are reported to have a high proportion of the market in recent months.

Sedan Taxi

6.18 The commercial taxi segment is predominantly comprised of pre-owned vehicles. The vehicle models used for taxi services are similar to mass market car models. Local engagement suggests that a typical daily run ranges between 120-180 kms (in Ulaanbaatar considering prevailing traffic conditions). Some taxis are also provided as premium services (e.g. for business use, airport transfers) through formal companies, and tend to be purchased new.

Intra-urban buses

6.19 Intra-urban bus transport in Ulaanbaatar comprises mainly of conventional ICE buses (only 4% e-buses currently) regulated by the Government but operated by both public and private companies. The urban bus network in Ulaanbaatar is managed by MUB's PTD, which leads vehicle capital investment and distribution to public and private bus operating companies who provide bus services. MRTD is planning to buy 800-1000 new buses this coming year including 156 e-buses. This scenario models the 12m bus category (30-40 seat capacity) as the most predominant type in the fleet. Building on existing e-bus experience in Ulaanbaatar, this analysis assumes the use of diesel heating.

Minibus

6.20 Minibuses have played a significant role in public transport sector in Ulaanbaatar, both formally in the past and informally presently, and across Mongolia. Minibuses were phased out of Ulaanbaatar's registered public transport system, as part of the Smart Bus Initiative introduced in 2015, due to the congestion they were creating at bus stops and the patronage they drew from regular buses. The reintroduction of minibuses as part of an On-Demand Transit Service (ODTS) is now being considered as part of a World Bank-funded project in partnership with the PTD and the MUB.

6.21 The study into the reintroduction of minibuses to Ulaanbaatar as part of an ODTS is in its early stages, but minibuses are likely to be the vehicle chosen for the ODTS given their ability to navigate narrow, steep, and poorly surfaced roads in informal ger areas on the outskirts of the city.

Light freight

6.22 The light freight sector is considered here, recognising the interest of the commercial sector in this technology for its economic and strategic (number plate restriction) advantages.

Scenario inputs and results

6.23 The various specific inputs across vehicle models like model price, battery size, average vehicle efficiency, average run per day, and vehicle life is shown below in Table 6-3, with further detail and sources shown in

6.24 Appendix 2. Input costs were based on actual costs identified during the scoping mission and follow up with vehicle dealers. Input scenario parameters (including distances, fuel consumption and total 15-year vehicle lifespan) are based on international values validated with local stakeholders to adapt to the Mongolian market and operating conditions.

6.25 Sensitivity analysis is carried out on key parameters such as Vehicle Cost, Battery cost, Excise Tax, Custom/Import Duty, VAT and Electricity Cost. The results are presented in a tornado diagram, and the analysis accounts for an illustrative +/- 30 % variation from the baseline scenario. Additional sensitivity analysis considers the impact of energy price increases and (for buses) changes in daily operating kilometre (in case of increased performance through bus priority measures)

Climate considerations

6.26 Considering the cold weather conditions in Mongolia, the TCO analysis also includes the effect of temperature on vehicle efficiency. The temperature ranges from -30ºC to +25ºC, hence on analysis an average 20% reduction in vehicle efficiency is observed[6670].

TCO Analysis Inputs and Assumptions

6.27 The table below provides information on vehicle models utilized in the TCO analysis, along with essential input parameters. Further breakdown is provided in Appendix 2.

Table 6-3: TCO analysis assumptions

Parameters	Unit	Car			Taxi		Bus		Light freight
		Mass market	Mid-range	New	Standard	Premium	Urban (12m)	Minibus	Van
Model Name		ICE: Toyota Corolla HEV: Toyota Prius '20 EV: Nissan Leaf	ICE: Lexus NX HEV: Toyota Harrier EV: BAIC EU5	ICE: Mercedes Benz C class EV: BYD Han	ICE: Toyota Corolla HEV: Toyota Prius '20 EV: Nissan Leaf	ICE: Mercedes Benz C class EV: BYD Han	ICE: Yutong ZK6108HGH EV: Yutong E12	ICE: Mercedes Benz Sprinter EV: Altas Novus Ecoline	ICE: Ford Transit Van EV: BYD T3
Production Year	Year	2012-2016 (across all)	2016-2020 (across all)	2023 (New vehicle)	2012-2016 (across all)	2023 (New vehicle)	2023 (New vehicle)	2023 (New vehicle)	2023 (New vehicle)
Purchase cost upon import	USD	ICE: 7,600 HEV: 7,380 EV: 19,500	ICE: 18,800 HEV: 17,350 EV: 24,100	ICE: 52,000 EV: 69,000	ICE: 7,601 HEV: 7,390 EV: 19,500	ICE: 52,000 EV: 69,000	ICE: 90,000 EV: 270,000	ICE: 142,000 EV: 225,500	ICE: 43,300 EV: 45,300
Life post import	Years	7	10	15	7	15	12	15	15
Charging Infra	USD/year	-	-	-	-	-	884	762	-
Daily km run	Kms	50	50	50	150	150	ICE: 246 EV: 220	180	180
Days/year	#	ICE/HEV: 283 EV: 330	ICE/HEV: 283 EV: 330	ICE: 283 EV: 330	ICE/HEV: 283 EV: 330	ICE: 283 EV: 330	310	ICE: 283 EV: 330	ICE: 283 EV: 330

Fuel use	Litre/Km	ICE: 0.109 HEV: 0.056	ICE: 0.109 HEV: 0.056	0.060	ICE: 0.109 HEV: 0.056	0.060	0.35	0.13	0.0694
Energy use	kWh/Km	0.229	0.229	0.181	0.229	0.181	1.26	0.33	0.689
Fuel cost	USD/Litre	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
Energy cost	USD/kWh	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037
Maintenance cost	USD/KM	ICE: 0.031 HEV: 0.062 EV: 0.023	ICE: 0.031 HEV: 0.062 EV: 0.023	ICE: 0.022 EV: 0.015	ICE: 0.031 HEV: 0.062 EV: 0.023	ICE: 0.022 EV: 0.015	ICE: 0.193 EV: 0.135	ICE: 0.097 EV: 0.068	ICE: 0.022 EV: 0.015

<u>*Operational Life assumptions:</u>

1) Used vehicles, including car mass market and standard taxis, are imported into the country, typically with an age ranging from 8 to 10 years. These vehicles are still operational for 7 years post import based on consultations with local experts.
2) Used mid-range car vehicles are imported into the country, typically with an age ranging from 5-7 years. These vehicles are still operational for 10 years post import based on consultations with local experts.
3) For new vehicle, operational life is considered as 15 years for cars and 12 years for buses.

TCO modelling results

6.28 Table 6-4 below provides TCO analysis results for the different vehicle segments.

Table 6-4: TCO analysis result summary

Vehicle segment		TCO (USD/km)			ICE vs EV differential (%)[74]	
		ICE	Hybrid EV	EV		
Car	Mass Market	0.260	0.214	0.275	0.015	6%
	Mid-Range	0.367	0.338	0.269	-0.099	-27%
	New	0.571	-	0.578	0.007	1%
Taxi	Standard	0.186	0.175	0.139	-0.047	-25%
	Premium	0.248	-	0.209	-0.039	-16%
Bus	Intraurban (12m)	0.792	-	0.889	0.096	12%
	Minibus	0.600	-	0.718	0.121	20%
Light freight	Van	0.229	-	0.162	-0.067	-29%

Scenario 1: 'Mass Market' Car

6.29 The TCO analysis for mass market car segment, comparing ICE, Hybrid, and EV models are shown in Figure 6-4. The selected models include 'Toyota Corolla' for ICE, 'Toyota Prius 20' for hybrid, and 'Nissan Leaf' for EV, as these are most prominent and widely used in Mongolia (also confirmed with our local experts).

6.30 The baseline scenario[75] analysis is done considering operational parameters as: i) Average kms run per day as 50 Kms ii) Operational days per year is 283 days for ICE and Hybrid EV (Non-operational 1 day per week due to restrictions) and 330 days for EV iii) Vehicle life post import to Mongolia is considered to be 7 years. The taxes applicable are: Customs/ Import Duty at 5%, VAT at 10% and Excise tax of $2000, $1697 and $109 for ICE, hybrid and EV respectively.

[74] As percent of ICE TCO
[75] Charging infrastructure cost will not be applicable as these vehicles will be charged at home

Figure 6-4: 'Mass Market' Car (4W) TCO Analysis in USD/Km

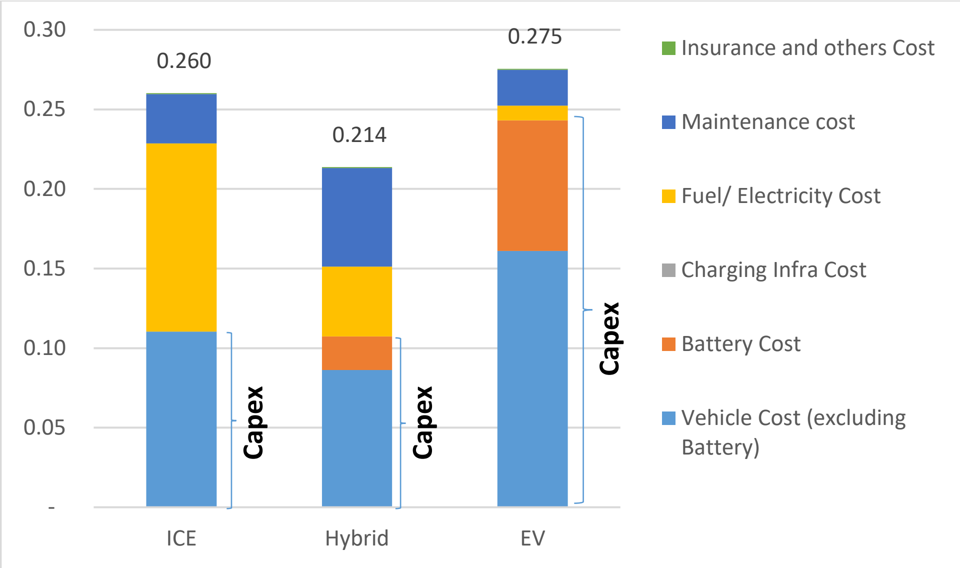
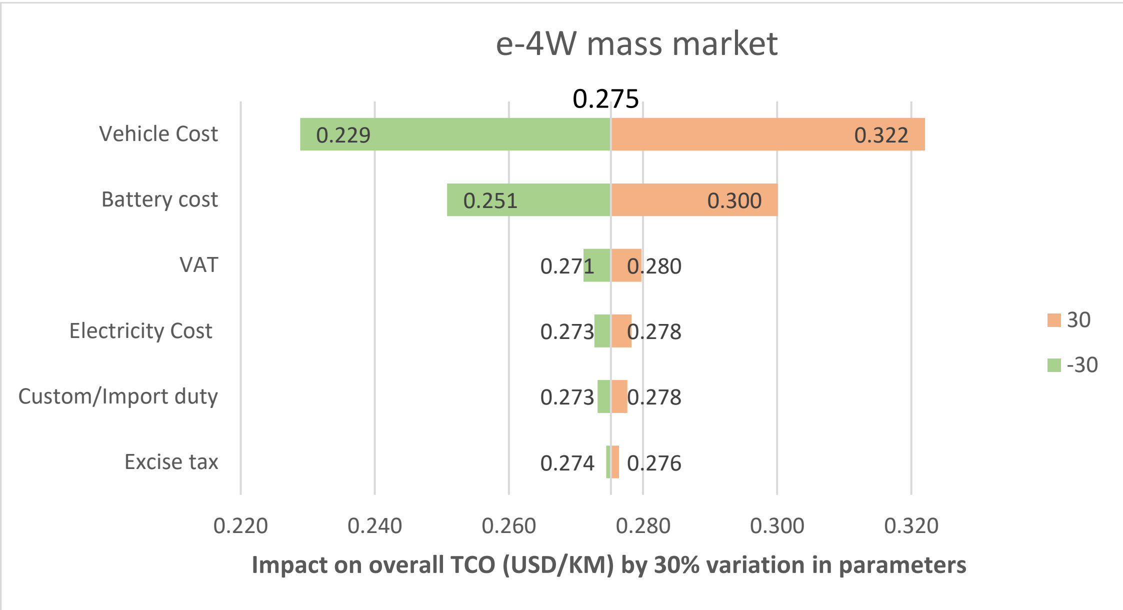


Figure 6-5: Tornado analysis for Mass Market e-4W



Inferences

6.31 The TCO of the used mass market EV car is ~6% higher than ICE and ~30% higher than Hybrid car in Mongolia. EV vehicle cost is a major contributor to this high TCO. Hybrid cars have the lowest TCO as very old and even end of life (EOL) models are still being imported into the country.

6.32 The analysis findings demonstrate that the OPEX for EVs are substantially lower, i.e. 78% and 68% lower than ICE and HEV respectively.

6.33 Battery replacement will not be needed given only 50 km run per day by an individual user and the assumed total life of the EV (7 years). If the daily run increased to 115 km, then battery replacement cost will be incurred in vehicle's lifetime.

6.34 The tornado analysis (as shown in Figure 6-5) demonstrates EV TCO is highly sensitive to vehicle and battery cost. Across taxes, VAT has higher impact on EV TCO in comparison to other taxes.

Scenario 2: 'Mid-range' Car

6.35 The TCO analysis for mid-range car segment, comparing ICE, Hybrid and EV models are shown in Figure 6-6. The selected models include 'Lexus NX 300h' for ICE, 'Toyota Harrier XU60' for hybrid, and 'BAIC EU5' for EV, as these are most prominent and widely used mid-range cars in Mongolia (also confirmed with our local experts).

6.36 The baseline scenario analysis is done considering operational parameters as: i) Average kms run per day as 50 Kms ii) Operational days per year is 283 days for ICE and Hybrid EV (Non-operational 1 day per week due to restrictions) and 330 days for EV iii) Vehicle life post import to Mongolia is considered to be 10 years. The taxes applicable are: Customs/ Import Duty at 5%, VAT at 10% and Excise tax of $3000, $725 and $109 for ICE, hybrid and EV respectively.

Figure 6-6: 'Mid-range' Car (4W) TCO analysis

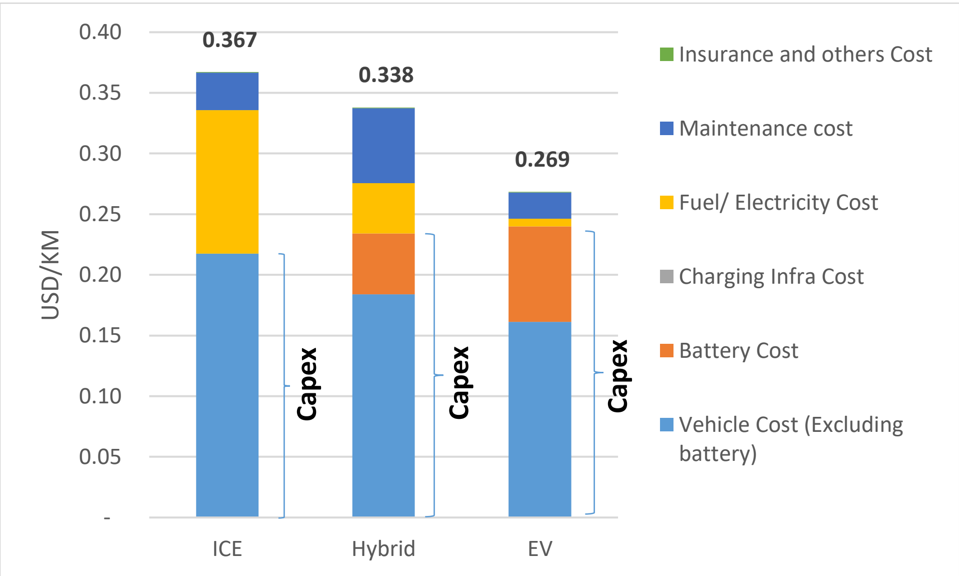
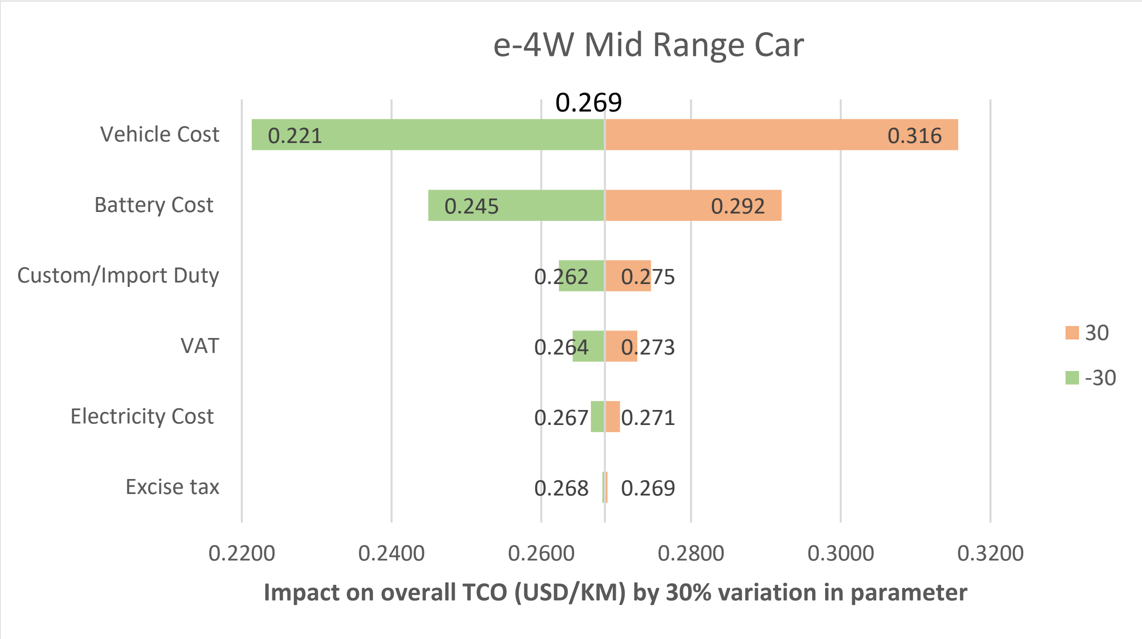


Figure 6-7: Tornado analysis for Mid-Range e-4W



Inferences

6.37 The TCO of a used EV car is ~27% lower than ICE and ~21% lower than Hybrid car in Mongolia. EV TCO has reduced and other vehicle models' cost (i.e., ICE and Hybrid) are higher and more aligned with the EV model. The operational savings from EV is resulting in its TCO being lowest.

6.38 Battery replacement will not be needed given only 50 km run per day by an individual and the assumed total life of the EV (10 years). If the daily run increased to 180 km, then battery replacement cost will be incurred in vehicle’s lifetime.

6.39 The tornado analysis (as shown in Figure 6-7) demonstrates EV TCO is highly sensitive to vehicle and battery cost. Across taxes, Custom/Import Duty has higher impact on EV TCO in comparison to other taxes.

Scenario 3: ‘New Car’ Segment

6.40 The TCO comparison for new car segment, comparing ICE and EV models shown in Figure 6-8. The selected models include ‘Mercedes Benz C class’ for ICE and ‘BYD Han’ for EV, as these are prominent and widely used new cars in Mongolia (also confirmed with our local experts).

6.41 The baseline scenario[76] analysis is done considering operational parameters as: i) Average kms run per day as 50 Kms ii) Operational days per year is 283 days for ICE

[76] Charging infrastructure cost will not be applicable as these vehicles will be charged at home

and Hybrid EV (Non-operational 1 day per week due to restrictions) and 330 days for EV iii) Vehicle life post import to Mongolia is considered to be 15 years. The taxes applicable are: Customs/ Import Duty at 5%, VAT at 10% and Excise tax of $500 and $109 for ICE and EV respectively.

Figure 6-8: 'New Car' (4W) TCO analysis

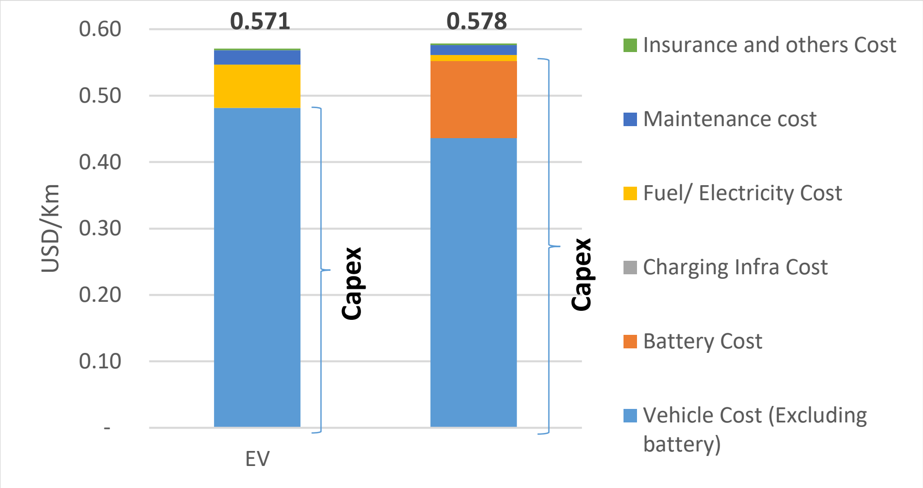
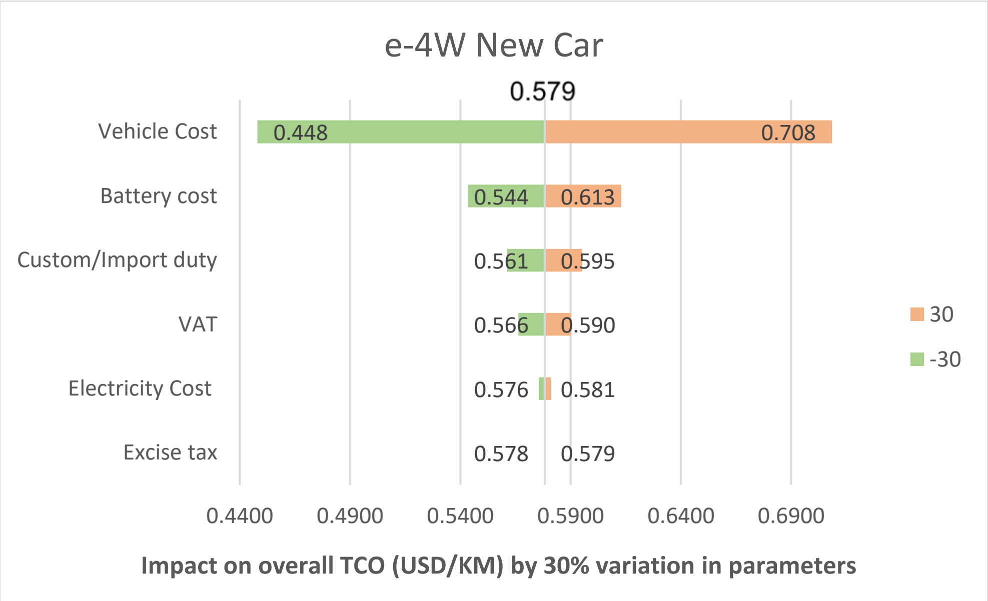


Figure 6-9: Tornado analysis for New Car e-4W



Inferences

6.42 TCO analysis of a new EV car is ~1% higher than ICE. The upfront cost of EV vehicle (33% higher than ICE) is a major contributor to the high TCO. The OPEX for ICE is 3 times the EV OPEX.

6.43 Battery replacement will not be needed given only 50 km run per day by an individual and the assumed total life of the EV (15 years). If the daily run increased to 300 km, then battery replacement cost will be incurred in vehicle's lifetime.

6.44 The tornado analysis (as shown in Figure 6-9) demonstrates EV TCO is highly sensitive to vehicle and battery cost. Across taxes, Custom/Import duty has higher impact on EV TCO in comparison to other taxes.

Scenario 4a: Sedan Taxi

6.45 The TCO analysis for commercial taxi car segment, comparing ICE, Hybrid, and EV models are shown in Figure 6-10. The selected models include 'Toyota Corolla' for ICE, 'Toyota Prius 20' for hybrid, and 'Nissan Leaf' for EV, as these are most prominent and widely used in Mongolia (also confirmed with our local experts).

6.46 The baseline scenario analysis is done considering operational parameters as: i) Average kms run per day as 150 Kms ii) Operational days per year is 283 days for ICE and Hybrid EV (Non-operational 1 day per week due to restrictions) and 330 days for EV iii) Vehicle life post import to Mongolia is considered to be 7 years. The taxes applicable are: Customs/ Import Duty at 5%, VAT at 10% and Excise tax of $2000, $1697 and $109 for ICE, hybrid and EV respectively.

Figure 6-10: 'Commercial Taxi' Car (4W) TCO Analysis

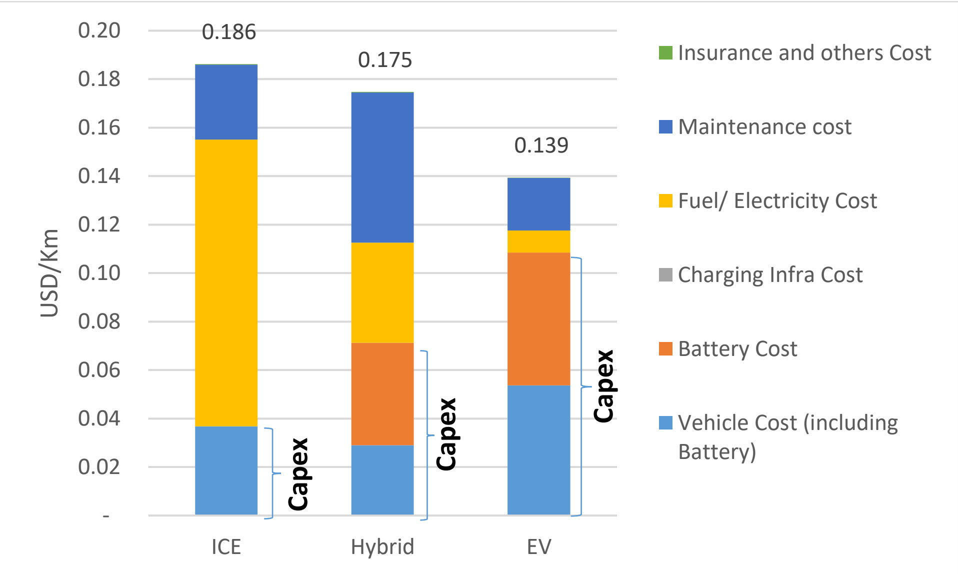
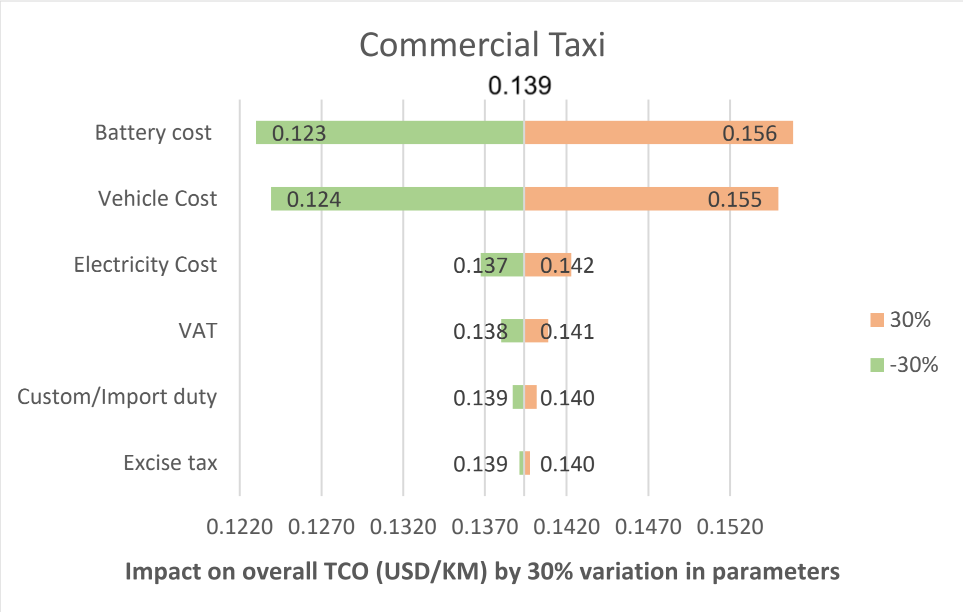


Figure 6-11: Tornado analysis for Commercial Taxi e-4W



Inferences

6.47 TCO analysis of used EV Commercial Taxi car is ~25% lower than ICE and ~20% lower than Hybrid car in Mongolia. Given high km run per day, i.e., 150 km and reasonably lower electricity tariff the EV TCO is favourable. TCO of ICE is highest as with increase in average run per day, fuel cost has increased significantly.

6.48 The findings demonstrate that the OPEX for EVs are substantially lower i.e., 78% and 74% lower than ICE and HEV respectively considering the current operating parameter.

6.49 The tornado analysis (as shown in Figure 6-11) demonstrates EV TCO is highly sensitive to vehicle and battery cost followed by electricity cost. Across taxes, VAT has higher impact on EV TCO in comparison to other taxes.

Scenario 4b: 'Premium' Taxi

6.50 The TCO analysis for new taxi vehicle segment, comparing ICE and EV models are shown in Figure 6-12. The selected models include 'Mercedes Benz C class' for ICE and 'BYD Han' for EV, as these are most prominent and widely used new cars in Mongolia (also confirmed with our local experts).

6.51 The baseline scenario[77] analysis is done considering operational parameters as: i) Average kms run per day as 150 Kms ii) Operational days per year is 283 days for ICE (Non-operational 1 day per week due to restrictions) and 330 days for EV iii) Vehicle

[77] Charging infrastructure cost will not be applicable as these vehicles will be charged at home using slow overnight charging (it is assumed their range will be sufficient for daily use within the city).

life post import to Mongolia is considered to be 15 years. The taxes applicable are: Customs/ Import Duty at 5%, VAT at 10% and Excise tax of $500 and $109 for ICE and EV respectively.

Figure 6-12: 'Premium Taxi' Car (4W) TCO Analysis

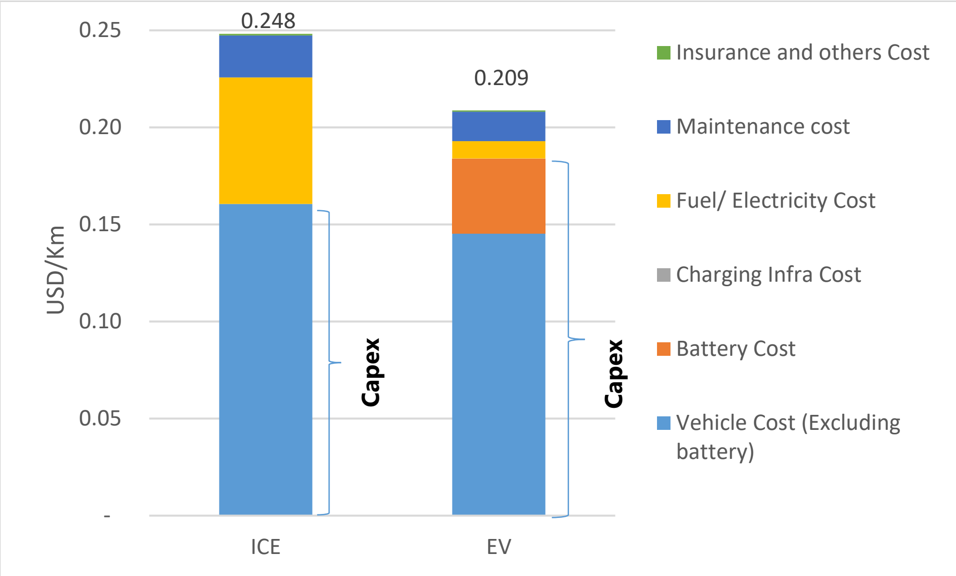
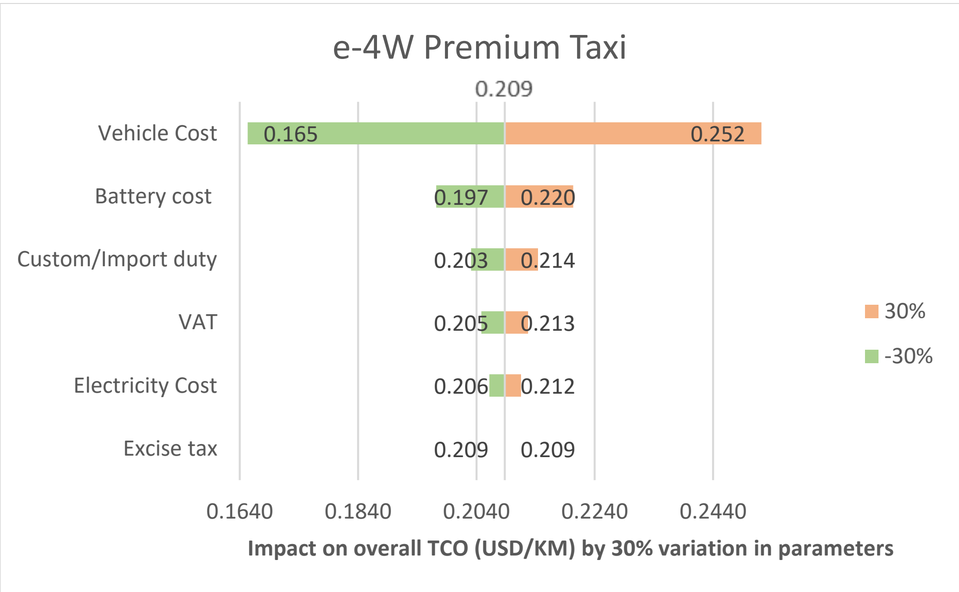


Figure 6-13: Tornado Analysis for Premium Taxi e-4W



Inferences

6.52 Analysis suggests that the TCO of a new, premium EV taxi is ~16% lower than that of an equivalent ICE. The lower TCO is obtained because of lower OPEX for the EV given the high vehicle utilization. The OPEX for ICE is 3 times the OPEX for the EV.

6.53 Battery replacement will not be needed given only 150 km run per day by an individual and the assumed total life of the EV (15 years). If the daily run increase to 250 km, then battery replacement cost will be incurred in vehicle's lifetime.

6.54 The tornado analysis (as shown in Figure 6-13) demonstrates EV TCO is highly sensitive to vehicle and battery cost. Across taxes, VAT has higher impact on EV TCO in comparison to other taxes.

Scenario 5: 'New Bus' Segment

6.55 The TCO comparison for the new bus segment, comparing ICE and EV models, is shown in Figure 6-14. The selected models include 'Yutong ZK6108HGH' (USD 90,000) for ICE, and 'YUTONG E12' (USD 270,000) for EV.

6.56 The baseline scenario analysis is done considering operational parameters as: i) Average kms run per day as 220 Kms ii) Operational days per year is 310 days for ICE and EV iii) Vehicle life post import to Mongolia is considered to be 12 years.

Figure 6-14: New Bus Segment TCO Analysis

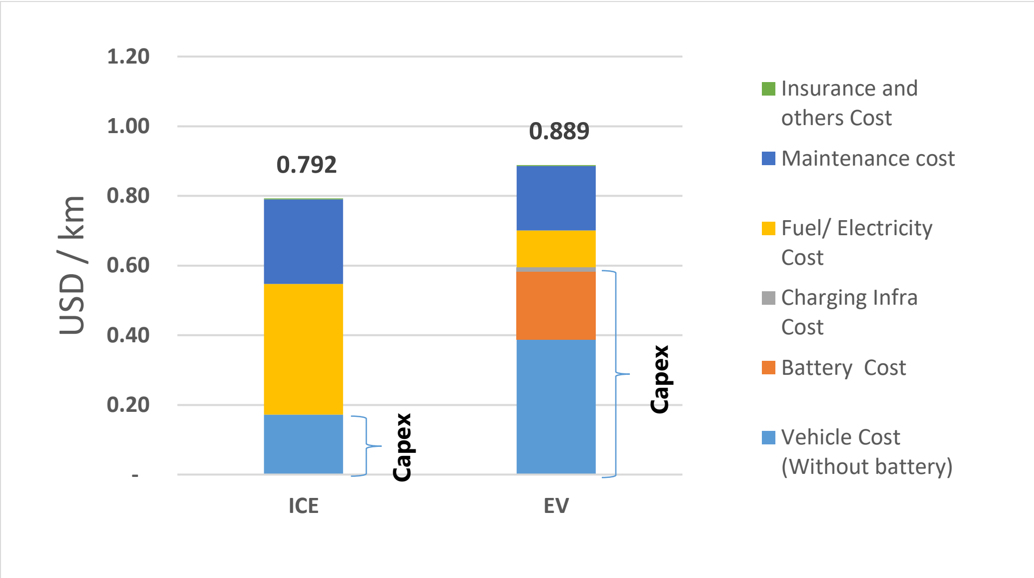
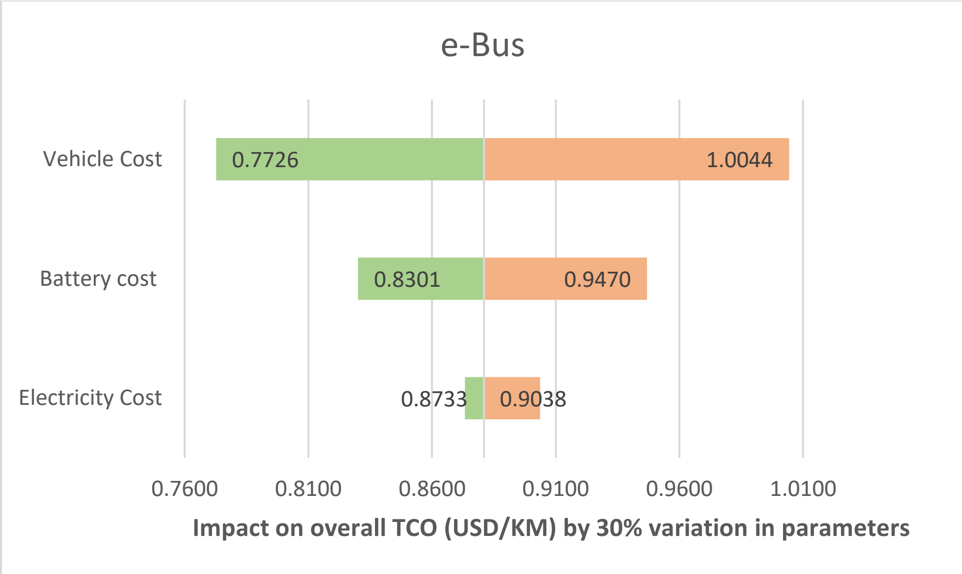


Figure 6-15: Tornado Analysis for e-bus



Inferences

6.57 TCO analysis of e-buses is ~12% higher than ICE. The primary contributor for high TCO is the e-bus vehicle cost which is around 3 times higher than ICE bus.

6.58 Battery replacement will not be needed given only 220 km run per day by an individual user leading to battery life is greater than the assumed total life of the EV (12 years). If the daily run increased to 270 km, battery replacement cost will be incurred in vehicle's lifetime.

6.59 The findings demonstrate that the OPEX for EVs are 58% lower considering the current operating parameter. The tornado analysis (as shown in Figure 6-15) demonstrates EV TCO is highly sensitive to vehicle and battery cost.

Scenario 6: 'Light Freight' Vehicle

6.60 The TCO assessment for the new light freight vehicle segment, comparing ICE and EV models is shown in Figure 6-16. The selected models include ' Ford Transit Van' for ICE and ' BYD T3' for EV, as these are most prominent and widely used vehicles in Mongolia (also confirmed with our local experts).

6.61 The baseline scenario[78] analysis is done considering operational parameters as: i) Average kms run per day as 180 Kms ii) Operational days per year is 283 days for ICE (Non-operational 1 day per week due to restrictions) and 330 days for EV iii) Vehicle life post import to Mongolia is considered to be 15 years. The taxes applicable are:

[78] Charging infrastructure cost will not be applicable as these vehicles will be charged at depot using slow overnight charging (it is assumed their range will be sufficient for daily use within the city).

Customs/ Import Duty at 5%, VAT at 10% and Excise tax of $500 and $109 for ICE and EV respectively.

Figure 6-16: 'Light Freight' Vehicle

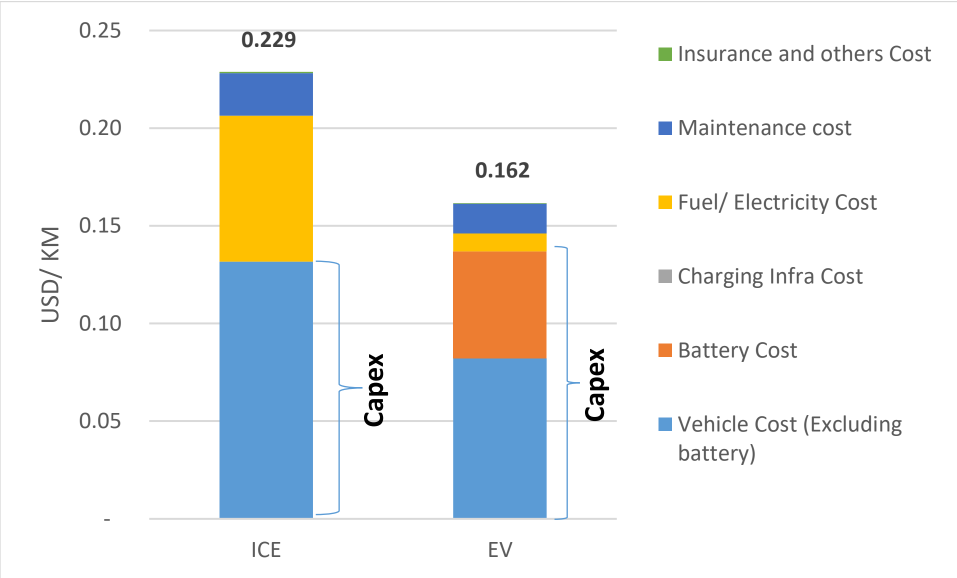
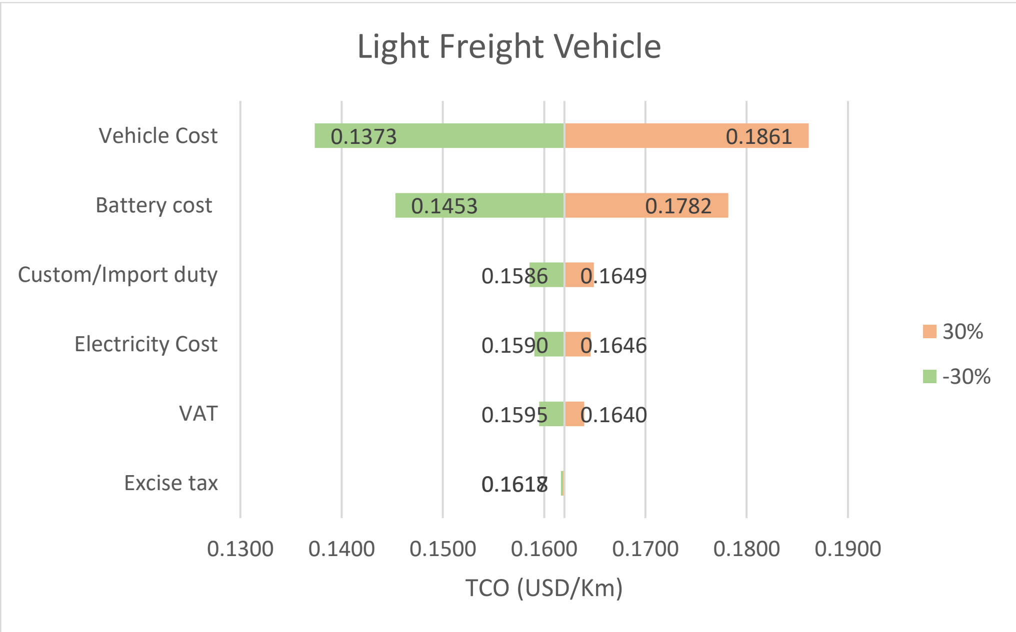


Figure 6-17: Tornado Analysis of Light Freight Vehicle



Inferences

6.62 The TCO assessment of new light freight vehicle ICE is ~29% lower than EV, the upfront cost is 11% higher for ICE.

6.63 The findings demonstrate that the OPEX for EVs are substantially lower, i.e. 70% lower than ICE.

6.64 The tornado analysis (as shown in Figure 6-17) demonstrates EV TCO is highly sensitive to vehicle and battery cost. Across taxes, Custom/Import Duty has higher impact on EV TCO in comparison to other taxes.

Scenario 7: Minibus

6.1 The TCO comparison for the new minibuses segment, comparing ICE and EV models, is shown in Figure 6-18. The selected models include 'Mercedes-Benz Sprinter' for ICE, and 'Altas Novus Ecoline' for EV.

6.2 The baseline scenario analysis is done considering operational parameters as: i) Average kms run per day as 180 Kms ii) Operational days per year is 283 days for ICE (Non-operational 1 day per week due to restrictions) and 330 days for EV iii) Vehicle life post import to Mongolia is considered to be 15 years. The taxes applicable are Customs/ Import Duty at 5%, VAT at 10% and Excise tax of $500 and $109 for ICE and EV respectively.

Figure 6-18: Minibus TCO Analysis

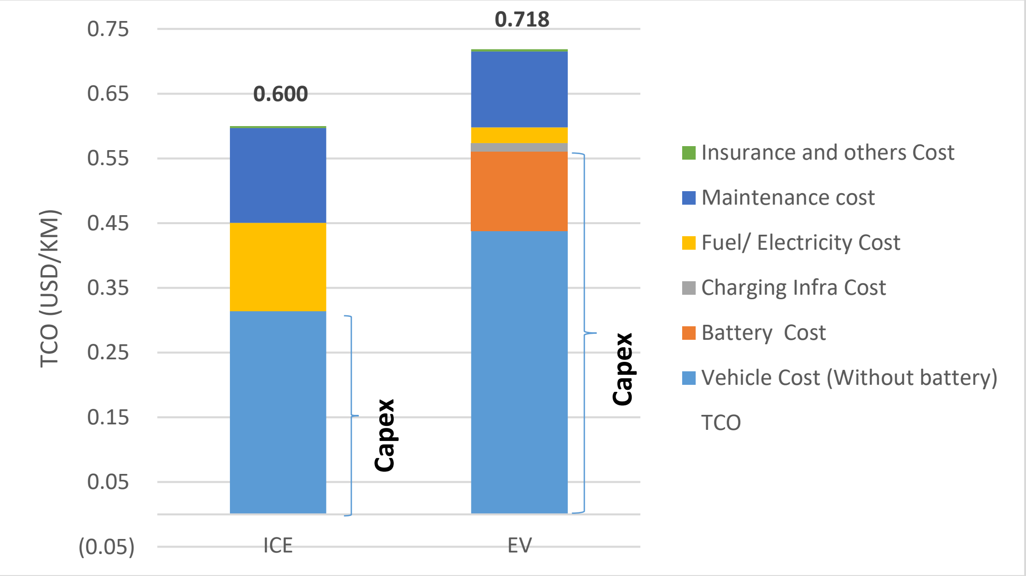
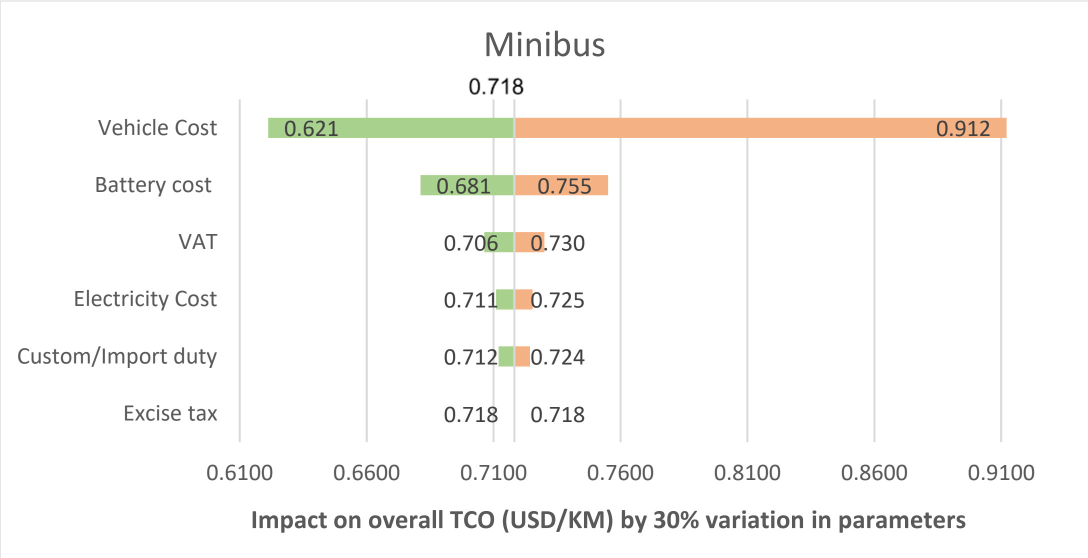


Figure 6-19: Tornado Analysis for Minibus



Inferences

6.3 The TCO assessment of new light freight vehicle EV is ~20% higher than ICE, the upfront cost is 50% higher for ICE.

6.4 The analysis findings demonstrate that the OPEX for EVs are substantially lower, i.e. 50% lower than ICE.

6.5 The tornado analysis (as shown in Figure 6-19) demonstrates EV TCO is highly sensitive to vehicle and battery cost. Across taxes, VAT has higher impact on EV TCO in comparison to other taxes.

Sensitivity analysis of input costs

6.6 Impact of individual parameters on TCO considering 30% increase/decrease from baseline scenario across vehicle segment is summarised in Table 6-5.

Table 6-5: Summary of sensitivity analysis

Segment	Impact of 30% increase/decrease in each category on overall TCO					
	Vehicle	Battery	VAT	Electricity	Import duty	Excise
Mass market car	High	High	Medium	Low	Low	Low
Mid-range car	High	High	Low	Low	Medium	Low
New Car	High	High	Low	Low	Medium	Low
Standard taxi	High	High	Low	Medium	Low	Low
Premium taxi	High	High	Low	Low	Medium	Low
Intraurban bus (12m)	High	High	Low	Medium	Low	Low
Minibus	High	High	Medium	Low	Low	Low
Light freight vehicle	High	High	Low	Low	Medium	Low

Impact on TCO	High	Medium	Low

Sensitivity analysis of electricity tariffs

6.7 Mongolia currently provides low cost and highly subsidized electricity, with rates at 4 cents per kWh, significantly below than the Asian average of 10 cents per kWh[79]. To understand the magnitude of impact of this upon the favourable TCO of EVs, Table 6-6 illustrates the impact of a tariff increase to the Asia average energy rate upon the TCO of the modelled EV segments. The analysis indicates the impact on low energy tariffs upon relative economic viability is greatest for the urban bus segment (reducing relative TCO by 11% compared to the Asian average) and lowest on new car segment (resulting in a % increase).

6.8 This will be an important consideration for roadmap development in terms of:

- Potential impact of future energy tariff reform upon EV demand (in light of the policy agenda towards full cost recovery in the energy sector)

[79] Statista. (2023, April 24). *Household electricity prices APAC 2022, by country*. https://www.statista.com/statistics/1378957/apac-household-electricity-prices-by-country/

- Potentially higher EV TCO where renewable energy is used for charging (either through the Feed in Tariff or on-site renewable generation).

Table 6-6: Impact of increasing electricity tariff on TCO

Vehicle Segment	EV TCO (Baseline Scenario)	EV TCO (Asia average)	Percent Increase in EV TCO	ICE vs EV differential (baseline)		ICE vs EV differential (after increase in tariff)	
				Percent[80] (%)	Absolute (#)[81]	Percent (%)	Absolute (#)
Mass market Car	0.275	0.292	6%	6%	0.015	12%	0.032
Mid-range car	0.268	0.280	4%	-27%	-0.099	-24%	-0.087
New car	0.578	0.594	3%	1%	0.007	4%	0.024
Commercial taxi car	0.139	0.156	12%	-25%	-0.047	-16%	-0.030
New premium taxi	0.209	0.224	8%	-16%	-0.039	-9%	-0.023
New bus	0.889	0.975	12%	12%	0.096	23%	0.180
Minibus	0.718	0.759	6%	20%	0.121	27%	0.160
New light freight vehicle	0.162	0.179	10%	-29%	-0.067	-22%	-0.050

Sensitivity analysis of bus speeds

6.9 To understand how the TCO of buses may vary in scenarios of worsening congestion (reduced daily mileage) or more effective segregation/charging strategies (increased daily mileage), we also analysed the impact of +/- 20% change on daily kilometre run for ICE and e-bus. The findings are shown in Table 6-7. The key inference from this is that increasing their productivity is key to reducing their economic premium relative to ICE (logically considering the vast differences between capital cost and operating cost profiles).

[80] Values shows TCO differential as percentage of ICE TCO
[81] Negative value indicates EV TCO is less than ICE TCO

Table 6-7: Impact of daily run (km.) on TCO

Avg. kms run per day	20% decrease	Baseline	20% Increase
ICE TCO (USD/Km)	0.836	0.792	0.763
EV TCO (USD/Km)	1.052	0.889	0.780
Differential ICE/EV	26%	13%	2%

Key conclusions and findings

6.10 In considering the business-as-usual potential for EV market development:

- **EV sedans** are broadly competitive with ICE and HEV equivalents in the higher value market segments and higher intensity use cases (e.g. taxis), with higher capital costs offset by much lower operating costs (particularly considering Mongolia's low energy costs). In the mass market vehicle segment, EVs are not currently financially competitive with ICEs (or particularly HEVs) for lower intensity private use, however when applied to commercial settings (e.g., Taxis) this is reversed.
- **E-buses** remain 12% more expensive per km than their diesel bus counterparts, driven principally by the high vehicle and battery capital costs. Optimising charging strategies and increasing operating speeds) is an important factor in addressing this gap.
- **Urban freight**: Light freight vehicles offer a lower TCO for EV than ICE when considering the additional circulation potential (i.e. not being subject to licence plate-based circulation restrictions in Ulaanbaatar). On this basis, capital costs per km is almost identical, with cost savings resulting from lower energy and maintenance costs. This analysis applied to the new vehicle segment, most relevant to larger corporate fleets.

Energy sector impacts of EVs

Energy demand scenario analysis

Scenarios

6.11 Responding to Mongolia's demand peak challenge, this section assesses the magnitude of energy demand impact of different (hypothetical) levels of EV deployment, laid onto a base of current Mongolia's CES demand profile (i.e., including

Ulaanbaatar). It is worth emphasising that these five scenarios are not those proposed to take forward to Phase 2 of the study, rather have been generated to support discussion around potential levels of ambition in the EV sector. As the major vehicle segments currently in operation in Mongolia, private cars and urban buses have been included. Light freight vehicles have not been included specifically due to limited data on their potential scope, however their energy consumption profile would be similar to the personal vehicles segment. The scenarios comprise:

- Scenario 1 – Is according to the MRTD working EV estimates. In this scenario, 30,000 of personal vehicles are electrified, and 50% of the bus fleet operates on electricity.
- Scenario 2 – Aligns with the OECD-ITF baseline projection for 2030. In this scenario, 0.14% of personal vehicles are electrified, and 50% of the bus fleet runs on electricity.
- Scenario 3 – Aligns with the OECD-ITF climate ambition target for 2030. In this scenario, 2.3% of personal vehicles are electrified, and 50% of the bus fleet runs on electricity.
- Scenario 4 – Aligns with the OECD-ITF baseline projection for 2050. In this scenario, 16% of personal vehicles are electrified, and 70% of the bus fleet runs on electricity.
- Scenario 5 - Aligns with the OECD-ITF climate ambition target for 2050. In this scenario, 50% of personal vehicles are electrified, and 100% of the bus fleet runs on electricity.

Forecasted CES demands.

6.12 Using linear growth factors found in literature, a forecasted demand profile is generated to represent the expected demand in the year 2030 and 2050. Demand for the year 2030 incorporates a growth factor that results in a peak demand of 1700 MW[82] and demand in the year of 2050 results in a peak demand 2200 MW[83].

[82] Based on projections found in ADB's report titled "Ulaanbaatar Air Quality Improvement Program: Sector Assessment Energy" Asian Development Bank. (2021, December 17). Ulaanbaatar Air Quality Improvement Program and Ulaanbaatar Air Quality Improvement Program – Phase 2: Program Completion Report. https://www.adb.org/sites/default/files/project-documents/51199/51199-001-53028-001-pcr-en.pdf

[83] Based on projections found in report titled "The Mongolian electricity sector in the context of international climate mitigation efforts" by Frederic Hans et al.
Hans, F., et al. (2020). *The Mongolian electricity sector in the context of international climate mitigation efforts*. https://newclimate.org/sites/default/files/2020/03/Decarbonization_Pathways_Mongolia.pdf

Charging strategies assumptions

6.13 To understand the impact upon the daily demand curve, charging modes will guide the timing of these charging modes and how they affect demand. The analysis takes into account the following parameters to provide context for Mongolia:

- **Vehicle Fleet:** The analysis is grounded in the latest data regarding the composition of the bus and personal vehicle fleets in Ulaanbaatar for 2021[5].
- **EV Charging Modality Mix:** This analysis takes factors in the demand for the following mix of EV charging modalities listed below. The future mix of EV charging modes is extrapolated from a European perspective[84] but adjusted to align with the expected composition for Mongolia.

6.14 The profile for Scenarios 1 and 2 (Table 6-8) considers the prevailing charging method to be home charging, while public slow charging is anticipated to have minimal market impact, predominantly for 'top ups'. This assumes that EV buyers in these scenarios are likely to come from a more affluent demographic and predominantly have access to private parking spaces with captive home charging.

Table 6-8: Charging mix – Scenario 1 and 2

Charging type	Charging modalities	Predominant charging time
Slow charging	70% home charging	Overnight
	20% public charging	All day
	5% workplace charging	Morning
Fast charging	5% fast charging stations	All day
E-bus charging	100% depot charging	Mid-day, end of service (fast)

6.15 In the higher Scenarios (3 and 4), this trend is expected to shift, with individuals lacking private parking spaces and greater overall vehicle penetration creating a demand for public charging. Consequently, public charging is projected to become more widespread, making the model considerably more viable. This is shown in Table 6-9.

Table 6-9: Charging mix – Scenario 3 and 4

Charging type	Charging modalities	Predominant charging time
Slow charging	30% home charging	Overnight
	60% public charging	All day

[84] ElaadNL. (2024, July 4). *ELAADNL Outlooks • Projecten • ELAADNL*. https://elaad.nl/projecten/elaadnl-outlooks/

	5% workplace charging	Morning
Fast charging	5% fast charging stations	All day
E-bus charging	100% depot charging	Midday, end of service (fast)

Adjustments for Mongolian climate

6.16 To contextualise the influence of Mongolia's climate, we apply an average factor of 1.26 to the total annual energy demand. This factor accounts for efficiency reductions observed in EV performance in colder-temperature countries, extrapolated based on Mongolia's average monthly temperatures.

6.17 To assess the impact of different EV scenarios, we categorise charging sessions into three time-of-use periods: shoulder (06:00-17:00), peak (17:00-22:00), and off-peak (22:00-06:00). It's important to emphasise that this assessment pertains to the overall demand within the central region. It's worth considering that the distribution of EVs may vary, potentially affecting substations in a non-uniform manner. Home charging is relatively distributed among the distribution grid, fast charging stations and e-bus charging depots are concentrated in several points. These can result in large stress on the grid during peak usage.

Energy demand profile: Scenario 1 – MRTD working scenario 2030

6.18 **Regarding Scenario 1**, there are an estimated 30,000 EVs (6%) in operation, primarily concentrated in Ulaanbaatar, along with approximately 530 (40%) electric buses. This results in a peak demand of almost 1,750 MW in the CES system by 2030. The analysis indicates that the most significant impacts occur late in the shoulder up to early off-peak (13:00-01:00), resulting in EV related demand increases up to 1 - 5%. Between 02:00 and 12:00, the demand only increases to a maximum of 1%.

Figure 6-20: Impact on peak demand of CES for Scenario 1

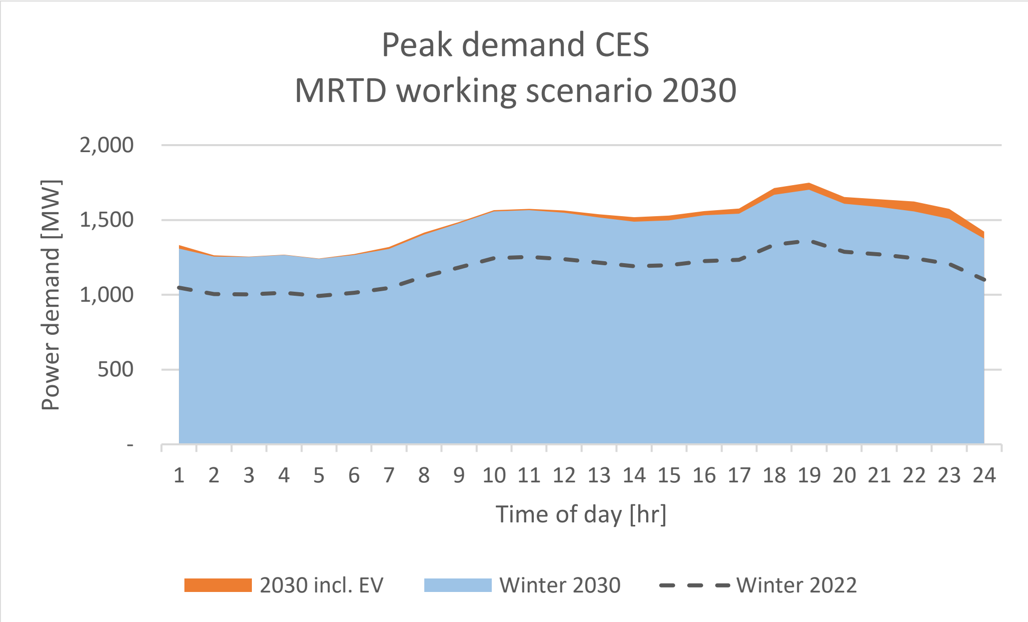
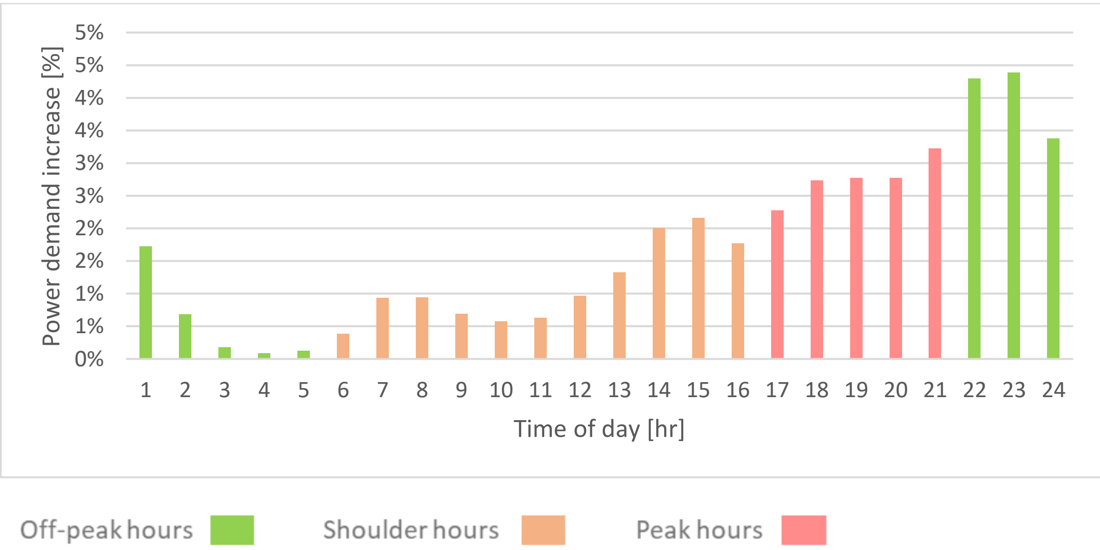


Figure 6-21: Power demand increase in percentage for Scenario 1



Energy demand profile: Scenario 2 – OECD-ITF Baseline target 2030

6.19 **In Scenario 2,** this scenario provides an initial glimpse into delayed integration of EVs in Mongolia. In this scenario, approximately 1,100 EVs (0.23%) are in operation by 2030, primarily in Ulaanbaatar, along with roughly 660 electric buses (ca. 50%). The analysis reveals that a minor impact to the peak demand and EV demand occur mostly late in the shoulder (13:00-16:00) and early in the off-peak hours (22:00-02:00), resulting in demand increases ranging from 1% to 2% of the demand at that particular time.

Noticeably there due to low penetration of EV, but relatively high e-bus results in almost no impact to the peak hours.

Figure 6-22: Impact on peak demand of CES for Scenario 2

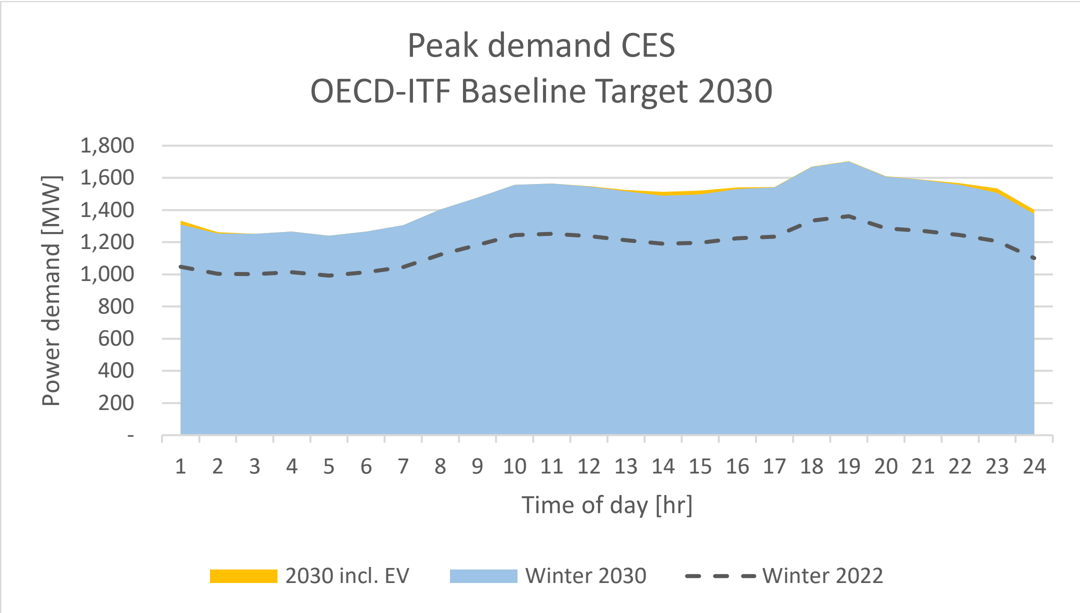
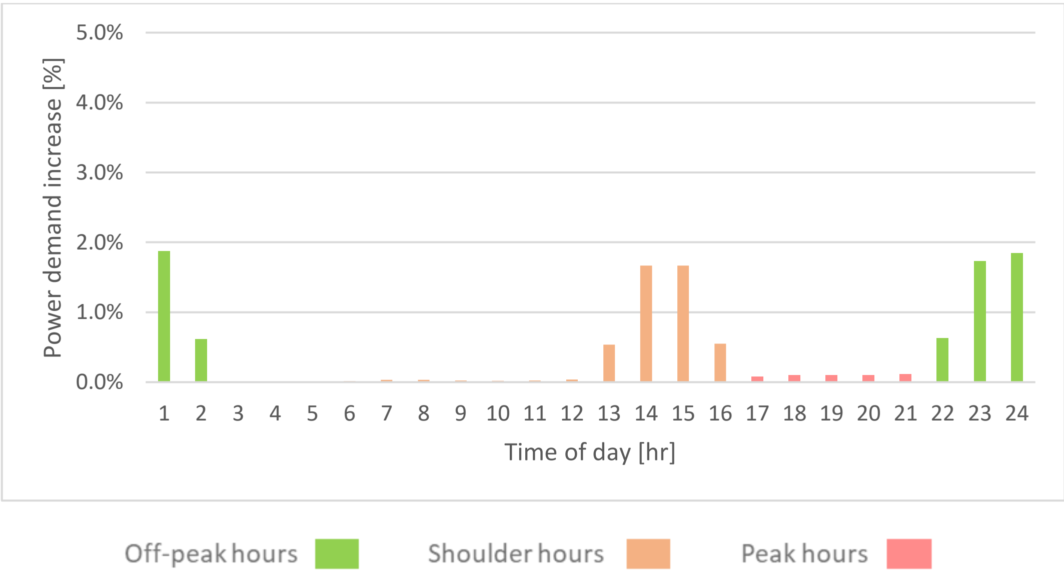


Figure 6-23: Power demand increase in percentage for Scenario 2



Energy demand profile: Scenario 3 - OECD-ITF climate ambition target 2030

6.20 **Regarding Scenario 3**, this scenario offers a glimpse into a future, where 2.3% of Mongolia's vehicle fleet is electrified, and 50% of buses are fully electric by 2030. Including EV charging the peak demand is around 1,730 MW. Furthermore, up to 12 and 15% of demand increase during peak hours are caused by EV, which is less than ideal. However, it is noticeable that the EV demand peaks concentrate in the early off-peak hours (22:00 – 01:00).

Figure 6-24: Impact on peak demand of CES for Scenario 3

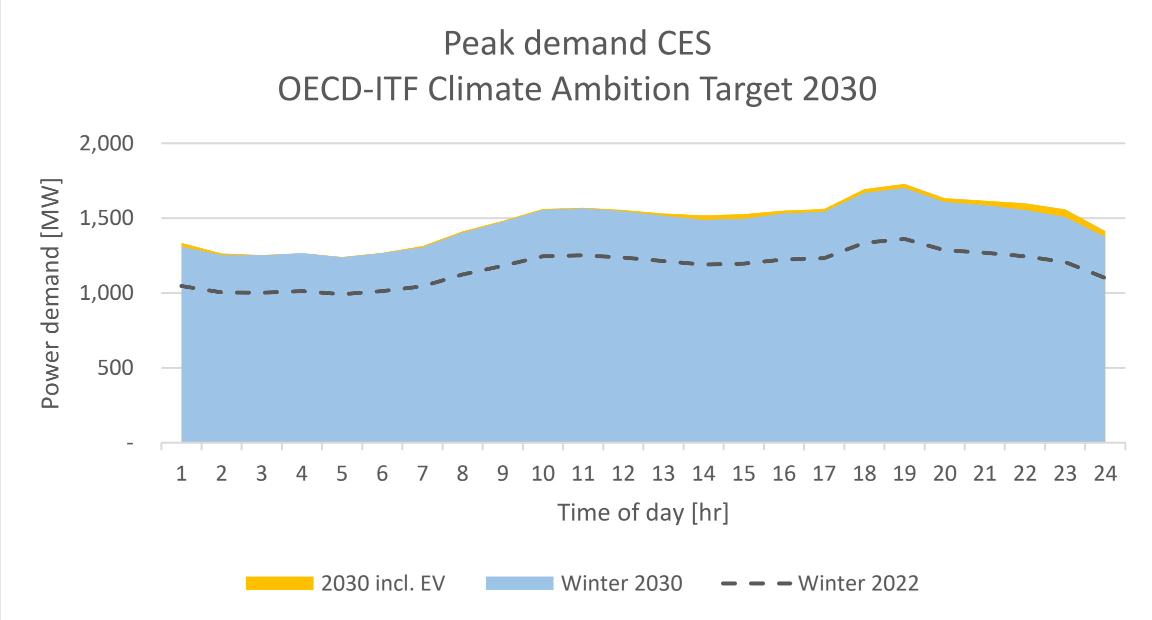
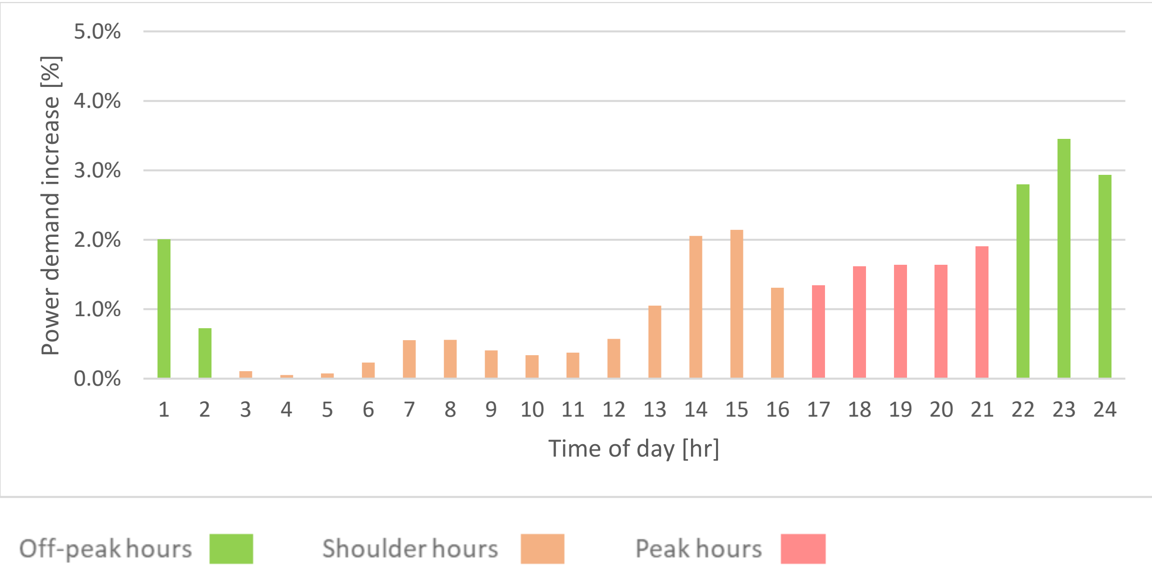


Figure 6-25: Power demand increase in percentage for Scenario 3



Energy demand profile: Scenario 4 - OECD-ITF Baseline target 2050

6.21 **Scenario 4 provides** a glimpse into a much more distant future in 2050 where Mongolia delayed electrification of its vehicle fleet (16% personal vehicles and 70% bus fleet. In this scenario, the impact becomes more prevalent. However, this is overshadowed by the growth in peak demand towards 2050 (ca. 2,400 MW). During peak hours (and early off-peak), there is an increase in peak demand due to EV's ranging between 6-8% during peak hours. These scenarios in 2050 also introduces a shift in the charging mix, where public charging becomes more prevalent. The analysis reveals that the impact of EV adoption on electricity demand becomes more substantial in this scenario, with a concentration of charging being more notable during the peak hours, specifically between 19:00 and 23:00.

Figure 6-26: Impact on peak demand of CES for Scenario 4

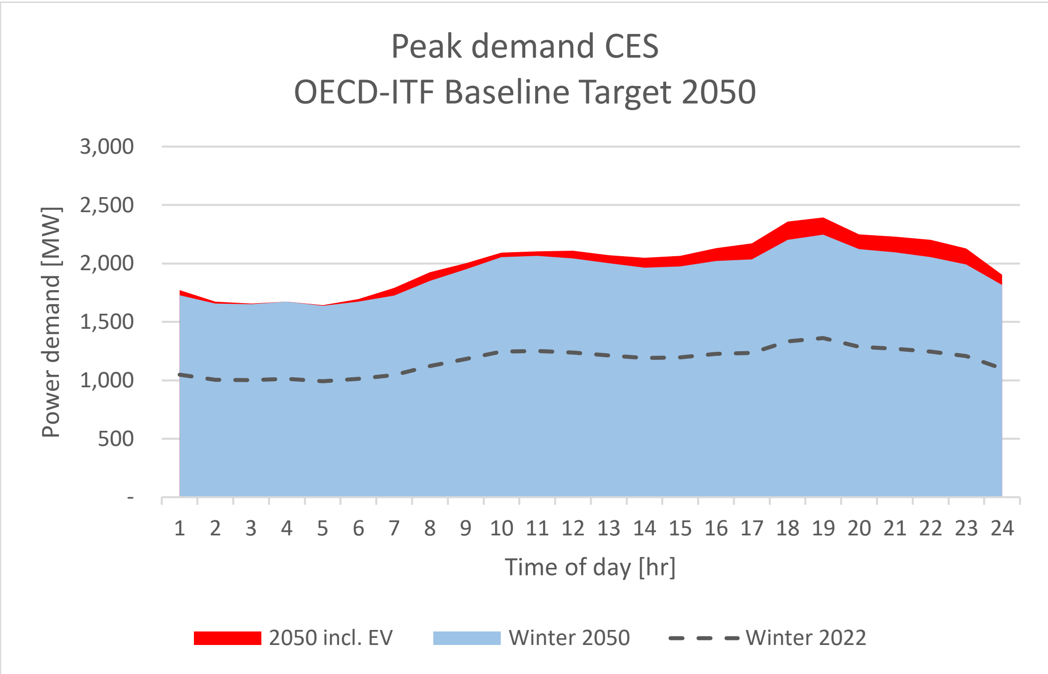
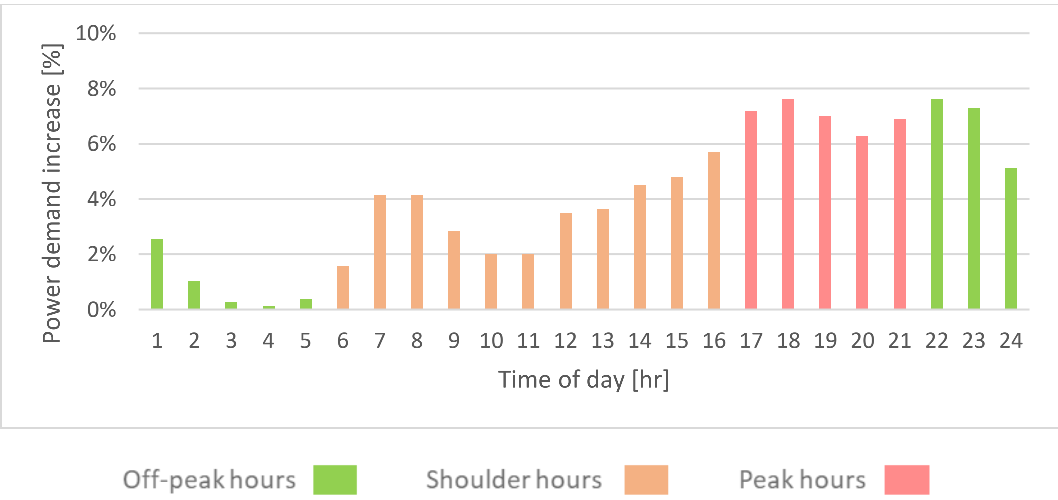


Figure 6-27: Power demand increase in percentage for Scenario 4



Energy demand profile: Scenario 5 - OECD-ITF climate ambition target 2050

6.22 **Scenario 5 provides** a view in 2050 where Mongolia achieves 50% electrification of its vehicle fleet nationwide and 100% of its bus fleet. For the central energy system, the impact is significant, and the traditional shape of peak demand begins to reshape due to the surge in EV demand. Also, there is a higher contrast between peak and off-peak hours. During peak hours (and early off-peak), there is an increase in peak demand ranging from 20% to 25%. In contrast, late in off-peak (after 00:00) the demand increase is less than 5% and during shoulder 5 – 16%.

Figure 6-28: Impact on peak demand of CES for Scenario 4

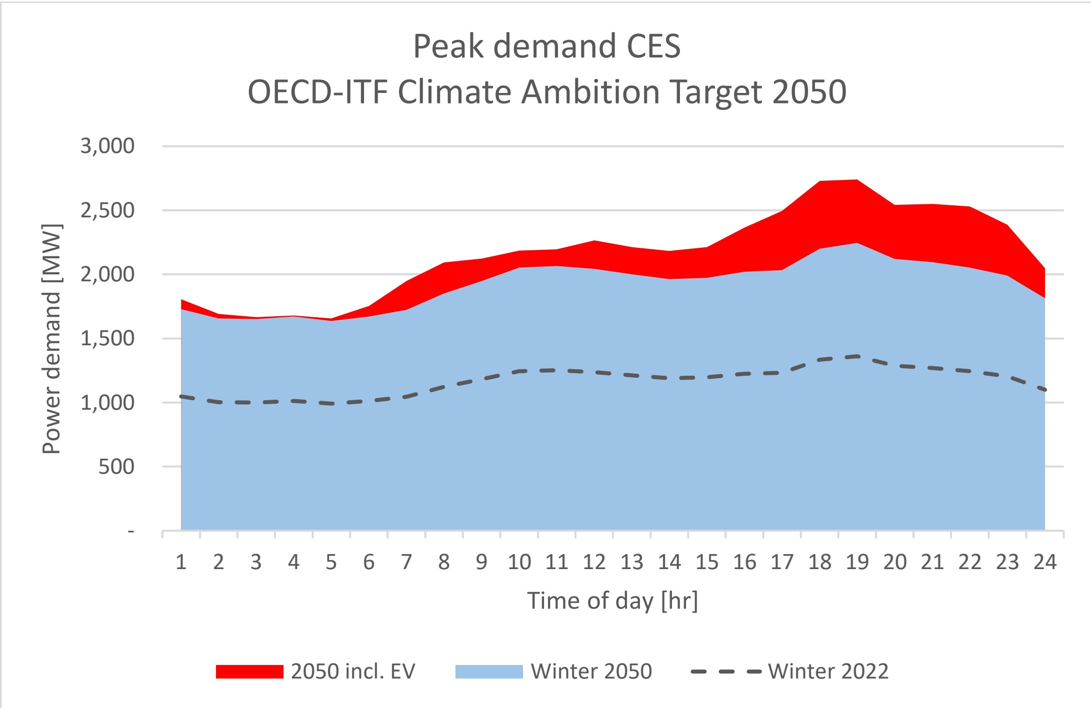
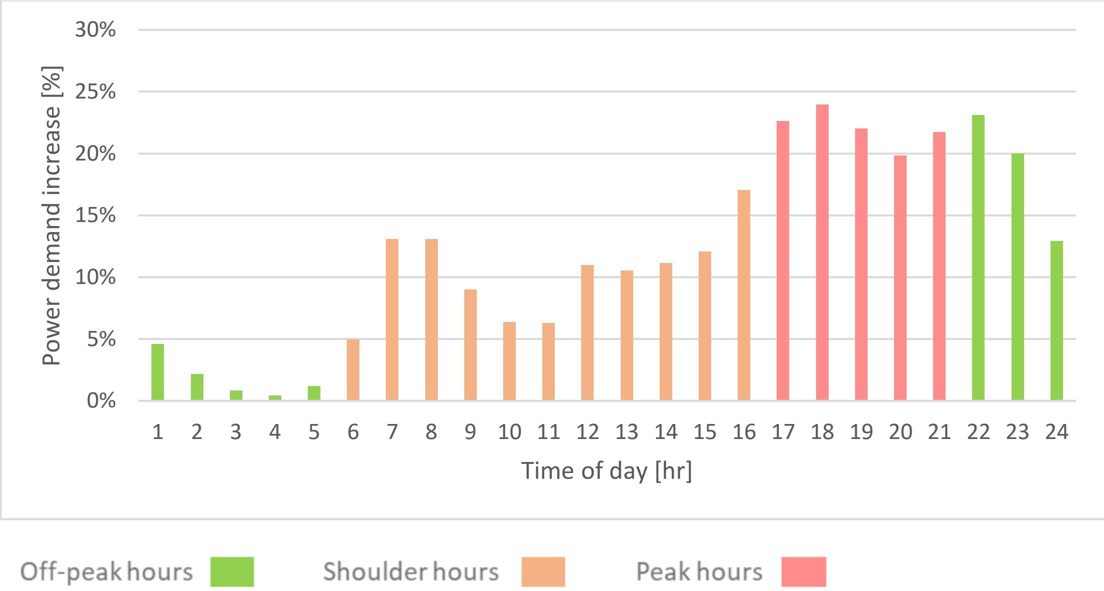


Figure 6-29: Power demand increase in percentage for Scenario 4



Conclusions

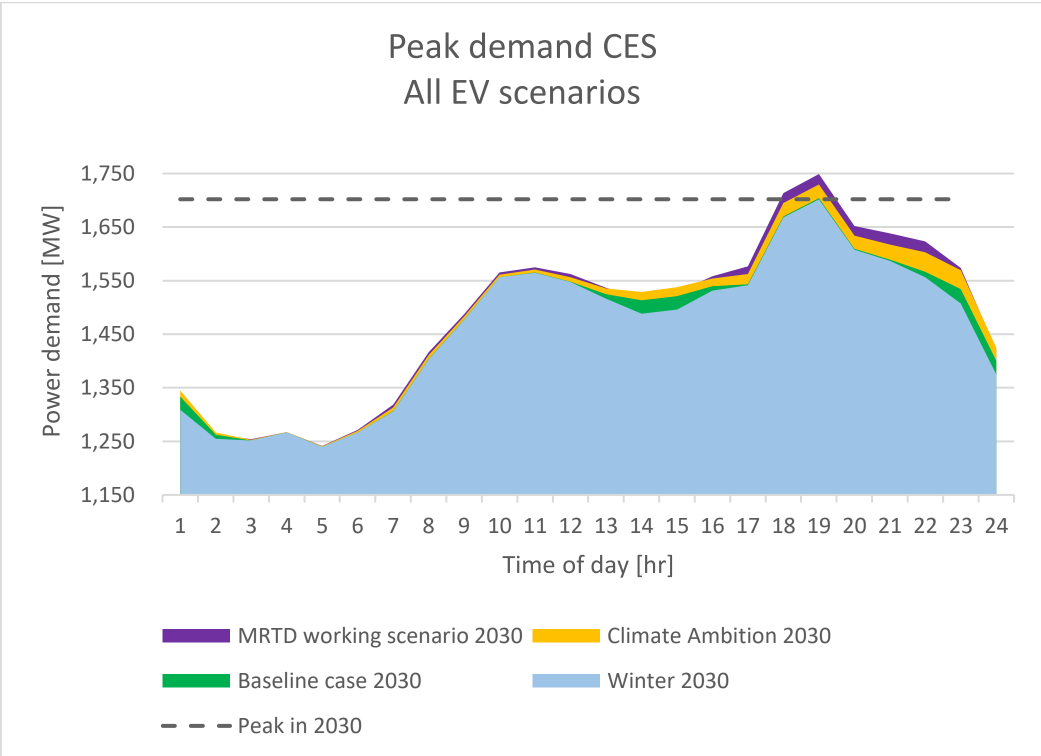
6.23 The impact of all scenarios is shown in Figure 6-30. These hypothetical scenarios indicate that:

- In the early stages of electrification of mobility, the base energy generation capacity would be sufficient to meet demand and have a relatively limited overall demand increase even in Scenario 2 (with a 30,000-vehicle ambition corresponding to MRTD's informal 2030 forecast).
- Without active strategies to shift EV charging demand to off-peak periods, the growth of EVs would have a significant impact upon demand peaks, with potential impacts on grid and transmission networks, and increasing energy imports.
    - At lower levels of ambition (for example Scenario 2 is similar to the MRTD's 30,000 EVs by 2030 estimate) this increase (of 1-5%) would be very minor relative to far higher background energy demand growth (considering population and economic growth to 2030).
    - A hypothetical high level of electrification (such as Scenario 5 and to an extent Scenario 4) would mean a major impact on demand peaks (despite minimal during off-peak and shoulder hours). Yet such a scenario is likely to take many years (if not decades) to achieve. Such ambition would need to be accompanied by energy planning.
- In all scenarios, the disproportionate impact of EV charging on peak demand would suggest promotion of peak shifting and peak-shaving strategies. This can

be considered through smart technology (e.g., implementing peak-shaving enabled EV charging stations) and/or economic governance of the energy sector (e.g., policies or tariffs incentivising EV charging outside of peak-hours and/or shifting the EV charging mix).

- Noting the predominance of renewable energy in daytime generation, the promotion of a destination charging, and rapid charging station sector could help to align EV charging with renewable energy, as well as shifting demand peaks and providing opportunities to centralise demand increases around grid capacity/upgrades (e.g. for new development).

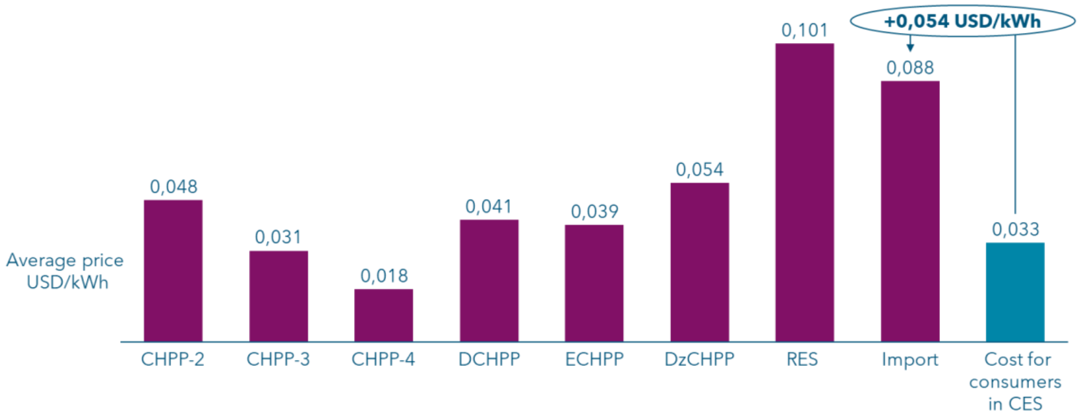
Figure 6-30: Demand growth for all EV scenarios versus peak demand in 2030



Energy subsidy impact of EV transitions

6.24 Building on earlier analysis of the potential energy subsidy impact of EV peak demand, this section seeks to provide a sense of scale of this issue in the different scenarios. This considers the current energy framework would increase the marginal peak demand would be from imported energy, which is currently among the most expensive energy sources and driver of the financial challenge facing Mongolia’s electricity sector.

Figure 6-31: Average sales price per source for 2022[57]



6.25 Based on analysis of available information, consumers typically contribute approximately 0.033 USD/kWh[85] towards generation and import costs (see Figure 5-9). In this context, the generation source used for the marginal energy demand will make a major bearing upon the impact of EVs upon the Mongolian energy subsidy challenge. For example, in the evening peak time, marginal energy would be supplied from imports at a rate of 0.087 USD/kWh. This suggests that, without energy tariff reform, the governmental energy stakeholders will have to subsidise 0.054 USD for each EV related kWh charged during peak demand[86]. To provide context, let's examine EV demand Scenario 1, where inside the CES approximately 224 MWh are charged during peak hours. If we assume that this extra demand is entirely met through imports at an extra cost of 54 USD/MWh compared to domestic electricity rates, it results in an additional energy expenditure of approximately $12,000 for a high demand day.

6.26 Table 6-10 annualizes these expenditures based the annual average EV demand. Additionally, an expenditure per vehicle is given taken into consideration the distribution of the impact between EV passenger cars and E-busses.

6.27 Additionally, the current on-grid renewable energy FIT regime sees RES being paid 0.10 USD/kWh. Where an increase in EVs is accompanied by additional on-grid RES within the current tariff and regulatory regime, the energy system (i.e., subsidy) impact would be approximately 0.06 USD/kWh.

[85] Based on 66% of what the consumers in CES pay per kWh (174 MNT/kWh) in line with ERC data from 2022.
[86] Under the assumption that all additional energy due to EV during peak hours has to be fully imported.

Table 6-10: Indicative subsidy impact of energy imports to cover peak hour EV energy demand

Scenario	Additional EV energy during peak hours (MWh)	Total additional annual subsidy towards energy use (USD)	Additional annual subsidy towards energy use per vehicle (USD)[87]	
			Automobile	E-bus
Scenario 1 – MRTD working scenario	63,539	$ 3,431,000	$ 90	$ 1,388
Scenario 2 - OECD-ITF Baseline 2030	3,269	$ 176,000	$ 15	$ 234
Scenario 3 - OECD-ITF climate ambition 2030	38,401	$ 2,074,000	$ 65	$ 1,001
Scenario 4 - OECD-ITF Baseline 2050	242,513	$ 13,096,000	$ 95	$ 1,470
Scenario 5 - OECD-ITF climate ambition 2050	772,117	$ 41,694,000	$ 101	$ 1,562

GHG impacts of EVs in Mongolia

GHG emissions intensity of the Mongolian grid

6.28 The GHG mitigation benefits of EVs are driven by the carbon intensity of a given energy grid. The carbon intensity of electricity grids fluctuates based on the energy source used and transmission losses as shown in Table 6-11.

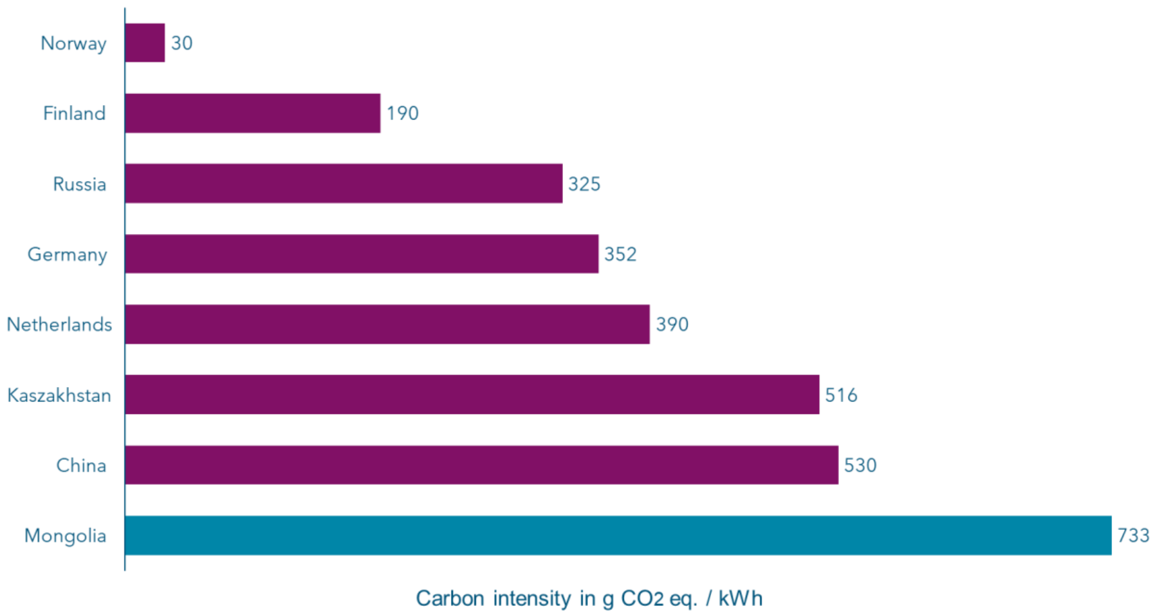
Table 6-11: Global carbon intensities of electricity generation technologies (source: ICCT)

Generation/energy source	Carbon intensity (g CO_2e/kWh)
Coal	1001
Oil	840
Natural gas	469
Bioenergy	309-1050
Hydropower	4
Nuclear energy	16
Other renewables	27

[87] Taken into consideration the energy impact of vehicle type.

6.29 The Mongolian electricity grid's focus on coal powered CHPPs means Mongolia has a CO_2 equivalent emission of 733 g CO_2/kWh[88], among the highest in the world, and significantly higher than other neighbouring countries (see Figure 6-32). This has a significant impact on the relative GHG mitigation benefits of EVs in the Mongolian context, particularly considering that grid decarbonisation is not currently a significant public policy objective. GHG mitigation is increasingly a driver of EV financing packages (and, through carbon markets, a potential source of funding/revenue for larger e-mobility investments), As such, decarbonisation of EV charging can potentially bring both social and economic/financial advantages.

Figure 6-32: Carbon intensity of Mongolia vs developed and neighbouring countries[88].



Comparison of ICE and EV emission factor – passenger cars

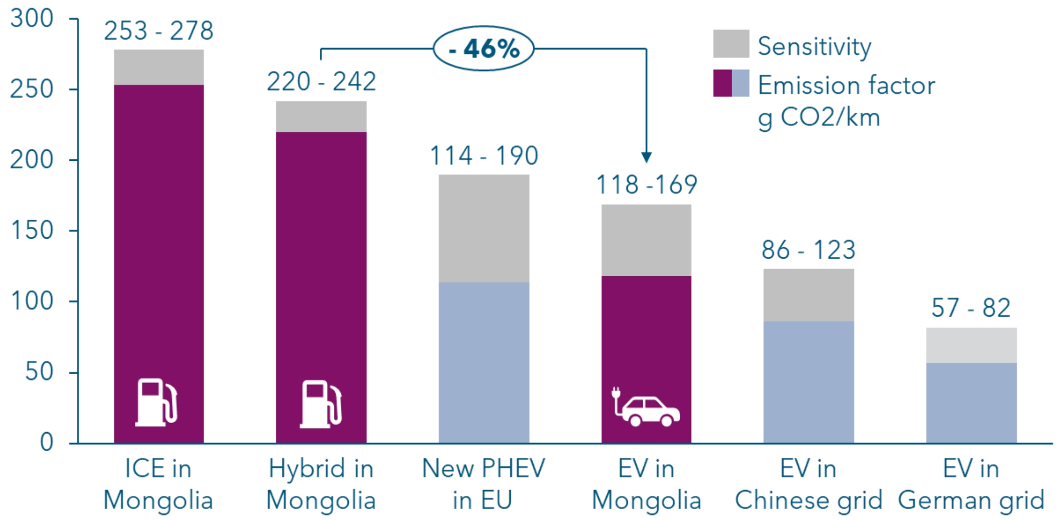
6.30 The relative emissions between EVs, HEV, and ICE passenger cars are shown in Figure 6-33 considering overall energy mix for Mongolia and benchmarks with other countries. Based on Mongolia's current generation mix, EV passenger cars are estimated to emit 46-53% less than the two ICE counterparts[89]. While this is positive overall, a BEV in Mongolia is within the range of a Plug-in-Hybrid Electric Vehicle

[88] Statista. (2024, August 1). Electricity sector carbon intensity APAC *2022, by country*. https://www.statista.com/statistics/1299708/apac-carbon-intensity-power-sector-by-country/

[89] This assessment relies on data related to vehicle mileage and efficiency, taking into consideration driving behavior and local conditions in Mongolia. It includes ICE vehicles achieving 9.1 km/liter, Hybrid 10.5 km/liter and EV 4.4 km/kWh. Zenobē. (2022, November 2). *£0.5m per 100 buses per year: the impact of e-bus driver performance on operational costs - Zenobē*. https://www.zenobe.com/insights-and-guides/0-5m-per-100-buses-per-year-the-impact-of-e-bus-driver-performance-on-operational-costs/

(PHEV) in the EU, and results in 30% more GHG emissions than an EV with the same characteristics powered by the Chinese grid.

Figure 6-33: Emission factor of passenger cars across ICE, Hybrid and EV[90]



Comparison of ICE and EV emission factor – buses

6.31 When applying the same analysis to buses, it can be deduced that, given the current carbon intensity of the grid, e-buses will emit 777 to 910 grams of CO_2/km, along with an additional 133 grams CO_2/km for heating during the winter. Depending on the type and age of the ICE bus in Mongolia, an electric bus may emit the same amount of emissions or up to 6% more than an equivalent diesel-powered bus, especially when considering the use of additional diesel-powered heating in winter. These findings originate from the increased GHG emissions of the Mongolian grid and the comparatively lower efficiency of e-buses in terms of energy per kilometre (0.16 kWh/km for passenger EVs versus 1.25 kWh/km for e-buses). This highlights the challenges associated with electrifying heavy vehicles[91].

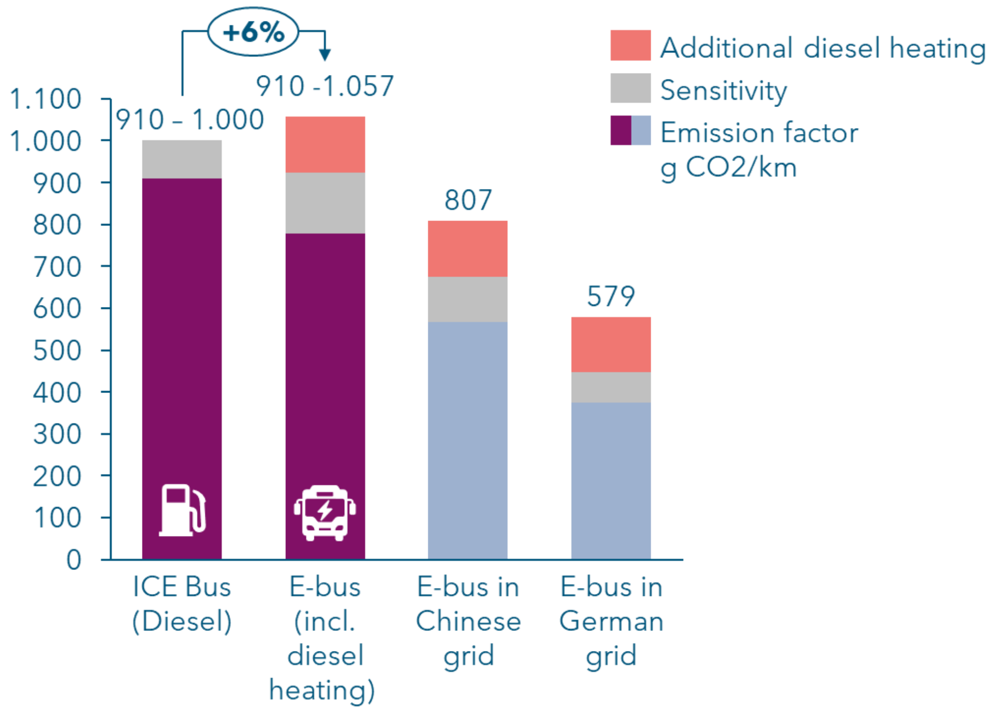
6.32 In contrast, if the same electric vehicle characteristics are examined in a Chinese or German grid, the results are more favourable for e-buses. This suggests a pressing need to reduce the GHG emissions of the Mongolian grid (or at least for e-bus

[90] This assessment relies on data related to vehicle mileage and efficiency, taking into consideration driving behavior and local conditions in Mongolia aligning with the TCO analysis. Grid GHG emissions based on data displayed in Figure 6-32. PHEV emissions based on data found in ICCT's whitepaper: "REAL-WORLD USAGE OF PLUG-IN HYBRID VEHICLES IN EUROPE" Real-world usage of plug-in hybrid vehicles in Europe: A 2022 update on fuel consumption, electric driving, and CO2 emissions - International Council on Clean Transportation. (2022, November 8). International Council on Clean Transportation. https://theicct.org/publication/real-world-phev-use-jun22/

[91] Pmanifold, A. (n.d.). *All EV segments are Green: A myth or reality? – Pmanifold.* https://www.pmanifold.com/blogs/all-ev-segments-are-green-a-myth-or-reality/

charging). It is important to reiterate that, when taking into account the passenger capacity that can be accommodated, the e-bus slightly outperforms passenger EVs in terms of GHG emissions per passenger[92].

Figure 6-34: Emission factor of ICE and EV buses in Mongolia[93]



Potential for decarbonisation of EV's

6.33 Of the 10% of Mongolia's energy generation supplied by RES (2021), 70% was from wind generation, 20% from solar PV plants, and 10% from hydro power. Mongolia has immense solar and wind energy potential, estimated at around 2600 GW combined. At the same time, the reality that expanding renewables is not a major current policy priority (particularly relative to the overall demand/capacity challenge) presents challenges to maximising the GHG mitigation benefits of personal EVs (and any significant GHG mitigation benefits for e-buses).

6.34 Addressing these will require support for interventions including large-scale renewable energy integration (potentially considering reforms to energy regulation or establishment of green certificates) or the establishment of locally supplied EV charging stations integrated with renewable energy systems.

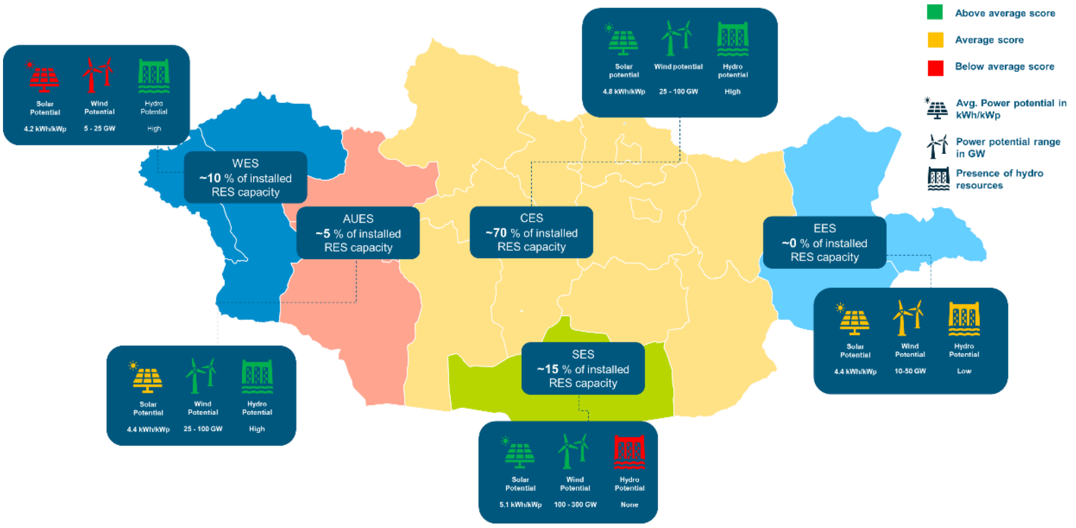
[92] Assuming a pasenger capacity of 32 for e-buses and 4 for passenger EV's.
[93] This assessment relies on data related to vehicle mileage and efficiency, taking into consideration driving behavior and local conditions in Mongolia. It includes ICE busses achieving 2.9 km/liter, and EV 0.8 km/kWh (incl. battery degradation of 20% in the winter) and an additional 0.05 litre diesel per km in the wintertime for heating purposes.

Renewable energy potential in Mongolia

6.35 The renewable energy potential of the different energy systems is shown in Figure 6-38. Overall, CES has the largest installed capacity in RES, with significant potential in all three sources and approximately 70% of the installed RES capacity (although this is a proportion lower than its overall relative generation). This provides a range of potential sources to support EV transition in Ulaanbaatar, either for deployment of off-grid infrastructure for large captive fleets or through supporting development of a market for RES among EV charging market actors.

6.36 A more detailed breakdown of renewable energy potential in Mongolia can be found in Appendix 5.

Figure 6-35: A nationwide assessment of Mongolia's RES generation for each energy system



Renewable energy development framework

6.37 Mongolia has, in recent years, taken significant steps to promote the development and utilisation of RES. Whilst further RES capacity development is not currently prioritised (with priorities focused on the financial and peak capacity challenges of the energy sector), past efforts have resulted in the development of a well-defined regulatory framework and tariff structures (Table 6-12) for RES. The country's Renewable Energy Law, enacted in 2007 and amended in June 2019, plays a key role in governing renewable energy power production. This made some modifications to the feed-in tariffs (see Table 5-3) and introduced net metering.

6.38 As the energy regulator within the energy system framework, ERC is responsible for coordination of investments and financial regulation of the energy system. The cost of the feed-in tariff is covered through a levy across all consumers. There is no wholesale or consumer competition within the market nor any green certificate-based mechanism for trading of renewable energy capacity by energy consumers.

6.39 Whilst development of new RES generation is subject to contracting by ERC, there are precedents for the use of new Net Metering provisions for small scale grid connections, with buildings in Ulaanbaatar returning energy back to the grid from PV panels.

Table 6-12: Renewable energy sector legal framework

Document	Approved / Last updated	Contents
Energy law of Mongolia	2001 / 2015	Regulate matters relating to energy generation, transmission, distribution, dispatching and supply activities, construction of energy facilities and energy consumption that involve utilisation of energy resources & Tariff, License.
Renewable energy law of Mongolia	2007 / 2015/ 2019	Regulate generation and supply of energy utilising RES & Tariff, License
Concession law	2010	Establish the framework for granting concessions to private investors to use existing infrastructure facilities owned by the state, and to construct new infrastructure facilities for the purpose of providing services to the general public
Investment law	2013	Protect the legal rights and interests of investors in the territory of Mongolia, to establish a common legislative guarantee for investment, to stabilise the tax environment.

Ulaanbaatar level grid impacts

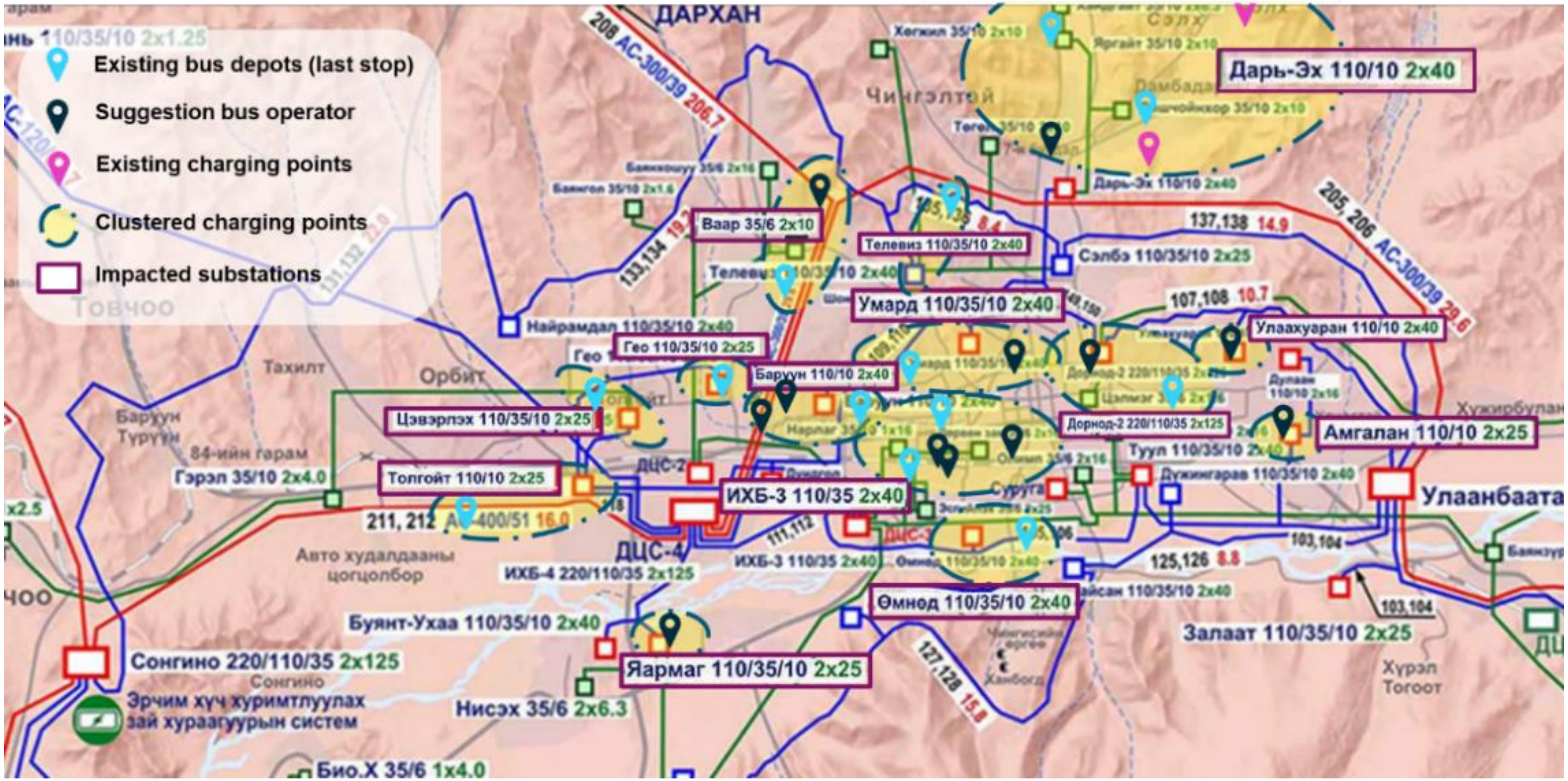
6.40 Recognising the concerns of UBEDN on the impact of EV charging infrastructure upon the distribution network, this section makes assessment of the impact of proposed charging infrastructure within the distribution system. This is based upon our understanding of the network of substations and their specifications, and the proportion that this would represent of overall capacity. The team were not able to source the typical current and future substation loading from UBEDN and acknowledge that this, in many contexts, is considered confidential (for example, an issue of national security relevance).

Review of UBEDN EV charging location feasibility

6.41 Given current plans, it is evident that the expansion of e-bus charging infrastructure within the city will undergo substantial growth in concentrated locations. To facilitate timely collaboration among stakeholders, an analysis is conducted to predict the substation in Ulaanbaatar that is most likely to supply power to these charging stations.

6.42 Based on data sourced from MRTD, a recent study has identified 25 viable locations (in terms of transportation) within Ulaanbaatar for potential e-bus charging infrastructure. This analysis seeks to assess how these locations may exert a significant strain on the supplying power grid. To conduct this analysis, these charging points are projected onto Ulaanbaatar's distribution grid and aggregated according to the substation most likely to supply them (see Figure 6-36 and larger version included in Appendix 4). Table 6-13 provides an overview of the substations that are anticipated to be impacted.

Figure 6-36: Expected locations of charging points in Ulaanbaatar in relation to the power grid



6.43 Overall impacts will depend upon the number and type of chargers proposed (which has not been provided). However, it is noted that substations Amgalan (Дарь-Эх) and GIKhB-3 (ГИХБ-3) are projected to receive the highest number of charging points. Assuming opportunity charging of e-buses can be between 50-350 kW and charging depots between 350 – 1000 kW, it is worth noting that of these two Amgalan, with a capacity of only 25 MVA, presents a potential concern, especially when taking into account the limited grid capacity in Ulaanbaatar (as indicated by UBEDN) and the fact that each point can potentially represent between 2-4% of the substation’s total capacity.

6.44 Furthermore, special attention should also be directed toward substation Vaar (Ваар), given its limited capacity of 10 MVA, which is expected to support two charging points.

6.45 Additionally, it is noteworthy that the charging point indicated to be supplied by Tolgoit (Толгойт) is significantly distant from their respective substations. This spatial gap may indicate the likelihood of higher investment costs should grid reinforcements become necessary to accommodate these charging stations.

Table 6-13: List of substations most likely to be impacted by proposed e-bus charging infrastructure.

Substation name		Voltage rating [kV]	Installed capacity [MVA]	Charging locations	Estimated substation loading caused by EVs[94]
Дарь-Эх	Amgalan	110/10	25	5	7% – 20%
ГИХБ-3	GIKhB-3	110/35	40	5	4% - 13%
Баруун	Baruun	110/10	40	3	3% - 8%
Дорнод-2	Dornod-2	220/110/35	125	2	1% - 2%
Умард	Umard	110/35/10	40	2	2% - 5%
Ваар	Vaar	35/6	10	2	7% - 20%
Амгалан	Dari-Ekh	110/10	40	1	1% - 3%
Телевиз	Tyelyeviz	110/35/10	40	1	1% - 3%
Улаахуаран	Ulaankhuaran	110/10	40	1	1% - 3%
Гео	Gyeo	110/35/10	25	1	1% - 4%
Цэвэрлэх	Tseverlekh	110/35/10	25	1	1% - 4%
Толгойт	Tolgoit	110/10	25	1	1% - 4%
Өмнөд	Ömnöd	110/35/10	40	1	1% - 3%
Яармаг	Yaarmag	110/35/10	25	1	1% - 4%

[94] Based on a bus charging load ranging from 350 to 1000 kW

National level grid impacts

Methodology

6.46 At national level, the assessment considers the readiness of the energy system for EV deployment based on grid density (scale of impact for upgrades), installed capacity (relative magnitude of impact of EVs), and energy system reliability (avoiding conflict between EVs and other uses).

- Grid density is established by examining the concentration of total installed kilometres of distribution lines, providing insight into the likelihood of proximity to electricity access points.
- Installed capacity is determined by evaluating the quantity of substation capacity installed into the energy system, with the assumption that this correlates with the available capacity in the corresponding energy system.
- Reliability is quantified using the System Average Interruption Duration Index (SAIDI), which signifies the average duration of outages experienced by each customer within the respective energy system.

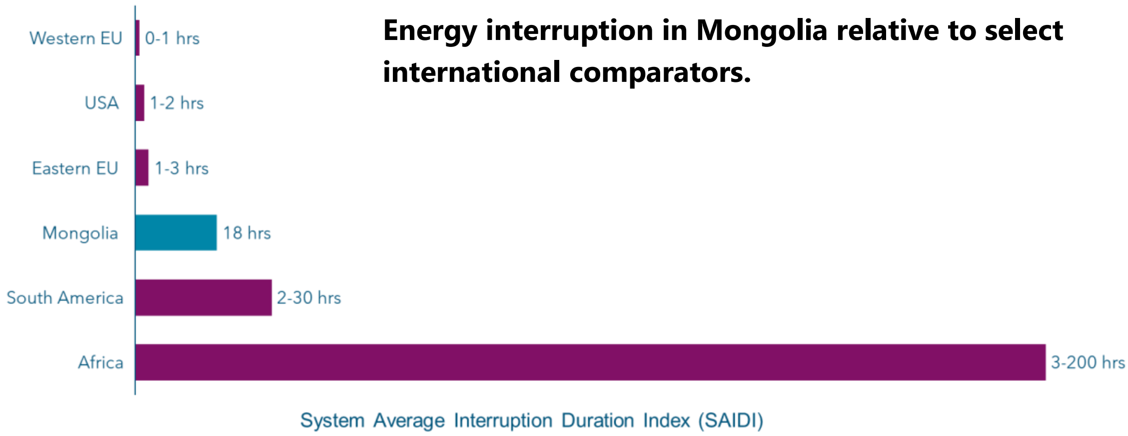
Assessment

6.47 **Grid Density:** Despite its extensive size the average grid density is 15 m/km^2. Notably, the CES exhibits the highest grid density of 25 m/km^2, which is unsurprising given its inclusion of the capital city and dense population. In contrast, the SES displays lowest grid density of 7 m/km^2, likely due to the presence of deserts and mining activities. The EES, along with AUES and WES, falls within a mid-range category in terms of grid coverage having between 12 to 18 m/km^2 of transmission and distribution lines.

6.48 **Installed Capacity:** Approximately 80% of the total installed substations is concentrated in the central region, while the other regions each account each for only 3 to 9% of the substations. In the CES, substations range up to 200 MVA, while interestingly, the SES has the lowest number of substations, although these can reach up to 125 MVA in capacity. The EES, WES, and AUES systems are equipped with substations that only have capacities up to 16.5 MVA.

6.49 **Reliability:** We evaluate reliability through the System Average Interruption Duration Index (SAIDI) scores. Over the past few years, Mongolia has made significant improvements in its SAIDI scores, demonstrating a consistent decline from 62 hours in 2018 to just 18 hours in 2021. When we compare the different energy systems, both the CES and AUES perform better than the average, having SAIDI scores of 16 and 8 hours, respectively. In contrast, the WES and EES fall below the average performance, registering SAIDI scores of 44 and 21 hours, respectively. For the SES there is no specific data, hence it assumed to perform according to the entire grid at 18 hours. To provide context, Figure 6-37 compares the SAIDI values of other parts of the world to Mongolia's average.

Figure 6-37: Comparison of SAIDI of various countries around the world[95]

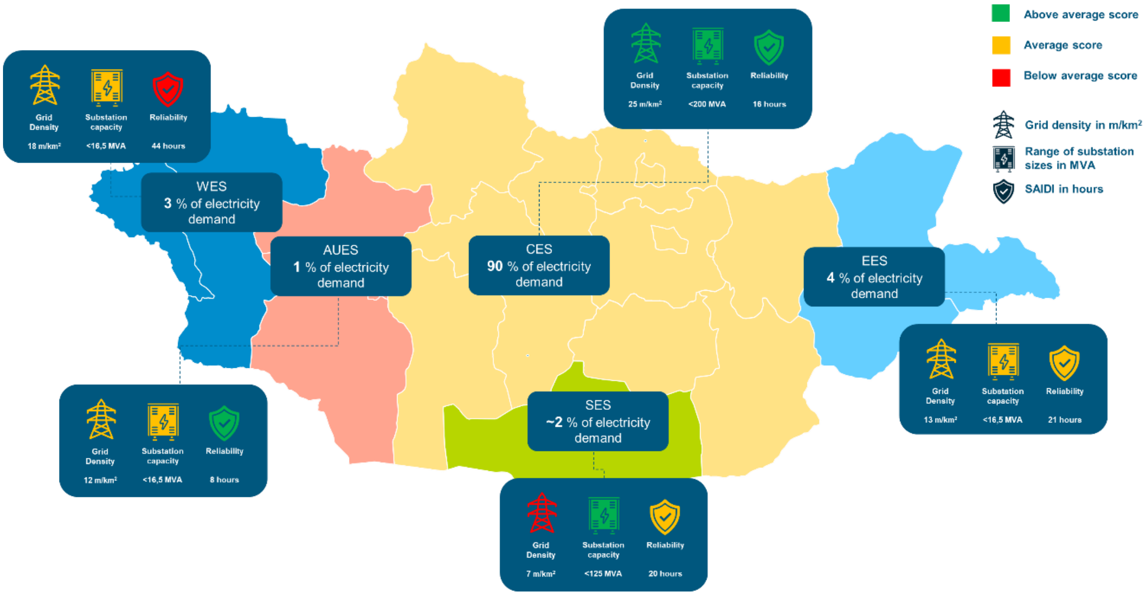


Results

6.50 The results of the assessment can be found in Figure 6-38 below. The CES region emerges as the top performer, primarily attributed to its high grid density and substantial installed substation capacities (primarily around Ulaanbaatar). Nevertheless, it remains below average in terms of reliability when measured against international standards. Additionally, it should be taken into account that CES caters to 90% of Mongolia's electricity demand. The AUES and EES regions achieve average scores across all three criteria, while the SES region has lower density due to its remote desert terrain. The WES region exhibits a high density of transmission and distribution lines, yet its installed capacity is average, and it scores the lowest on reliability.

[95] Getting electricity: System average interruption duration index (SAIDI) (DB16-20 methodology) | Indicator Profile | Prosperity Data360. (2021). https://prosperitydata360.worldbank.org/en/indicator/WB+DB+55

Figure 6-38: A nationwide assessment of Mongolia's grid based on grid density, installed substation capacities and reliability



Charging infrastructure connection impacts

6.51 Connection of charging infrastructure to the grid can be a major determinant of cost and complexity for e-mobility deployment projects. In particular, aside from slow public or home charging, most fast-charging stations and/or e-bus charging installations are likely to require medium voltage (MV) connections. It is therefore important to consider the available connection when siting EV chargers.

Typical grid upgrade requirements

6.52 The extent of necessary grid reinforcement can be estimated based on the specific type and scale of these connections:

- **Industrial scale:** These locations tend to have grid-connections that are considered as medium voltage connections (i.e., above 1 MVA). With an industrial scale grid connection, the infrastructure can be easily extended for e-charging, with only minor on-site adjustments on the local distribution panels and/or supplying cables.
- **Large commercial:** These sites tend to have grid connections suitable for large businesses such as malls or supermarkets, typically ranging from 38 kVA to 1 MVA. While medium voltage infrastructure may already be in place, capacity upgrades might be necessary in on-site distribution to accommodate high charging demands.

- **Small businesses:** Locations falling into this category have low voltage connections usually found in simple commercial buildings, usually below 38 kVA (for example small scale retail or petrol stations). In most cases slow or public charging can be facilitated at these locations. However, to accommodate fast charging or e-bus charging, it becomes necessary to establish a new on-site connection and distribution system with adequate capacity. This often entails the construction of a separate utility room as well.
- **Household scale:** At these locations, grid connections resemble typical household connections, usually measuring below 4 kVA or may even be entirely absent. In terms of EV charging, these connections are only suitable for (slow) home charging purposes.

EV charging strategies and grid implications

6.53 The connection impacts of different EV charging typologies are shown below in Table 6-14.

Table 6-14: EV Charging typologies

Charging modalities	Mongolian context	Expected intervention
Household charging (< 3,7 kW) Grid connection type: Low voltage household connection 	Typically located in households or apartment complexes with dedicated parking spaces, used for slow charging of private vehicles. Vehicle retailers have been installing them with EV sales. As EV adoption increases, they will become more widespread in concentration.	In the early stages, there is usually sufficient capacity available, and only minor on-site adjustments may be necessary. Increased concentration may present capacity issues at a later stage of EV adoption.

Public charging (3,7 – 22 kW) Grid connection type: Low voltage connection 	Being implemented in in high-traffic public locations, commercial areas, public garages and residential areas. Used for 'top ups', residential parking or destinations where drivers leave their vehicles.	Minor adjustment is expected to the on-site infrastructure. Potential capacity issues when found in high numbers at for example commercial areas or public garages.
Workplace charging (3,7 – 22 kW) Grid connection type: Depending on scale, low voltage and medium voltage connections (10 kV). 	Typically implemented at industrial, large or small businesses. However, this is expected to be low for Mongolia. Depending on the situation, there is usually enough capacity for a number of chargers during the initial stages. As EV adoption grows in workplaces, obtaining sufficient capacity for an extended charging facilities becomes a challenge.	Minor adjustment to the on-site infrastructure. With approximately 8 hours of charging time availability and the presence of multiple charging points at the workplace, smart charging methods can be considered in a later stage to address the increasing demand.

Fast charging stations (50-1000 kW) Grid connection type: Medium voltage connections (10 kV or 33 kV[96]) 	These stations are typically located at existing petrol stations, which generally have a connection similar to that of small businesses. In the early stages only located in and around the city. An example is the 50 kW fast charger in operation at Petrovis's petrol station Peace Bridge. In the later stages expanding beyond the city limits and more frequent along major highways.	Due to the high peak demands, establishing these stations will require an entirely new on-site grid connection and distribution system.
E-bus depot charging (350 – 1000 kW) Grid connection type: Medium voltage connections (10 kV or 33 kV[96]) 	Likely to be located at existing bus depots as indicated in Figure 4-4 Most bus depots have connections suitable for large businesses or industrial-scale usage. The current bus depot in Ulaanbaatar has an 800 kVA grid connection with a 350 kW charger in operation.	In most cases, minor upgrades or adjustments may be needed in the distribution system of a bus depot supplied by a medium voltage grid connection.

[96]Depends on the voltage available at location of charging station.

E-bus opportunity charging (50-350 kW) Grid connection type: Medium voltage connections (10 kV or 33 kV[96]) 	Charging on-route for electric buses presents challenges in determining suitable locations since capacity availability varies. Most bus stops either have a household connection or no grid connection at all.	Addressing this requires the establishment of entirely new on-site connections and distribution systems, with consideration for limited available land at such locations for additional infrastructure.

Grid connection procedures

Connection process

6.54 Mongolia's grid connection procedure is governed by the grid code. The procedure, which considers available grid capacity and existing land, spans a timeline of approximately 1 to 2 years. This process involves the following key steps:

- Acquiring connection permission from UBEDN or MOE (for installations exceeding 1 MW).
- Upgrading the on-site electrical infrastructure.
- Installing the charging equipment.
- Commissioning and initiating operation.

Figure 6-39: Typical connection procedure for an EV charging point

Estimated timeline: **1 – 2 years**

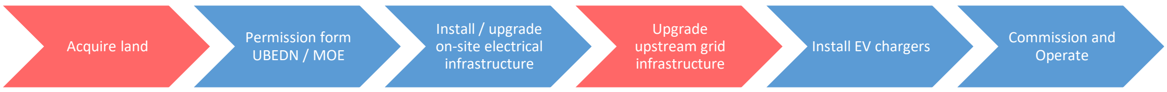
Grid connection complexities

6.55 A key challenge for grid upgrades in the context of Mongolia relates to acquisition of land through which a connection must pass. The issue of land ownership in Mongolia is a complex one, subject to ownership disputes and with an unclear process for compulsory purchase for essential infrastructure. This can significantly increase the timeline for connection. For example, in a situation where there is no existing grid capacity and new land must be acquired for connection, a typical timeline may be as long as 3-5 years, with the following steps:

- Acquire land.
- Obtain connection permission from UBEDN or MOE (for installations exceeding 1 MW).
- Install or upgrade the on-site electrical infrastructure.
- Upgrade the upstream grid infrastructure to accommodate the new installation.
- Install the EV chargers.
- Proceed with commissioning and commence operations.

Figure 6-40: Connection procedure for an EV charging point including possible bottlenecks

Estimated timeline: **3 – 5 years**



Operating and investment model for urban buses

Bus operating model in Ulaanbaatar

6.56 The current public transport governance and operating model is based on the framework introduced in 2015-16 under the "Smart Bus Initiative". This saw bus operations transition to a gross cost contract with Public Transport Department (PTD) becoming overall system manager, contracting public and private operators to deliver services according to defined specifications.

Funding and financing for public transport operations

6.57 Since implementation of the Smart Bus Initiative, PTD accepts overall revenue risk for the public transport system. A centralized fare collection system was implemented (e-ticketing/smart card), with bus operators remunerated through a proportion of this revenue calculated (topped up with subsidy), which is paid as a tariff to operators per bus operational hour.

6.58 The system now operates with a large structural deficit, which PTA (as revenue risk owner) is responsible for covering, with subsidies as of 2018 reaching 15% of the City budget[97] (and representing 70-75% of operator revenue). Revenue generation of the system is low, with issues including low user fares, limited operator incentives to enforce passenger fare payment (contributing to high levels of fare evasion), and low fleet productivity (principally due to high levels of congestion).

Public transport capital investment

6.59 Bus operators (both public and private) are responsible for providing fleet for service in line with their contractual obligations and current bus regulations (e.g. size, age limits). The cost of fleet investment is covered through the hourly fee paid to bus operators (public and private) by PTD, which includes a value for amortization depending on the type of bus in service and whether it was purchased new or used.

6.60 There are two mechanisms for bus investment in Ulaanbaatar, private procurement model and public leasing model:

- **Private procurement model** has been traditionally used by the private bus operators, in which diesel buses are procured from developed economies (typically South Korea) once considered 'life expired' there (but within the 12-year regulation in Mongolia). In practice, a vehicle with 3-4 years of service life in Ulaanbaatar would cost US$15-18,000 which is financed by the operator using commercial finance in Mongolian Tugriks (annual interest of 18-20% over 3-year term).
- **Public leasing model** has been recently implemented for private operators, through which MUB has procured new EURO V diesel buses and made them available to private operators through leasing arrangements. This responds to the challenges faced by private operators in financing new urban bus models, with higher capital investment requirements (US$80,000 per vehicle) and foreign currency borrowing requirements which make the risk and interest components unacceptable. The public leasing model sees buses procured by publicly-owned Ulaanbaatar Development Corporation JSC (using MUB municipal budget) and leased over seven years to operators in Tugriks with a service fee on capital equivalent to annual interest of 5.5%.
- The public leasing model has been well received by private operators (reportedly oversubscribed) for enabling them to access new high-quality vehicles (also

[97] This proportion has not been updated since 2018 but, from discussions with MUB and PTD, ITP believes it is still a substantial proportion of the City's budget. Contact has been made with the PTD to try to obtain an updated figure.

offering benefits such as opportunities for ancillary revenues from advertising) while mitigating currency risks.

6.61 Public bus operators are understood to acquire vehicles on terms similar to the public leasing model (with amortization included in their hourly payments), although it has not been possible to validate this directly.

Bus operating conditions

6.62 Buses operate in mixed traffic throughout Ulaanbaatar, meaning that operating speeds are low. In theory, buses are supposed to be able to run in the kerbside lane free of private vehicular traffic. However, this is not widely enforced or respected by drivers, hampering bus speeds and travel times (the average speed of buses in the city is only 11.6 km/h). Notably, on occasions where the bus lane has been enforced on Ehtayvan Freeway, bus speeds have been found to rise to 15 km/h, indicating the potential for vehicle productivity gains (particularly during peak hours).

Development of e-bus business models

6.63 As shown in the TCO analysis section, there is a significant difference between the lifecycle cost of e-buses and diesel buses, and transition to e-buses using the current model implies a 20% TCO increase. Higher CAPEX also increases the prominence of financing capacity and financing costs, while technology transition introduces new cost categories such as batteries and charging infrastructure. While these are included in the TCO, these factors all affect risk, complexity, and institutional/governance arrangements.

6.64 Successful transition of urban bus fleets to e-bus operation requires system managers to develop an institutional and business model arrangement which:

- **Makes e-buses available to operators** in a way consistent with their financial and technical capabilities (capital investment strategy)
- **Apportions risk to the parties best able to manage it**, alongside any rewards for positive performance in asset management (e.g. vehicle availability for service) (capital investment strategy)
- **Maximises overall system cost efficiency** so as to minimise the overall operating cost base per km (e-bus operational deployment strategy)
- **Ensures contractual arrangements deliver value for public system managers** while ensuring system sustainability for operators and incentivising efficient operation (bus contracting model).

Scope for e-bus business models and institutional assessment

6.65 The engagement carried out within the e-mobility assessment has enabled the identification of the current operating model and key issues in developing a viable e-bus operating model for public and private operators. The key areas for further focus as part of the institutional assessment and business model development are shown below (organised based on the business model requirements outlined above in 6.64):

- **Capital investment:** The current capital investment model sees MUB purchasing the vehicles and assigning these to operators[98]. Considering the financing capacity of operators and currency related risk, it doesn't appear feasible to ask operators to invest in their own fleet (and some form of leasing is likely to be required). However, this raises the question how MUB works with operators (public and private) to develop fleet and charging specifications with consider the full lifetime cost (TCO) including operational cost implications of capital investment.
- **Risk management**: Upon initial investment, risk includes technology risk (bus performance and availability), risk associated with batteries and charging infrastructure, and additional financial risk (due to higher capital cost component and potentially USD lending currency). The initial deployment of small e-bus fleets through public sector bus operators (with experience in trolleybuses) have helped to reduce the technology learning curve and allow for successful piloting of the technology. Future risks to be assessed and managed include:
    - A transition to private operators will provide additional expertise demands upon these entities and create new risks to the public sector in terms of ensuring the ongoing operation, maintenance and performance of that fleet.
    - Implementation of larger 'at-scale' e-bus fleets will require development of a charging strategy which can manage the technical, institutional and operational risks associated with charging infrastructure installation/ operation. This in particular will need to manage the risks associated with grid upgrades to accommodate larger charging facilities.
- **Operating efficiency**: As shown in the TCO modelling, high capital investment cost of e-buses increases the imperative to maximise fleet utilisation (and thus reduce overall fleet size/investment requirements for a particular service level). Given that the capital cost aspect of the TCO is borne by MUB, the operator has limited incentives to maximise fleet productivity in its operations and maintenance.

[98] To date this has been only to public bus operators, however in the future is understood will include e-bus assignment to private operators.

For example, the current charging strategy of depot-based fast charging means that buses lose one or more duty cycles per day (due to charging) which reduces fleet productivity. More efficient strategies (opportunity charging, overnight charging) may increase fleet efficiency (capital cost per km); however, the operator is not currently incentivised to explore these as they do not bear the cost of capital. Other considerations include 'rightsizing' of the vehicle fleet to passenger demand on lower demand routes, noting that an EV minibus has a ~12% lower lifetime TCO than a 12m ICE bus.

- **Decarbonisation:** While e-buses will support local air quality improvement efforts, modelling indicates they will not contribute to decarbonisation in the context of the Mongolian energy mix. This limits their contribution to Mongolia's decarbonisation efforts, and ability to raise financing for e-bus electrification through climate financing sources. It will be necessary to explore the institutional arrangements through which e-bus procurement and operations align with mechanisms to reduce the carbon intensity of e-bus energy sources.

6.66 This component of the TA will be delivered within the context of challenges facing the bus system in Ulaanbaatar in relation to operational performance and revenue generation. While seeking to support the goals of other studies seeking to improve performance (which includes adjustment to the business model), the focus of these recommendations will be on how to adjust the overall framework to support technology shift to e-buses from a financing, funding and institutional perspective. This will take as a starting point the current principle of gross cost contracting of bus operations within a mixed public/private system.

Technical regulatory barriers and opportunities

6.67 Technical standards are critical foundation of a national e-mobility ecosystem. EV and charging infrastructure standards promote safety, guiding interoperability between operators, ensuring quality, and defining environmental responsibilities. The existence of strong, considered EV standards can underpin an enabling environment, while their absence (or weaknesses within them) has the potential to undermine consumer confidence, stifle deployment, prevent operator competition (or innovation).

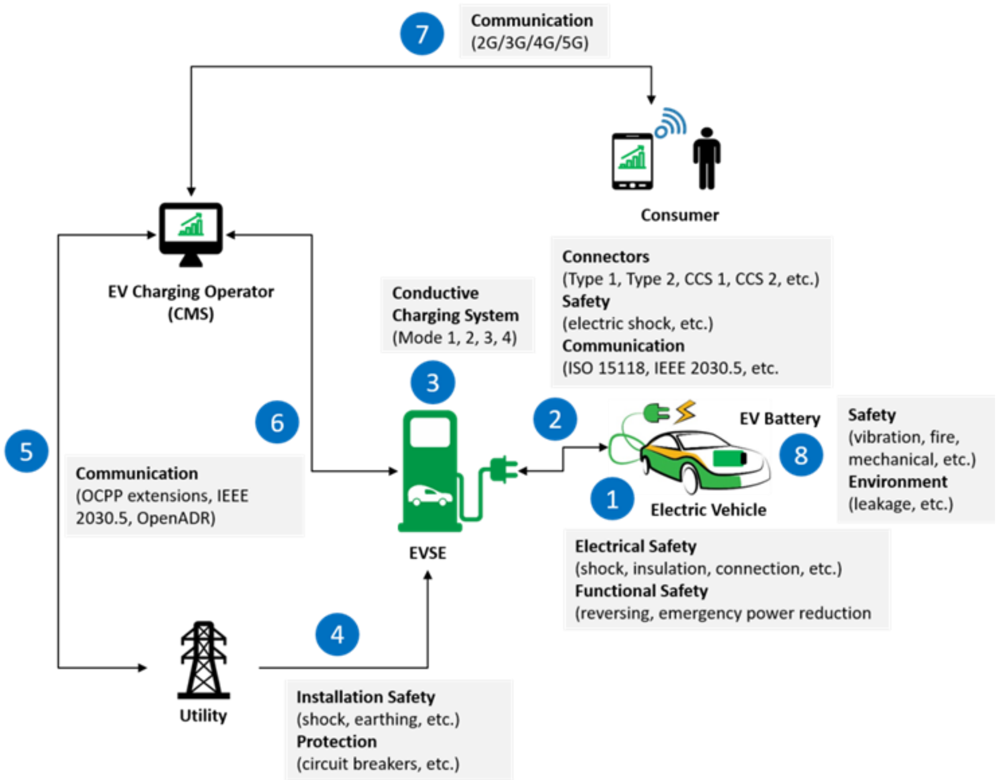
6.68 ICE vehicle technical standards can play a supportive (or undermining) role in promotion of EVs, setting the playing field against which EVs must compete. In the particular case of Mongolia, the current ICE vehicle standards facilitate an import market dominated by older, lower cost and more polluting vehicles. In being supportive of mass motorisation it has improved accessibility to lower income and remote populations, however, has also underpinned urban congestion, contributed to air pollution and, in the context of this study, increases the TCO differential between EV and ICE vehicles in the mass market segment.

6.69 The following section provides assessment of Mongolia's EV, charging infrastructure and ICEV standards, identifying key barriers to take forward within the roadmap.

EV and essential ecosystem framework for standards development

6.70 Regulations play a pivotal role in shaping and ensuring the success of the EV sector by providing standardised guidelines and safety measures across various dimensions of the EV ecosystem. This scope, as shown in Figure 6-41, includes establishing consistent standards for EV design and performance, battery technologies, charging infrastructure, and safety protocols.

Figure 6-41: EV and essential ecosystem framework for standards development



6.71 The EV (#1) is connected to the EV supply equipment (EVSE) (#3) for charging. This EVSE may contain only alternating current (AC) guns, only direct current (DC) guns, or both AC and DC guns. The interaction between EV and EVSE (#2) for conductive charging is through a physical cable that provides electrical connectivity as well as digital communication. Once connection is established between EV and EVSE, charging starts.

6.72 The power rating of the EVSE and infrastructure requirement will depend on vehicle type (two-wheeler, four-wheeler, or bus) and charging location (home, workplace, public or commercial). At the backend, the EVSE interacts with the utility grid (#4) for drawing power for charging. The utility grid interacts with the central management system (CMS) of the EV charging operator (#5) to manage its power demand and supply to the EVSE. The EVSE and CMS (#6) interact to exchange information related to charger's utilisation, user, metering, billing, and payment. Once the charging is completed, the bill is generated, and a charging summary can be shared with the consumer over a mobile app. In real time, the consumer can interact with the EV charging operator (#7) to receive updates around charging locations, tariffs, slot availability, etc. The battery inside EVs (#8) is treated as a separate unit as there exist separate standards for battery functional performance testing, and it is one of the most important and costliest parts of EVs.

EV and charging infrastructure technical standards in Mongolia

6.73 E-mobility is currently in its nascent stage within the country, boasting a fleet of less than 1,000 EVs. As EV technology gains momentum, it becomes increasingly vital to establish comprehensive regulations to govern this sector effectively. These regulations encompass various critical factors, including vehicle classification and type approval, to ensure the safe and efficient operation and maintenance of EVs on the nation's roads.

6.74 Mongolia already has well defined EV and Charging Infrastructure standards/ regulations such as MNS 6728: 2018, focusing on EVs and BEVs. The regulations encompass general technical requirements for performance and safety of EVs. The country also has MNS 6758: 2019 which outlines the general requirements for the installation and placement of various types of EV charging stations and associated equipment. These two regulations are summarised, followed by a technical barrier analysis.

MNS 6728: 2018 BEV. General technical requirements for performance and safety of EV

6.75 This EV regulation was adopted on 21st June 2018 and applied from 1st August 2018. Some of the key excerpts from this regulation are as follows:

6.76 **Purpose:** This standard aims to establish guidelines for:

6.77 The development, manufacturing, and utilisation of EVs that are powered by accumulator batteries. Standard sets forth rules and requirements to ensure the safe and efficient development of technical design, electrical, and traffic safety during production and use of BEVs.

6.78 **Vehicle Classification:** The standard encompasses design and technical safety norms for BEVs falling under vehicle categories M (motor vehicles for passengers) and N (vehicles designed for carrying goods).

6.79 **Vehicle Type Approval (VTA):** Vehicle type approval refers to the official certification granted by regulatory authorities or testing agencies to a particular type or model of vehicle, indicating that it meets the required safety, environmental, and technical standards. VTA helps ensure that vehicles meet quality and safety standards, contributing to overall road safety and environmental protection and is to be obtained by the vehicle OEM before it enters the market.

6.80 This MNS standard aligns with the United Nations Economic Commission for Europe (UNECE) UN R100 regulation requiring vehicles to be type approved for technical and safety standards within the M and N categories, ensuring compliance with essential regulations and requirement. The UN R100 regulation mandates prerequisites related to a vehicle's electrical safety and Rechargeable Energy Storage System (RESS). These encompass electrical aspects such as Protection Against Shock and Functional Safety, and RESS safety such as Thermal Shock, Mechanical Impact, Fire Resistance, among others. Upon compliance with these stringent regulations, a specific vehicle model qualifies for the issuance of the Vehicle Type Approval Certificate. For e.g. The VTA certificate needs to be obtained by the vehicle manufacturer from an accredited testing agency to ensure that the vehicle meets the electrical and battery safety requirements. In the context of Mongolia, the vehicle dealer/imported needs to have this certificate in place during the importation procedure.

6.81 **General Requirements:** The standard outlines various requirements for BEVs. It places mandatory emphasis on several critical technical conditions related to vehicle durability, maximum permissible total weight, and dimensions (length, width and height), power transmission, battery, Battery Electronic Management System (BMS), traction motor, steering mechanism, braking system, and electrical equipment requirements. The allowable total weight and dimension criteria of an EV (mentioned in MNS standard) is in alignment within general vehicle requirements, and EV subsystem follow UN R100 international standards, keeping the selection the types of subsystems (e.g., battery types, motor types, etc.) on discretion of manufacturers/OEM.

6.82 **Battery Requirements:** It encompass a range of battery types, inclusive of lead-acid, ferric phosphate, and lithium-based batteries. Additionally, the traction electric motor is specified to function on either direct or alternating current, possessing adequate power relative to the vehicle's weight, and intended purpose. An efficient BMS is deemed obligatory to ascertain safe operational conditions for the batteries. The BMS is mandated to monitor and manage critical parameters such as voltage, current, temperature, and battery cell charge levels. Furthermore, provisions highlight the passive and active system requirements for lithium-based batteries, ensuring a balance in voltage levels.

MNS 6758: 2019 Installation and placement of EV charging station types and equipment. General requirements

6.83 **Scope:** The standard establishes the general requirements for the type of EV charging stations, cables, plugs, charging options, and the installation and placement of charging station equipment. This standard applies to the selection, design, installation, operation, maintenance, and repair of electric charging stations. Overall, it is considered comprehensive and to meet the core expectations of an emerging e-mobility context.

6.84 **EV Charging Systems:** Current standards predominantly concentrate on conductive or plug-in charging technologies, encompassing all four modes in detail as follows:

Table 6-15. EV Conductive or Plug-in Charging Modes

Mode	Charging Type	Max Current (A)	Voltage (V)	Connectors
Mode 1	AC	16	250 (1 phase) 480 (3 phase)	AC Plug
Mode 2	AC	32	250 (1 phase) 480 (3 phase)	IEC Type 2 Mennekes (Europe) and GBT AC (China)
Mode 3	AC	63	480 (3 phase)	Type 1 (Japan) and Type 2 Mennekes (Europe)
Mode 4	DC	120	1000 (3 phase)	ChadeMo (Japan) and CCS2 (Europe)

6.85 For mode 3 and 4, Charging Protection System (CPS) designs offer varying degrees of protection and must meet specific standards. The required protection levels include an

"IP" (Ingress Protection) level not less than 54 and an "IK" (Impact Protection) level not less than 10. Additionally, a version 4 CPS must have an emergency button to control and stop charging.

6.86 **EV Charging Stations:** In the context of designing residential and public street areas, two critical aspects are addressed: the integration of EV charging stations and ensuring safety compliance.

6.87 **EV Charging Stations Installation:** The standard outlines the requirement for installing EV charging stations in residential and public areas. Each designated parking space must be equipped with the capability to simultaneously charge EVs, with a minimum total capacity of 11 kW. Key considerations include:

- **Infrastructure Integration**: Residential and public areas must incorporate the necessary electrical infrastructure, including charging stations, cabling, and power distribution systems.
- **Parking Lot Design:** Dedicated parking spaces for EVs must be allocated and marked clearly. Proper signage ensures users can easily locate these spaces.

6.88 **Safety Compliance:** The document underscores the need for safety when placing EV charging infrastructure in these areas, referencing fire safety requirements outlined in Government Resolution No. 339 of 2016 which includes Safety regulations guidelines for installation, maintenance, and operation of charging stations and fire safety protocols.

E-waste and battery disposal

6.89 The only clause in “Law on Waste” about EV waste is “distributors, importers to take the responsibility (collecting expired, discarded batteries from the market and return/export to the manufacturer or take part in building of local dissolving and recycling facilities)”, however the detailed process and procedures not explained, or defined. (EV battery is categorised as toxic waste by the order of Government 2018).

6.90 MNS 6594:2016 (reviewed elsewhere in the report) deals with end-of-life vehicle disposal and recycling (e.g. vehicle body parts, seats, metallic parts, battery used for auxiliary loads, etc.), but it does not cover EV battery recycling and waste management. There are no regulations at present regarding the disposal and waste management of EV battery. This presents a need for development of potential approaches to effectively manage battery waste as a key component of the roadmap.

Key barriers of technical regulations

MNS 6728: 2018 Electric car. BEV. General technical requirements for performance and safety of EV

6.91 The existing standard primarily emphasises vehicle classifications within the 'M' and 'N' categories. However, it does not include the 'L' vehicle category, which includes motorcycles, etc., accounting for around 6% of the country's registered vehicles. It also does not include 'O' vehicle category which includes semi-trailers, trailers, etc., constituting around 4-5% of the national vehicle stock.

6.92 The current standards exclusively pertain to BEVs and do not encompass other significant EV technologies, including Hybrid, PHEVs, and Fuel Cell (hydrogen) technologies.

6.93 A notable barrier lies in the absence of an age limit stipulation for the importation of 'used vehicles,' including ICE, HEV and BEV cars. This allows for the importation of deteriorated EV vehicles, as evidenced by the import of EV cars exceeding 15 years of age due to their availability at significantly reduced prices.

6.94 The existing VTA process is based on UN R100 only, non-inclusion of UN R136 (Light EV and Battery Safety), UN R10 (Electromagnetic Compatibility), UN R94 (Vehicle Frontal Collision Safety), UN R95 (Vehicle Lateral Collision Safety) and UN R68 (Vehicle performance) limits the comprehensive evaluation of the imported EVs concerning safety, performance, and compatibility. For example, this includes battery safety for (L category), electromagnetic radiation levels, vehicle sound emittance, protection of the occupants in the event of a frontal collision and lateral collision.

6.95 The current standard permits the utilisation of EV batteries of any type and purpose, encompassing lead-acid, ferric phosphate, and lithium-based batteries. However, it's worth noting that lead-acid batteries present challenges related to their weight, limited energy density, and potential environmental concerns due to the presence of lead.

6.96 The EV regulation does not include annual technical inspection of EVs. This is an important parameter which determines the operational safety and roadworthiness of an EV.

MNS 6758: 2019 Installation and placement of EV charging station types and equipment - general requirements

6.97 The existing charging standards do not encompass emerging charging methodologies, such as automated conductive charging (e.g., pantograph), wire-charging systems for trolleybuses, and battery swapping systems. These charging methodologies are presently undergoing pilot implementations in several countries and hold the potential for inclusion in the standards.

6.98 For EVs being imported from China, it is reasonable to consider the incorporation of GB/T standards (China national standards, also called as Guobiao Standards) into the existing standard. Currently, the standards do not explicitly specify whether the inclusion of GB/T standards is permitted or not.

6.99 The standards currently in place do not account for additional safety standards between EVs and EVSE. Specifically, IEC 62752, addressing in-cable control and protection devices for mode 2 charging of road EVs, is not integrated into the current standards. Also, IEC 62955, concerning residual direct current (RDC) detecting devices for use in mode 3 charging of EVs, is not incorporated within the standard.

6.100 Interoperability mechanisms, such as the Open Charge Point Protocol (OCPP) is not included in the existing standard. OCPP standardises communication between charging stations and central systems, fostering interoperability. This standardisation ensures that EV charging infrastructure can scale efficiently, enabling seamless interactions between different charging station brands and central management.

Overview of ICE technical standards

6.101 The end user attractiveness of EVs in the Mongolian context are relative to the standards for import of ICE (and HEV) vehicles. From a policy perspective, the benefits of EVs in terms of environmental protection are also relative to the standard of existing ICE vehicles in the national fleet. Understanding the criteria specified in MNS 5013:2009 and MNS 5014:2009 allows Mongolian vehicle emission limitations to be recognised and mapped to international norms, exploring how revisions to these standards can both help in the control of air pollution generated by petrol and diesel cars while making EVs relatively more economically attractive to consumers (e.g. through restricting imports of older and more polluting ICE vehicles). Finally, guidelines like MNS 5011:2003 for vehicle inspection centres and MNS 6594:2016 for end-of-life vehicle management are important in terms of ensuring compliance and enforcement with established standards and addressing policy concerns around safe and eco-friendly disposal practices.

6.102 A concise summary of these regulations is provided below.

ICE Emission Standards

MNS 5014:2009 Diesel vehicles smoke; maximum allowable amount of soot and measurement method

6.103 MNS 5014:2009 describes maximum allowable amount of soot and measurement method for diesel vehicles. The primary objective of this standard is to establish regulations governing the emission levels of diesel-powered vehicles, with the aim of limiting the permissible quantity of soot emitted as part of road transport-related air pollutants. The standard prescribes a sequence of measurements and procedural steps to be undertaken, along with the technical prerequisites for engine operation conditions and technical specifications for the soot measuring instrument.

6.104 The amount of soot in the exhaust of diesel engines of cars should not exceed the amount specified in Table 6-16.

Table 6-16: Maximum allowable amount of soot

Vehicle Type	Maximum smoke soot allowable, %[99]
Max. weight less than 3.5 tons (cars)	35.0
Max. weight more than 3.5 tons (bus, truck)	40.0

MNS 5013: 2009 Gasoline vehicles emissions; the maximum permissible level of toxic substances in the composition

6.105 MNS 5013:2009 set limits on permissible maximum levels of air pollutants, including carbon monoxide (CO) and hydrocarbons (HC), emanating from the exhaust emissions of gasoline-powered motor vehicles. The standard outlines a comprehensive set of procedures and measurement protocols. It also specifies the technical prerequisites for engine operation conditions to facilitate precise and standardised assessments of emissions. Additionally, the standard provides detailed technical specifications for the soot measuring instrument, thus ensuring the reliability and quality of emission testing.

6.106 It encompasses engines that run on both gasoline and liquefied petroleum gas (LPG), offering measurement modes for CO, carbon dioxide (CO_2), HC, and oxygen (O_2) levels in the composition of automobile exhaust.

[99] It represents the percent value of maximum soot permissible. The standardised metric for assessing soot emissions is quantified through the reduction in light intensity. This reduction is measured by the light absorption coefficient denoted as "K", which serves as the fundamental scale for gauging the light absorption capacity of diesel engine smoke. Subsequently, the measured coefficient is transformed into the following percentage value.

6.107 The permissible concentration limits for CO and HC in the exhaust gas composition must adhere to the values delineated in Table 6-17.

Table 6-17: Maximum permissible air pollutants limits

Car Type	Threshold type	CO composition in %	Hydrocarbon, SN smoke volume in million, ppm (per million)
Carburettor engine, total weight over 3.5 tons	n too low	2.0	800
	n increased	1.5	
Carburettor engine, all weight under 3.5 tons	n too low	1.5	500
	n increased	1.0	
Injection engine with working gas neutralisation	n too low	0.5	250
	n increased	0.3	

6.108 Note:

- n too low: in engine idle mode, on the control pedal.
- n increased: with increased frequency of rotation of the crankshaft.

Inferences based on MNS 5014:2009 and MNS 5013: 2009

6.109 Based on analysis of the above standards, it can be inferred that the current Mongolian emission limits sit between Euro II / Euro III standard. For example, this is evident as the hydrocarbon (HC) content are still in the range of 500-800 ppm. The same is required to be under 200 ppm for higher EURO IV standards and above. Emission limits[100] for HC, NOx, CO and PM specified under EURO standards are mentioned in Table 6-18.

6.110 As Euro standards become more stringent, they impose stricter limits on the permissible levels of pollutants emitted by vehicles. This leads to a noticeable decrease in the amount of harmful substances released through the tailpipe and helps improve the atmospheric air quality.

[100] *EU: Light-duty: emissions*. (n.d.). Transport Policy. https://www.transportpolicy.net/standard/eu-light-duty-emissions/

Table 6-18: Emission limits across Euro standards

EURO Standards	Vehicle Type		Passenger Cars <= 2.5T GVW, <=6 Seats		Large Passenger Cars (> 2.5T GVW, 7-9 Seats) and Light Duty Trucks (<=3.5T GVW)					
	Fuel Type				Petrol (g/km)			Diesel (g/km)		
	Emission	Unit	Petrol (g/km)	Diesel (g/km)	Class -I (<= 1250 kg)	Class -II (> 1250 & <=1700 kg)	Class - III (> 1700 kg)	Class -I (<= 1250 kg)	Class -II (> 1250 & <=1700 kg)	Class - III (> 1700 kg)
Euro II (1997)	HC	PPM	-	-	-	-	-	-	-	-
	NOx	g/km	-	-	-	-	-	-	-	-
	CO	g/km	2.2	1	2.2	4	5	1	1.25	1.5
	PM	g/km	-	0.08	-	-	-	0.08/0.1	0.12/0.14	0.17/0.2
Euro III (2000)	HC	PPM	800		800	1100	1340	-	-	-
	NOx	g/km	0.15	0.5	0.15	0.18	0.21	0.5	0.65	0.78
	CO	g/km	2.3	0.64	2.3	4.17	5.22	0.64	0.8	0.95
	PM	g/km	-	0.05	-	-	-	0.05	0.07	0.1
Euro IV (2005)	HC	PPM	200	-	200	380	560	-	-	-
	NOx	g/km	0.08	0.25	0.08	0.1	0.11	0.25	0.33	0.39
	CO	g/km	1	0.5	1	1.81	2.27	0.5	0.63	0.74
	PM	g/km	-	0.025	-	-	-	0.025	0.04	0.06
Euro V (2008)	HC	PPM	200	-	200	380	560	-	-	-
	NOx	g/km	0.06	0.18	0.06	0.075	0.082	0.18	0.235	0.28
	CO	g/km	1	0.5	1	1.81	2.27	0.5	0.63	0.74
	PM	g/km	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Euro VI (2015)	HC	PPM	200	-	200	380	560	-	-	-
	NOx	g/km	0.06	0.08	0.06	0.075	0.082	0.08	0.105	0.125
	CO	g/km	1	0.5	1	1.81	2.27	0.5	0.63	0.74
	PM	g/km	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

6.111 Globally, many developed and developing countries are moving or in phase of transition towards EURO V and higher standards (depending on their existing standard) to reduce exhaust tailpipe emissions from the vehicles. This requires the vehicle manufacturers to install various types of particulate matter filters and catalytic converters. These emission control technologies are absent (or indeed often removed and sold) from the pre-owned vehicles imported in Mongolia resulting in increased air pollution in major urban cities. By preventing the import of the most polluting (i.e. oldest and/or stripped of tailpipe emissions filters), this will also reduce the capital expenditure gap between ICE and EVs at the entry level of the market.

MNS 5011:2003- Instruction for technical inspection of motor vehicles

6.112 Building on the above, vehicle inspection standards and practices form the basis for compliance and enforcement of vehicle standards and regulations.

6.113 MNS 5011:2003 delineates the fundamental principles governing diagnostic centres for vehicle inspections and their technological operations. It establishes requirements for enterprises authorised to conduct technical assessments of motor vehicles and issue conclusions. The motor vehicle inspection includes passenger car, taxi, heavy loading trucks, and buses.

6.114 The standard primarily focuses on inspection tests aimed at assessing the roadworthiness, safety, and overall integrity of a vehicle. These inspections entail a detailed examination of various vehicle components and systems, with specific procedures outlined for each area of inspection. The methods employed for these assessments include the use of standard equipment, visual inspections, auditory assessments, and operational checks. Importantly, these inspection procedures are non-destructive and non-obstructive in nature.

6.115 The standards provide a step-by-step framework for conducting these checks and defines acceptable ranges of results. Furthermore, it categorises the inspection results into major and minor violations based on the severity of the deviations from the standard criteria. Depending on the number of violations detected, the standard prescribes specific actions. The inspection of the technical condition encompasses the following areas:

- Car general condition
- Engine and power transmission class
- Smoke and noise measurement
- Braking system
- Steering mechanism
- Chassis, springs, shock absorbers, and roller mounts
- Car traffic safety kit
- Ecological and ergonomic indicators
- Lighting and electrical system
- Normal operation of the engine system
- Lifting devices and special equipment

Inferences based on MNS 5011:2003

6.116 The current inspection framework provides a comprehensive step for inspection of ICE vehicles across vehicle segments, including tailpipe emissions testing (which is critical to enforce vehicle standards). Based on stakeholder engagement, we understand that the vast majority of vehicles comply on the annual testing requirement (approximately 90% nationally, broadly universal in Ulaanbaatar)

6.117 Many of these tests such as brakes, steering systems, light, etc. related to the safety of the vehicles would also be applicable for EV inspection as well (except smoke test). However, there would be additional inspection tests that will have to be carried out for ensuring roadworthiness and safety of hybrid and electric vehicles. These inspection tests are currently missing in this standard and proposed to be added to form all-encompassing inspection across all vehicle technologies. This is detailed in the recommendation's section.

MNS 6594: 2016: Production of recycling of end-of-life vehicles (ELVs). General requirements ELVs

6.118 MNS 6594:2016 in Mongolia sets forth stringent regulations and oversight for the management of ELVs, emphasising environmental sustainability and safety. The standard targets enterprises, organisations, employees, and officials involved in ELV activities, urging environmentally safe handling of hazardous waste and raw materials. It categorically defines hazardous waste, encompassing materials presenting potential harm due to their toxic, corrosive, or other harmful properties. The standard mandates compliance with both international and Mongolian standards, underscoring the importance of responsible vehicle disassembly, sorting, recycling, and storage, with specific attention to the safe removal of batteries and fuel tanks. Requirements extend to facilities, ensuring adequate infrastructure, equipment, and precautions to prevent environmental pollution, reinforcing the need for sustainable practices throughout the ELV recycling process.

6.119 MNS 6594:2016 provides a comprehensive framework for the environmentally conscious management of ELVs, encompassing responsible waste handling and recycling practices. It accentuates compliance with safety and environmental standards, aiming for sustainable and eco-friendly treatment of ELVs and their components.

Inferences based on MNS 6594:2016

6.120 This standard emphasizes on need to safe disposal of hazardous waste including ICE vehicle auxiliary batteries. However, it falls short in terms of outlining specific initiatives, targets, or government support. The absence of policy interventions suggests that battery waste from vehicles might, in many cases, find its way to landfills, raising concerns about environmental impact and the need for more comprehensive waste management strategies.

6.121 The existing standard focuses on recycling on ICE ELV and can be extended to recycling of electric ELV (excluding battery), however there is a need for the development/upgrade of the Waste Law to address the recycling and management of EV batteries to be developed as part of the EV roadmap.

6.122 Based on the analysis of the existing ICE MNS standards, it is evident that there is a need to make them more inclusive of EVs while also aligning them with international trends and advancements. Enhancing these standards will also support the transition towards hybrid and electric vehicles by restricting the availability of older and more polluting ICEVs that are typically cheaper. Moreover, as these standards for ICEVs are reinforced, the tailpipe emission savings achieved by replacement of ICEV with an EV will decrease over the years.

Policy and strategic barriers and opportunities

6.123 This section presents other strategic considerations which will affect EV readiness in Mongolia as identified through research and stakeholder engagement. These are: supply chain; just transition and equity; e-mobility co-benefits; and EVs in the context of Avoid-Shift-Improve.

EV supply considerations

6.124 The nature of the Mongolian vehicle market as import dominated and focused on used vehicles means that supply side considerations will be a critical readiness factor in addition to consumer demand. In particular, the EV transition of its major trading partners will be the key determinant of vehicle supply throughout the period. Table 6-19 below shows recent (2022) and future (2030) EV sales targets for Mongolia's key vehicle import origins (based on IEA's Global EV Data explorer[101]) which will shape availability in Mongolia to meet what demand exists. For used vehicle markets, there will be an important time lag dynamic (for example, with new EV volumes in 2022 suggestive of relative supply in the last 2020s).

[101] *Global EV Data Explorer – Data Tools - IEA*. (2023). IEA. https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer

Table 6-19: Current and forecast EV sales penetration by market (yellow highlight denotes principal import market for Mongolia)

	Japan		China		South Korea	
	2022	2030	2022	2030	2022	2030
Cars	**3%**	**20%**	29%	62%	9%	33%[102]
Buses[103]	0%	30%	**10%**	**49%**	1%	N/A
Vans	4%	N/A	14%	54%	**27%**	**N/A**

Source: IEA (except where otherwise noted)

6.125 Key market considerations in terms of EV supply include:

- **Japan has one of the lowest EV adoption rates in the developed world**. In the private car sector, EVs made up only 3% of sales in Japan in 2022, projected only to rise to 20% by 2030. This will be particularly significant in the short- to medium-term, since Japan is the origin of 94% of used automobiles in Mongolia (the reasons for which are discussed in next section below).
- **South Korea has an ambition for 33% EV penetration by 2030 (and 27% of van sales are currently EV[102]).** South Korea has an extensive used vehicle export sector, but its driving side gives it a wider market than Japan (and therefore less favourable prices). It is the second biggest import source for Mongolia, principally for commercial vehicles and buses.
- **China is the world's largest EV manufacturer by volume, with EVs making up 38% of new private automobiles in 2023[104], a share which is expected to rise to 62% by 2030.** China is also the global market leader for electric buses, with approximately 60% of global BEB sales in 2023, and over 50% of all bus sales nationally being electric[105]. Whilst not as high as Korea in terms of market share of

[102] *South Korea: electric vehicles market share 2023 | Statista*. (2024, March 28). Statista. https://www.statista.com/statistics/1099571/south-korea-electric-vehicles-market-share/
[103] While the greatest number of vehicles in the large passenger vehicles segment has traditionally been South Korea (see data in section 2), for urban public transport the most recent procurement was for 507 Yutong buses from China (approx. 40% of the urban bus fleet).
[104] International Energy Agency. (2024). *Trends in electric cars – Global EV Outlook 2024 – Analysis - IEA*. IEA. https://www.iea.org/reports/global-ev-outlook-2024/trends-in-electric-cars
[105] International Energy Agency. (2024b). *Trends in heavy electric vehicles – Global EV Outlook 2024 – Analysis - IEA*. IEA. https://www.iea.org/reports/global-ev-outlook-2024/trends-in-heavy-electric-vehicles

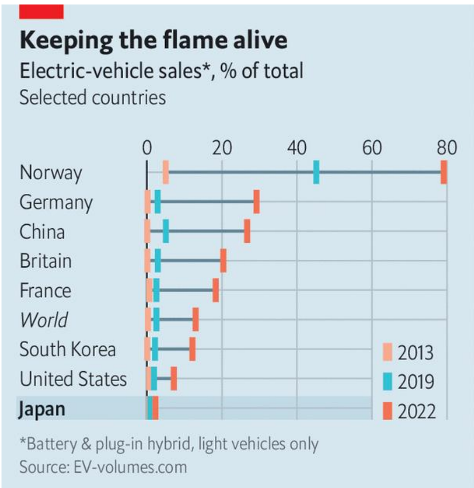
van sales, China was the global leader of electric van sales in terms of overall sales in 2022, with over 130,000 units sold (14% of its market)[106].

The influence of Japanese used automobile sourcing on EV penetration

6.126 The current vehicle supply chain in Mongolia is driven by the permissive regulatory framework to the import of used right hand drive Japanese vehicles. This permissiveness means that Japanese vehicles tend to have a price advantage over other import sources. While debates are ongoing on both vehicle age limits and right-hand drive vehicle operation (see below sections), the baseline future trajectory for used automobile imports in Mongolia will be influenced by Japanese market trends.

6.127 Japan has one of the lowest rates of electrification of its vehicle fleet among developed nations. While, according to Japan Automobile Dealers Association (JADA), sales of new EVs in 2020 reached close to 1.4 million (36.2% of total new car sales), 98% of these were HEVs and just 1.1% were BEVs (approximately 5,500) – equivalent to less than 15% of Mongolia's total annual vehicle imports.

Figure 6-42: Japan has been slow to adopt electric vehicles



Source: The Economist, 2023[107]

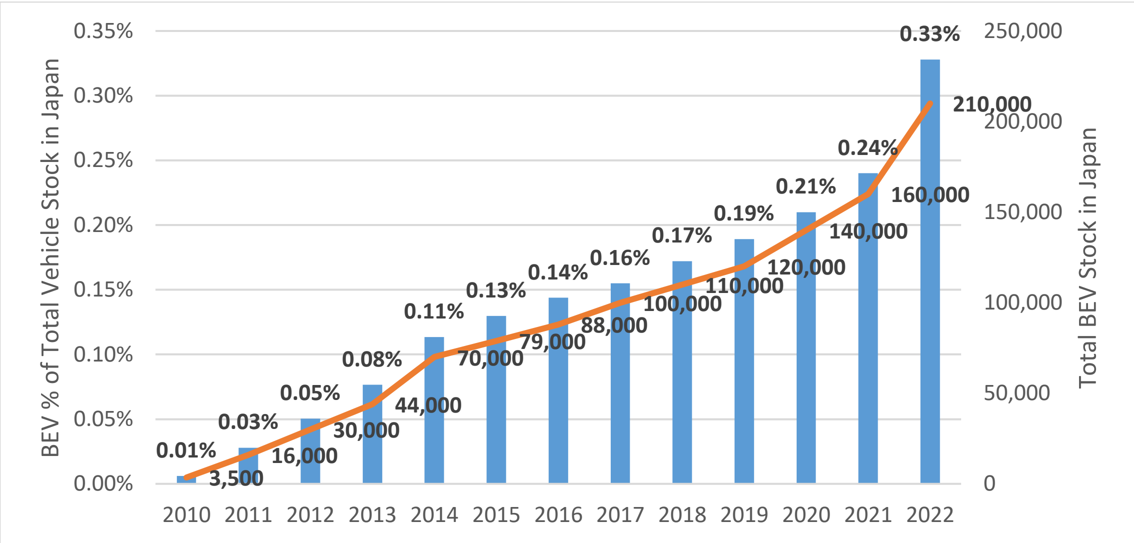
6.128 The Government of Japan recently set a requirement that, by 2035, all new cars sold will be environmentally friendly (defined as Clean Energy Vehicles (CEVs)). This category includes BEVs, PPHEVs and Fuel Cell Electric Vehicles (FCEVs), and HEVs. A CEV subsidy scheme has been set up, with a maximum value of US$ 7,200. Although

[106] *Trends in electric light-duty vehicles – Global EV Outlook 2023 – Analysis - IEA*. (2023). IEA. https://www.iea.org/reports/global-ev-outlook-2023/trends-in-electric-light-duty-vehicles
[107] The Economist. (2023, April 16). How Japan is losing the global electric-vehicle race. *The Economist*. https://www.economist.com/asia/2023/04/16/how-japan-is-losing-the-global-electric-vehicle-race

HEVs are considered eco-friendly cars, they are not eligible for the CEV subsidy program.

6.129 The prominence of Japan for vehicle supply in Mongolia represents a significant supply-side restriction. In 2010, there were just 3,500 BEVs registered in Japan, representing 0.01% of Japan's total vehicle stock (Figure 6-43), according to the International Energy Agency (IEA). Whilst the stock of BEVs has risen gives a snapshot of a limited pool of used BEV stock available for export to developing markets in the late 2020s and 2030s.

Figure 6-43: Japan's uptake of BEVs



Source: IEA, 2023[101]

6.130 For the EV readiness of the automobile segment to change, it would require the diversification of the range of its import sources. This may result from changes in the position of GoM to right-hand drive vehicles (on safety grounds) or vehicle age limits (on environmental grounds). The continued rapid development of a Chinese used vehicle export market may also see a shift in market dynamics in coming years. These are described briefly in the below sections.

Safety concerns over right-hand drive vehicles

6.131 The dominance of Japanese imports means most vehicles' steering wheels are on the right of the car, when they ought to be on the left. This phenomenon is sometimes referred to as 'wrong-hand drive'[108].

[108] The causal effect of wrong-hand drive vehicles on road safety. (2017). In *CEPIE Working Paper* [Working Paper]. https://www.econstor.eu/bitstream/10419/170527/1/1001186524.pdf

6.132 This is a serious safety concern due to the blind-spots of wrong-hand drive vehicles. Sweden demonstrated this in 1967 when the country switched from left-hand to right-hand traffic. For reasons of international trade and customer demand, almost all vehicles had been left-hand drive (LHD) before 1967, i.e. 'wrong-hand drive'. When the country switched to right-hand traffic, its road fatality, injury and accident risk fell by approximately 30%[109]

6.133 Solutions to Mongolia's mass imports of wrong-sided vehicles has long been a topic of debate within the country. In 1991, right-hand drive (RHD) vehicles were banned, only for the law to be lifted within the same year[110]. With even more RHD vehicles on the road now, this demonstrates the infeasibility of such a ban at present.

6.134 While the Mongolian policy discussion around right-hand drive vehicles is outside of the scope of this study (being principally a safety consideration), were this change to be brought in, the impact upon the potential for EVs would be to diversify the range of import sources for mass market vehicles, resulting in increasing prices of used ICEVs and increasing supply of used EVs of comparable specifications from more developed EV markets (e.g. China and Republic of Korea) in coming years.

Age of imports

6.135 The abundance of older (and, therefore, cheaper) ICEVs reduces the relative price of these segments compared to EVs (and results in a far lower supplier of comparator EVs of relatively early technology). As the EV market only began to grow substantially from 2020 globally (rising from 4% of total global vehicle sales in 2020 to 14% in 2022[111]), age limits on vehicle imports to Mongolia would increase supply of comparable EVs.

6.136 It is likely that such a regulation would significantly increase vehicle prices in Mongolia. This would support efforts to tackle the country's rapidly accelerating motorisation rate, however, would risk the socioeconomic distributional challenge of 'pricing out' lower income groups from car ownership.

Growth in Chinese vehicle exports

Chinese vehicle exports have surged in recent years, in 2023 seeing 64% growth to 4.1 million units. Chinese brands (e.g. BYD, Geely) are increasingly recognised on international markets. China has a well-established internal used vehicle market, however there was no official export of used vehicles from China until 2019, meaning

[109] The causal effect of wrong-hand drive vehicles on road safety. (2017). In *CEPIE Working Paper* [Working Paper]. https://www.econstor.eu/bitstream/10419/170527/1/1001186524.pdf

[110] Enkhnaranjav, T. (2022). *Right-hand drive cars are not the cause of traffic congestion*. PressReader. https://www.pressreader.com/mongolia/the-ub-post/20220912/281522229928465

[111] *Electric vehicles* - IEA. (2023). IEA. https://www.iea.org/energy-system/transport/electric-vehicles

Mongolian vehicle imports from China have been limited. However, since this restriction was removed exports have quickly grown (albeit to a still relatively low 69,000 units in 2022)[112]. While no breakdown is available by drivetrain fuel technology, given that EV technology is more competitive with ICE in relative terms in the Chinese market, such a shift could potentially accelerate used EV readiness in export markets over time.

Equity and just transition

6.137 The EV transition requires consideration of 'Just Transition', broadly understood as the distributional impacts of e-mobility's benefits and costs, with costs understood both in terms of the allocation of public resources (e.g. subsidies, investments) but also the wider supply chain impacts (e.g. maintenance, operation). For instance:

- **Considering the socioeconomic groups that benefit from fiscal incentives** (loans/subsidies/tax breaks). For example, subsidies targeted at private EVs may help relatively wealthier early adopters rather than less wealthy bus users, while being phased out later on when lower income groups want to adopt. While Mongolia has concessional EV financing programmes available, ensuring there are effectively targeted to 'nudge' groups towards EVs who would not otherwise purchase them, with greater GHG mitigation impacts (e.g. higher use cases) and social co-benefits (such as livelihoods – e.g. taxis or deliveries).
- **The distributional impact of mandates or regulatory changes** which increase the cost of ICEVs (how will that affect lower income groups who depend on vehicles, such as taxi drivers). Key balances will include the impact of regulations to increase emissions standards and their impact on mobility of poorer groups.
- **Considering the long-term sequencing of incentives** to ensure that support remains for future challenges to address as EVs become more mainstream. For example, incentives should be carefully targeted across socioeconomic demographics as different market segments transition. Support is likely to be needed for public charging infrastructure or building-level charging infrastructure for those relatively less wealthy user groups without off-street parking at their homes[113], and potentially different approaches in ger areas, where grid access is lower (and neighbourhoods more dispersed).

[112] People's Daily Online. (2024). *China accelerates pace of second-hand car exports - People's Daily Online*. http://en.people.cn/n3/2024/0229/c98649-20138843.html#:~:text=Since%20the%20launch%20of%20a,about%2015%2C000%20units%20in%202021.

[113] Witchalls. (2018). *Power poverty: the new paradigm for social and economic inequality of electric vehicles*. https://www.stantec.com/en/ideas/power-poverty-the-new-paradigm-for-social-and-economic-inequality-of-electric-vehicles

- **Equity implications of providing exemptions to road use restrictions** in Ulaanbaatar to green license plates (and e-scooters' ability to skip traffic queues) when these technologies are largely restricted to higher-income groups
- **Managing the labour market impacts of the EV transition**. EVs require fewer moving parts than their ICEV counterparts and have reduced maintenance requirements requiring a smaller overall maintenance workforce[114]. Of those jobs which remain, there is greater demand for chemical, battery and software engineering, for which upskilling is required. More positively, the Mongolian workforce has rapidly adapted to HEV technology as the market developed and there is clearly an entrepreneurial local EV ecosystem developing in sales and service, able to advocate for sector needs. Skills transition is also subdued by the limited high-skilled job pool in the automotive sector in Mongolia given the absence of local vehicle industry.
- **Spatial distribution of air pollution impacts** will need to be considered where increased energy generation demand is met from additional emissions from coal-fired power stations (which have often been located in residential areas due to their heating function).

Co-benefits of EVs

6.138 Electric vehicles offer a range of co-benefits beyond their primary advantage of reducing GHG emissions. These co-benefits contribute to various aspects of society, the economy, and the environment. These include:

- **Improved air quality through tailpipe emissions**, resulting in improvements to citizen health, life expectancy and associated economic benefits. For example, it has the potential to reduce rates of respiratory and cardiovascular diseases (which are, in part, attributable to poor air quality in Ulaanbaatar, although this is not only due to transport).
- **Perception improvements in the image of a city or place**, with the possibility to support strategies to enhance global investment attractiveness.
- **Opportunities for investment in reform of public transport systems** through the requirement to adjust or reimagine the bus investment and operating model.
- **Opportunities for investment in supporting renewable energy** investment.

[114] McMahon, J. (2019, May 30). More electric cars mean fewer mechanical jobs. *Forbes*. https://www.forbes.com/sites/jeffmcmahon/2019/05/30/more-electric-cars-fewer-manufacturing-jobs/

- **Reduced noise pollution** when compared to ICEVs, with improvements to urban liveability, particularly in dense urban centres, such as Ulaanbaatar.
- **Reduced dependence on fossil fuels (depending on energy source) and improved energy security**. For example, in Mongolia this would reduce Mongolia's reliance on imports for oil (although may increase dependency on national and imported coal energy generation to meet the increased demand for electricity).

EVs in the context of "Avoid-Shift-Improve"

6.139 E-Mobility should be contextualised within a wider "Avoid-Shift-Improve" hierarchy to transport decarbonisation (and wider sustainable development). This provides a framework for reducing the environmental and social impacts of transportation systems. Within this:

- "Avoid" refers to the distances travelled to access activities and services (in this instance, reducing distances travelled) by motorised modes, in doing so avoiding the impact of the transportation system on the environment.
- "Shift" refers to encouraging people to shift from less sustainable modes of transportation, such as single-occupancy vehicles, to more sustainable options. For example, shifting from a single-occupancy car journey to a bus journey. In many cases which can be much lower cost to achieve than technology change (e.g. electrification), and offer other policy co-benefits (such as improved health, air quality, and urban realm benefits).
- "Improve" refers to existing transportation options and how their carbon impacts can be reduced, for example through electrification or increased vehicle standards.

6.140 It is important to recognise, particularly in the context of Ulaanbaatar's increasingly unsustainable congestion issues, that e-mobility is one consideration within a wider sustainable mobility policy to decarbonise transport. Transition to EVs alone is not a replacement for the higher priority (and potentially more impactful) imperative to reduce travel demand and shift towards sustainable urban mobility (e.g. through shifts to public transport) as currently being promoted by the World Bank USUTP program and others. E-mobility should be seen as an opportunity to decarbonise residual motorised travel demand alongside these efforts (rather than an alternative).

7. E-mobility readiness assessment

7.1 This section provides a structured, multi-criteria approach to assess the readiness of different EV sectors in Mongolia, considering the technical, economic, policy, environmental and other strategic factors outlined above. The assessment seeks to identify those EV segments with the potential to contribute to decarbonisation and other policy goals. Recognising the reality of a relatively limited public fiscal resources (e.g. for vehicle subsidies, as provided in developed contexts), readiness also considers the extent to which EV segments can be catalysed through:

- **Public Policy (Enabling) Case:** Segments with high potential for private sector led transition, which align with public policy and which can be enabled or stimulated primarily through non-fiscal support (e.g. regulation, coordination).
- **Proactive Public Investment (Promotion) Case**: Segments which are supportive of public policy goals but for which more proactive public sector engagement and/or investment is likely to be required to develop this market.

Segments and criteria

Vehicle segments and groupings

7.2 The segments considered in the TCO analysis have been grouped based on their functional similarities, specifically:

- Private Automobiles, including mass market, mid range and new vehicle sub-segments (See Table 7-1)
- Light Commercial Vehicles, including light freight vehicles (vans) and taxi segments (See Table 7-2)
- Urban buses, considering different operating characteristics and charging strategies (See Table 7-3)

Readiness criteria and scoring

7.3 Five readiness criteria have been considered, in line with the key analytical areas of this study: 1) economic readiness; 2) technology readiness; 3) supply readiness; 4) GHG/energy readiness; 5) urban mobility policy readiness. Criteria 1-3 relate to Market Readiness, with Criteria 4-5 showing readiness in terms of the segments ability to contribute to Mongolia’s public policy goals. Each criteria has been scored out of five, with qualitative appraisal against defined sub-criteria (with a total score out of a possible 25).

Market readiness

Economic readiness

7.4 For the **economic** considerations, the **Total Cost of Ownership (TCO)** of each segment is compared to its ICEV (and in many cases also HEV) equivalent, followed by a **future economic feasibility** assessment, based on anticipated trends for each segment. The potential of consumers in each segment to **finance the upfront capital costs** is the final economic consideration. The overall readiness for electrification of each segment for these three considerations is attributed a score out of five.

Technology readiness

7.5 For the **technological** considerations, the main concern is the **range** of the vehicles in each segment, which will be largely determined by the distances covered by the vehicles and, particularly in Mongolia, the climatic conditions they operate in. Related to this is the **availability of chargers** and the **ability of chargers to operate** in extremely cold conditions. The readiness of each segment is again given a single score out of five for the three technological considerations.

Supply availability/readiness

7.6 The availability of EVs in each segment for the Mongolian market was considered both at present and into the near future. An important factor here was EV availability from key import markets, particularly for used market segments. A single readiness score out of five was given for this criteria.

Public policy readiness

Green House Gas (GHG) emissions & impact on the grid

7.7 The current **net GHG impact** of the electrification of each segment is an important consideration to assess the rationale for the electrification of that segment. This assessment is conducted using 2024 data to use the most recent data without introducing the uncertainty of projections. To consider how this may change in the future, an assessment of the **potential for grid-based** and **off-grid Renewable Energy Sources (RES)** is made. A cleaner energy supply for each segment would strengthen the case for electrification.

7.8 These three factors are considered together and given a single score out of five.

Urban mobility policy readiness

7.9 The potential impact of the electrification of the segments on **air quality** and **modal split**, two policy focusses for the GoM and MUB, are considered together and given a single score out of five.

Readiness Assessment: Private automobiles

7.10 Table 7-1 provides an overview of the factors affecting private car transition to EVs in the Mongolian context, and their alignment with public policy.

Table 7-1: Assessment of readiness and approach for private automobile segments

	Mass Market	Mid-Range	New
Fleet size	264,709 85% of 2021 registrations	37,371 10-12% of 2021 registrations	9,343 3-5% of 2021 registrations
Market Size (imports pa)	Total segment imports pa 66,000 in 2022, 75,000 in 2023		
Past Segment Growth rate	4% per annum (5-year average to 2021) - (stock)		
Future Segment Growth rate	2% per annum (UB 2040 Masterplan Projections – 2022-2040) (stock)		
Current EVs	Nissan Leafs	BAIC E5	BYD, Mercedes, VW, others available
ECONOMIC READINESS	**LOW (1)**	**MEDIUM (3)**	**HIGH (4)**
Current Economic Feasibility (TCO Differential)	EV 6% higher than ICE EV 28% higher than HEV	EV 27% lower than ICEV EV 20% lower than HEV	1% higher than ICEV N/A for HEV
Future Economic Feasibility	Uncertain market dynamics as developed economies phase out ICEVs	Expected capex parity as soon as 2028, however potential high competition	Expected capex parity as soon as 2025
Ability to finance upfront cost	Purchasers have low financing capacity, cost sensitive	Moderate financing ability, some cost sensitivity	High financing ability
TECHNOLOGY READINESS	**LOW-MODERATE (2)**	**MODERATE (3)**	**MODERATE (3)**
Range	Limited range in winter (current models) even for urban journeys	Range anxiety for longer journeys	Range anxiety for longer journeys
Charging Technology	Some issues with Fast Charging in winter, however can be mitigated with user education, charging strategies (overnight, destination), and increased fast charger deployment.		

Charging Availability	Moderate coverage in urban areas, very limited outside of Ulaanbaatar, which contributes to range anxiety		
SUPPLY READINESS	**LOW (1)**	**LOW-MODERATE (2)**	**HIGH (5)**
Supply Chain	Restricted Constrained by low Japanese EV rates (3% in 2022) in the medium term.	Developing Comparably priced used EVs from Korea/China available.	Developed No restrictions on supply chain.
GHG & GRID READINESS	**LOW-MODERATE (2)**	**LOW-MODERATE (2)**	**LOW-MODERATE (2)**
GHG Impact - 2024	46% reduction vs. predominant HEVs	46-54% reduction depending on technology.	54% reduction vs predominant ICEVs.
Potential for grid-based RES market	No RES market via grid.	No RES market via grid.	No RES market via grid.
Potential for off-grid RES	Limited opportunity High-cost relative to grid (1-2x higher)	Limited opportunity High-cost relative to grid (1-2x higher)	Limited opportunity High-cost relative to grid (1-2x higher)
URBAN MOBILITY POLICY READINESS	**LOW-MODERATE (2)**	**LOW-MODERATE (2)**	**LOW-MODERATE (2)**
Air Quality Impact	Significant but limited by low mileage and HEV technology May be offset by EV energy source (urban thermal power plant)	Significant but limited by low mileage and newer emissions technology May be offset by EV energy source (urban thermal power plant)	Significant but limited by low mileage and newer emissions technology May be offset by EV energy source (urban thermal power plant)
Mode Shift Impact	Reduces marginal cost of automobile use.	Reduces marginal cost of automobile use.	Reduces marginal cost of automobile use.
OVERALL READINESS	**8/25**	**12/25**	**16/25**
Readiness	**Low**	**Moderate**	**Moderate-High**

Summary recommendations

7.11 The assessment finds a positive environment for private automobiles to transition to EVs in higher end vehicles in the short/medium term. This will some positive impact upon GHG emissions, and reduced tailpipe pollutant emissions, however the reliance of the grid upon thermal energy (and location of current and future planned plants within city limits) may reduce these benefits. Reduced marginal cost of vehicle use will also conflict with policy to reduce private automobile use.

7.12 Transition to EV in these segments is nevertheless a net benefit, and policy and regulation could enable and, where possible, accelerate this privately led transition without compromising on its commitment to traffic demand management and public transport priority.

7.13 Mass market vehicle segments may be attractive for electrification in the longer term, but current technologies for older EVs means poor performance (particularly in winter), while their supply is limited and competes with cheap Japanese ICEV and HEV imports. Given the prevalence of HEVs in the mass market vehicle segment, the relative benefits of this sector are lower than other vehicle markets.

Readiness Assessment: Commercial vehicles

7.14 Table 7-2 provides an overview of the factors affecting transition of urban commercial light vehicles to EVs in the Mongolian context, specifically focusing on taxis, premium taxis (e.g. transfer services) and light freight vehicles (new vans).

Table 7-2: Assessment of readiness and approach for light commercial vehicle segments

	Urban Taxis (Mass Market)	Private Hire (New vehicles)	Light Urban Freight (Vans)
Market Size (imports per year)	Approx. 40,000[115] (of which approx. 600 formal[116])	Unknown	Approx. 28,000[117]
Past Segment Growth	Unknown but assumed to be approx. 9% per annum in the 5 years up to 2021 (the last year of available data from NAVC on sedan vehicle registrations).	Unknown	3% per annum (2013-2023 average, excluding anomalous reclassification year) - stock[117]
Future Segment Growth	Assumed will grow in line with GDP per capita from 2022.	Assumed will grow in line with GDP per capita from 2022.	Assumed will grow in line with GDP per capita from 2022.

[115] Estimate from UB Cab, which makes up the majority of the market
[116] MUB PTD. (2023). Response to study team's data request.
Combination of PTA operated taxis and 8 private taxi operators
[117] Based on NAVC "bus" data, having been informed by NAVC that in 2019 vans became re-classified as "buses", and subtracting estimated bus & minibus figures for that year

Current EVs	No formal taxis are electric (as of 2023)[24]. It is unknown how many informal taxis are EVs (although the fleet is thought to be limited if it exists).	Unknown (although thought to be none given the range constrictions).	BYD T3 is the most commonly imported new Light Urban Freight vehicle, with Wuling EV50 & Ford Transit E-350 also imported but in low numbers (16 total in 2023) [118]
ECONOMIC READINESS	**MODERATE (3)**	**MODERATE-HIGH (4)**	**MODERATE-HIGH (4)**
Current Economic Feasibility (TCO Differential)	EV 25% lower than ICE EV 20% lower than HEV	EV 15% lower than ICEV N/A[119]	EV 29% lower than ICEV[120] N/A[121]
Future Economic Feasibility	Despite some risk of reduced used ICEV capital cost, expected to remain lower TCO than ICEV due to high mileage and low Opex	Expected to continue with lower TCO. Capital cost parity by 2025.	Despite some risk of reduced used ICEV capital cost, expected to remain lower TCO than ICEV due to high mileage and low Opex
Ability to finance upfront cost	Low capacity by individual taxi owners, particularly if mid-range vehicle required	Moderate, depending on size of business	Moderate, depending upon size of business
TECHNOLOGY READINESS	**MODERATE-HIGH (4)**	**LOW (1)**	**MODERATE-HIGH (4)**
Range	Urban use only, so limited range anxiety. Mass market vehicle operationally inappropriate due to frequent charging needs, however mid-range EV appropriate with marginal TCO impact.	Vehicles required to travel to remote areas (e.g. for tourism) and intercity journeys. Increased challenges during winter months.	Urban use only, so limited range anxiety subject to opportunity charging during winter.
Charging Technology	Slower charging speeds in winter, however can be mitigated with user education, charging strategies (pre-heating, overnight, destination), and increased fast charger deployment.		

[118] MSM. (2024). Mongolian Customs data [Dataset].
[119] New HEV are not commonly sold on the Mongolian market
[120] New vehicles. Used LCV expected to have similar TCO profile as mass market taxis
[121] New HEV are not commonly sold on the Mongolian market

Charging Availability	Moderate coverage in urban areas. Potential for captive charging arrangements.	Limited to non-existent outside of Ulaanbaatar.	Captive overnight charging possible at depots. Moderate opportunity charging coverage within Ulaanbaatar for fast charging.
SUPPLY READINESS	**MODERATE (3)**	**HIGH (5)**	**MODERATE-HIGH (4)**
Supply Chain	Mass market vehicles constrained by low Japanese EV rates (3%) however comparable Chinese/Korean mid-range EVs increasingly available.	No restrictions on supply chain.	No restrictions for new vehicles High volumes of used vehicles will become available from Korea (28% sales penetration 2022) and China (5%)
GHG & GRID READINESS	**MODERATE (3)**	**MODERATE (3)**	**MODERATE-HIGH (4)**
GHG Impact	46% reduction vs. predominant HEVs on high daily mileage	54% reduction vs predominant ICEVs on high daily mileage.	54% reduction vs predominant ICEVs on high daily mileage
Potential for grid-based RES market	No RES market via grid.	No RES market via grid.	No RES market via grid.
Potential for off-grid RES	Limited opportunity High-cost relative to grid (1-2x higher)	Limited opportunity High-cost relative to grid (1-2x higher)	Opportunity at depots/garages High-cost relative to grid (1-2x higher)
URBAN MOBILITY & POLICY READINESS	**MODERATE (3)**	**LOW-MODERATE (2)**	**MODERATE-HIGH (4)**
Air Quality	High mileage in urban areas means significant benefits (though relative to HEV) May be offset by EV energy source (urban thermal power plant)	High mileage means significant benefits, though often in non-urban areas so limited impact May be offset by EV energy source (urban thermal power plant)	High mileage in urban areas means significant benefits relative to ICEV vans. May be offset by EV energy source without RES use
Mode Shift	No impact on modal shift	No impact on modal shift	No impact on passenger modal shift.
OVERALL READINESS (pts)	**16/25**	**15/25**	**20/25**
OVERALL READINESS (L-M-H)	**Moderate**	**Moderate**	**High**

Barriers	Financing challenge for taxi operators Availability of opportunity charging and deployment of captive charging	Technology not suitable EV charging infrastructure outside UB	Financing challenge for smaller operators Availability of opportunity charging and deployment of captive charging

Summary recommendations

7.15 The assessment finds that:

- Urban taxis have low potential in the short term, pending the more contextually appropriate technologies of more recent EV generations. However, they are likely to be technically and commercially feasible in the medium-long term (particularly if accompanied by institutional and governance changes in the taxis sector).
- Light goods vehicles show strong potential in the short term for deployment within the urban freight sector and planned initiatives.
- Private hire vehicles are not suitable to take forward since the requirement for them to be able to travel to remote rural areas limits their technical feasibility.

Readiness Assessment: Urban buses

7.16 Table 7-3 provides an overview of the factors affecting transition of the urban bus sector to EVs. The analysis has highlighted two critical challenges in relation to the deployment of battery electric buses, specifically:

- **Low capital productivity of the current fleet**, owing to low speeds in mixed traffic operation and suboptimal charging strategies. Sensitivity analysis found that by achieving a 20% increase in daily service kilometres, the differential in TCO per km could be reduced from 12% to 2%, making BEB more financially viable.
- **Negligible GHG mitigation impact** when charged using the current grid energy mix and factoring in emissions from diesel heating in winter. This would weaken the case for BEBs, particularly in relation to climate financing. Provision of off-grid renewable energy for e-bus charging would address this barrier, requiring investment understood to be equivalent to US$0.08-10/kWh, in increasing the TCO gap from 12% to 23%.

Battery Electric Bus deployment options

7.17 Having identified these two issues, the opportunity assessment considers three further options for urban bus electrification to assess scenarios in which BEB may be appropriate and feasible in the context of Ulaanbaatar.

1) '**Current Model':** This assumes expansion of the current approach to BEBs, with vehicles operating predominantly in mixed traffic and charged through grid-connected depot charging located off route.
2) **'Optimised Operation':** This assumes an approach of implementing BEBs with a 20% increase in fleet productivity (km per day), which could be achieved through improved charging strategies (e.g. opportunity charging on route) and increased bus speeds through dedicated BEB lane (e.g. Green Corridor) interventions. In this context, reduced air pollution and sustainable transport investment would be assumed to strengthen public support for enforced road space reallocation towards public transport compared to existing diesel buses.
3) **'Green Energy':** This assumes an approach through which BEBs would be charged using a captive renewable energy system to enable them to provide carbon mitigation benefits. This would increase energy costs from $0.04/kWh to $0.10kWh (in line with local cost estimates). The BEBs would continue to operate as in the base model (i.e. mixed traffic running and off-route opportunity charging).
4) **Combined Optimised Operation + Green Energy:** This option would combine options 2 and 3, resulting in increased bus operating efficiency and providing carbon mitigation benefits.

Table 7-3: Assessment of readiness and approach for urban buses

	1. Urban Buses (Current Model)	2. Urban Buses (Optimised Operation)	3. Urban Buses (Green Energy)	4. Urban Buses (Optimised Ops+ Green Energy)
Market Size	110 per year	110 per year	110 per year	110 per year
Growth Rate	Growth is in line with urban public transport policy			
Current EVs	54 pilot e-buses	54 pilot e-buses	54 pilot e-buses	54 pilot e-buses
ECONOMIC READINESS	**LOW-MODERATE (2)**	**MODERATE-HIGH (4)**	**LOW (1)**	**LOW-MODERATE (2)**

Current Economic Feasibility (TCO Differential) – In Service	**EV 30% higher than ICE**	**EV 14% higher than ICE**	**EV 50% higher than ICE**	**EV 33% higher than ICE**
Future Economic Feasibility	Unlikely to achieve TCO parity with ICEV in medium-long term	TCO parity likely in medium term	Unlikely to achieve TCO parity with ICEV in medium-long term	TCO parity may be possible in long-term[122] in line with reduced RES costs
Financing ability	Only through public financing	Only through public financing	Only through public financing	Only through public financing
TECHNOLOGY READINESS	**HIGH-MODERATE (4)**	**HIGH-MODERATE (4)**	**HIGH-MODERATE (4)**	**HIGH-MODERATE (4)**
Range	No issues subject to adequate charging strategy			
Charging Technology	Service planning requires consideration for winter performance			
Charging Availability	Captive charging used. Requires deployment of efficient charging strategy for opportunity charging.			
SUPPLY READINESS	**HIGH (5)**	**HIGH (5)**	**HIGH (5)**	**HIGH (5)**
Supply Chain	No issues	No issues	No issues	No issues
GHG & GRID READINESS	**LOW (1)**	**LOW (1)**	**HIGH (5)**	**HIGH (5)**
GHG Impact	**No change**	**No change**	**Up to 100% reduction (excl. heating)**	**Up to 100% reduction (excl. heating)**
Potential for grid-based RES market	No RES market via grid.	No RES market vio grid.	No RES market via grid.	No RES market via grid.
Potential for off-grid RES	Not included in this option	Not included in this option	Depot based RES provision possible, at cost premium	Depot based RES provision possible, at cost premium.
URBAN MOBILITY & POLICY READINESS	**LOW-MODERATE (2)**	**MODERATE-HIGH (4)**	**MODERATE (3)**	**HIGH (5)**

[122] Relative also to reductions in the cost of renewable generation

Air Quality Improvements	High impact at tailpipe. Contributes to grid energy demand (urban thermal supply)	High impact at tailpipe. Contributes to grid energy demand (urban thermal supply)	High impact at tailpipe and reduced grid energy demand.	High impact at tailpipe and energy source
Mode Shift	No impact on modal shift	Substantial impact to promote modal shift	No impact on passenger modal shift.	Substantial impact to promote modal shift
PT System performance	No impact on PT system performance	Improved PT system performance	No impact on PT system performance	Improved PT system performance
OVERALL READINESS (pts)	**14**	**18**	**18**	**21**
OVERALL READINESS (L-M-H)	**Moderate**	**Moderate-High**	**Moderate-High**	**High**
Engagement Feedback	Unclear justification for e-bus transition using the current model. Recent focus on EURO V Diesel and mode shift.	Reducing the cost of e-bus transition would reduce barriers. Achieving bus priority to increase bus speeds has been challenging.	Meeting energy demand without major grid impact is positive. No clear transport sector benefits.	Cost and affordability important.

Readiness	Technically deliverable, but high costs and limited tangible benefits.	Aligns e-mobility with wider public transport priority if e-buses increase political acceptability of bus priority (e.g. green corridor). Decarbonisation impact would be through modal shift impacts.	Technically deliverable. Limited policy and political support: Addresses RES (not a primary urban mobility goal) and increases costs without improving performance.	Technically deliverable. Strengthens technical case for option 2. Strengthens case for 'green corridor' approach to bus priority.
Recommended Approach	No clear justification	Appropriate option if Option 4 not affordable	No clear justification	Recommended approach

Summary recommendations

7.18 There is no clear justification for a wider scale-up of BEBs in Ulaanbaatar based on the current charging and operating model. The charging of BEBs using the current grid mix results in negligible (to even negative) impacts upon GHG emissions and reduces their operating productivity (vs diesel buses). There are no significant user benefits (e.g. improved accessibility) vis-à-vis modern diesel buses, while the air quality benefits at tailpipe have to be seen in the context of increasing demand for energy in UB, for which expansion of thermal energy remains the preferred option (potentially within the city limits). In this context, there is unlikely to be a justification for additional investment cost in BEBs versus other options for urban transport decarbonisation.

7.19 Other options may however provide the basis for BEBs to support transport decarbonisation and other policy goals in Ulaanbaatar:

- **If investment in BEBs can be used as a catalyst for more efficient operation, this would create a strong case for further expansion**. On the cost side, this would reduce the TCO of BEBs, bringing them closer to parity with diesel buses. The benefits case for use of BEBs can be strengthened if their introduction can support implementation (and robust enforcement) of bus priority measures (such as a Green Corridor approach). In this scenario, benefits will accrue from improved accessibility. Decarbonisation would occur not from technology change (which would remain similar), but from improving public transport journey times relative to private vehicles which would in turn promote modal shift from more energy intensive modes (e.g. private cars). For example, in Bogota, Colombia, the use of BEBs to increase the public and political support has been critical to current implementation of the Seventh Avenue Green Corridor BRT in Bogota, Colombia[123], following at least 20 years of opposition.

- **Use of RES for BEB charging** would support the case for a Green Corridor-type approach, in demonstrating zero emissions both at tailpipe and energy source. It would, however, offset some of the TCO savings achieved through the operational efficiencies (although it could also potentially open up climate financing options) which would need to be assessed based on the project. RES charging for BEBs in the existing operating model is unlikely to offer value for money relative to mode-shift based approaches and would add to the financial deficit of the bus operation.

Conclusions on segment-level EV readiness

7.20 The outcome of the EV readiness assessment is summarised in Table 7-4 below, which provides the basis for prioritising those segments with high market readiness, positive contribution to public policy goals, and no 'fatal flaw' barriers to wider deployment in the Mongolian context.

- In the **private automobile** segment, there is a widely varying level of market readiness while overall policy support is limited by Mongolia's energy grid mix (and reliance on coal generation in urban locations) and focus on reducing automobile use in Ulaanbaatar as part of a sustainable mobility approach to improving accessibility, reducing congestion and increasing urban liveability. Nevertheless, on balance EVs in this segment are considered preferable to the ICE or HEV alternative and an enabling policy approach should be taken towards this objective.
- **Light commercial vehicles** (urban taxis, vans) offer the highest overall readiness both in market and policy terms. This largely on account of their higher use, which both reduces their economic cost per kilometre and increases their co-benefits such as GHG mitigation and local air quality impact. Additionally, these vehicles are less readily shifted to more sustainable modes, making them supportable within a context of sustainable urban mobility. Nevertheless, it will be necessary to overcome a fragmented market for both freight and taxis segments.
- **Battery electric buses** have the potential to support sustainable mobility, increasing the attractiveness of public transport and acceptability of road space

[123] ¿Transmilenio por la séptima?: verdades y mentiras del corredor verde de Claudia López. (2020, November 24). *RTVC*. https://www.canalinstitucional.tv/noticias/corredor-verde-septima-claudia-lopez-transmilenio

reallocation. However, the current deployment model results in e-buses having a high cost to MUB (due to low bus speeds and capital productivity) while not delivering a reduction in GHG emissions due to Mongolia's energy mix. BEBs can therefore only be supported when accompanied by bus priority interventions (and other productivity enhancements such as opportunity charging) and where they can be demonstrated to drive modal shift to public transport and are charged using lower carbon energy sources (necessarily off-grid solutions in the current energy context).

Table 7-4: Summary of segment readiness for electrification

	Private Automobiles			Commercial			Urban Buses			
	Mass Market	Mid-range	New	Mass Market Taxi	Private Transfer	Light Comm Vehicle	Current Model	Opt. Operation	Green Energy	Opt. Ops+ Green Energy
Economic Readiness	1	3	4	3	4	4	2	4	1	2
Technology Readiness	2	3	3	4	1	4	4	4	4	4
Supply Readiness	1	2	5	3	5	4	5	5	5	5
GHG & Grid Readiness	2	2	2	3	3	4	1	1	5	5
Urban Mobility Policy Readiness	2	2	2	3	2	4	2	4	3	5
Market Readiness	4	8	12	10	10	12	11	13	10	11
	Low	Moderate	Very High	High	High	Very High	Very High	Very High	High	Very High
Policy Support	4	4	4	6	5	8	3	5	8	10
	Low	Low	Low	Moderate	Low-Moderate	High	Low	Low-Moderate	High	Very High
Overall Readiness	8	12	16	16	15	20	14	18	18	21
Low/Moderate/High	Low	Low-Moderate	Moderate	Moderate	Moderate	High	Moderate	Moderate-High	Moderate -High	High
Fatal Flaws	TCO Supply				Technology		GHG Impact	GHG Impact	TCO	

8. Vision for e-mobility development

8.1 As with any public strategy, the vision upon which Mongolia's e-mobility roadmap is based should be driven by the potential of the technology to contribute to public policy objectives, including but not limited to decarbonisation.

8.2 Whilst this readiness assessment identifies significant user and wider social benefits to EV transition, the strategic potential for e-mobility in Mongolia is limited in both absolute and relative terms. Decarbonisation impact is limited by the very high grid carbon intensity (now and in the medium-long term under current projections). The potential contribution of e-mobility to urban air quality is unclear given the reliance on urban CHPP for energy (and its potential expansion). At the same time, public policy priorities to address air quality and decarbonise the transport sector focus on other solutions (sustainable urban mobility, vehicle emission standards, domestic heating) which, while not simple to implement, may ultimately offer favourable co-benefits and value for money. Unlike many other countries actively promoting EVs, Mongolia does not have either an existing industrial base or ambitions to develop an EV-related industry, which limits wider economic rewards and strategic investment drivers.

8.3 While mass-scale EV transition is unlikely to be feasible or justified in the short-medium term, this study has demonstrated opportunity areas in which e-mobility can deliver clear and specific contributions to tackle public policy challenges with proportionate public sector involvement/investment. This will also provide a strong foundation for future mass EV transition, which is already well underway globally.

8.4 Mongolia's E-Mobility roadmap should seek to harness these opportunities, setting objectives to:

- **Enable a private sector led EV transition in high readiness segments,** ensuring alignment with other mobility priorities (e.g. modal shift) through a supportive policy and regulatory framework, level fiscal playing field for EV purchase, catalysing an EV charging industry, and ensuring an enabling energy sector approach.

  Actively promote the growth of high-readiness EV sectors where this can contribute to decarbonisation and/or other public policy goals (e.g. public transport improvement, growth of renewable energy in EV charging). In addition to an enabling environment, implementation of pathfinder projects in the e-bus and light commercial vehicle segments should in particular focus on developing the business models which enable long term economic and institutional feasibility.

8.5 Table 8-1 below outlines how these objectives should be applied to key vehicle segments included within the E-Mobility Roadmap.

Table 8-1: Proposed approach to supporting EV development in key segments

Segment and approach	Recommendation	Segments to take forward
Private Automobiles ENABLE	• Develop an enabling environment (e.g. charging, supply chain) for EV transition for necessary private vehicle journeys while prioritising modal shift towards sustainable transport. • Initial focus on newer vehicle segments in the short term (to 2030), with mass market models becoming more economically and technically competitive towards 2035. • Based on engagement feedback, EVs are not considered feasible for areas outside of UB in medium term (requirement to cover long distances in remote environments)	Vehicles up to 3 years upon import (new, mid-range) Vehicles over 3 years upon import (mass market).
Light commercial vehicles ENABLE & PROMOTE	• Promote further deployment of light freight vehicles (vans) for urban use • Urban mass-market taxis will become more appropriate in the medium-long term as technology improves and with governance reform of the sector.	Light commercial vehicles (vans) Taxi (mass market)
Urban buses ENABLE & PROMOTE	• Promote urban BEBs are an appropriate option only as part of wider package of operational improvements (with or without RES adoption).	Urban buses (Optimisation + Green Energy).

Bibliography

Argue, C. (2023, August 17). To what degree does temperature impact EV range? *Geotab*. https://www.geotab.com/uk/blog/ev-range/

Asian Development Bank. (2021, December 17). *Ulaanbaatar Air Quality Improvement Program and Ulaanbaatar Air Quality Improvement Program – Phase 2: Program Completion Report*. https://www.adb.org/sites/default/files/project-documents/51199/51199-001-53028-001-pcr-en.pdf

Asian Development Bank. (2023a, September 4). *Ulaanbaatar Air Quality Improvement Program – Phase 2*. https://www.adb.org/projects/53028-001/main#:~:text=ADB%20Releases%20%2460%20Million%20for,the%20Mongolian%20capital%20of%20Ulaanbaatar.

Asian Development Bank. (2023b, September 12). *ADB to support construction of road network in Western Mongolia*. https://www.adb.org/news/adb-support-construction-road-network-western-mongolia

Bayasgalan, B., & Matsumoto, T. (2017). Estimation and prediction of road traffic emissions in Ulaanbaatar. *Journal of Japan Society of Civil Engineers Ser G (Environmental Research)*, *73*(5), I_183-I_190. https://doi.org/10.2208/jscejer.73.i_183

Bayram, I. S. & Department of Electronic and Electrical Engineering, University of Strathclyde. (2021). Impacts of Electric Vehicle Charging under Cold Weather on Power Networks. In *IEEE* (pp. 1–10) [Journal-article]. https://strathprints.strath.ac.uk/79154/1/Bayram_UPEC_2021_Impacts_of_electric_vehicle_charging_under_cold_weather_on_power_networks.pdf

Car-Free Day promotes risk-free, healthy city. (2019). www.theubposts.com. https://www.theubposts.com/a/11688#:~:text=The%20annual%20Car%2DFree%20Day,the%20third%20week%20of%20May.

Castillo, V. Z., De Boer, H., Muñoz, R. M., Gernaat, D. E., Benders, R., & Van Vuuren, D. (2022). Future global electricity demand load curves. *Energy*, *258*, 124741. https://doi.org/10.1016/j.energy.2022.124741

Cecco, L. (2023, December 19). Canada to require all new cars to be zero-emission by 2035. *The Guardian*. https://www.theguardian.com/world/2023/dec/19/canada-car-emissions-automaker-electric-2035

Darkhan State Registration Department. (2023). https://www.facebook.com/photo/?fbid=306437692033437&set=basw.AboSExea67u-LyW0PyDfgnL9TPfhXHclAp75JMhj2qd-

ag3u01GsqORpmbOkoAHtOsC_4sVTf8FQ5DuxcgGI4-cA65qtu6cS4w5wa2uT6e9GJ9dzRx1vX_XDAeeKxYBEXNGmlu0hHxQeZrRrPGIm-ATHp3Y8ZQbwaK68yI4oUU2NE3H4W9zZXVfzXNOd6NOgh4voNGHNVYy7xw3C7G3lW90-8tUaqoGxrT29irlOlYwy1PVpVpkG7qWJTQXKvI7cY8VsFrEWZ20oG45aPTdHsBPsUC3ajUKcY9IxZ1Q7tnSTFc_LgOf694dmEG8gzd_3NK4&opaqueCursor=Abq2pcSG3rb8Iq04TsJouBlFi1lK18hcIRh8Novd0M_TugxIephYlFjoPq6Uqu_a9r8nmN_qIwNNw_eWrtddzU2iFfzTkZ-kE-veYzwPWf8j91i4Lyf2a_eaaaxAo0T8eqsz1vfmlhhekivKZiGjVVfcJykxcxIO7FNfnTFYX-bSsfkeXBlPGvHARuqh_GVsS9ErZ5KQ1Z5fH7hDiqSGnHZT83fw0YoSENtw2CAqflIHqCgkKShos2AfbI2wWoEAYlcgKJrz9GC-z_6b3Txn238ZSbv7Ap1TwKuDCVgBrYX4HeXh9OphmVgu_nkzxRMbwJHw-9uBtvqsaus31Dr8ODcHB23zLRDq7m6y7r3_1St-Q2HStU3tNB15MpEGa4Kc8R_tKpnEgpRHsCFRsUoXSiVoY-MOUQi9YnpEpR_cUBE0ZThpVVGXl1eo5JbaonLpjVRulMjhWSRGbqbY_8K4PAB_BhWzjlfygDEwIBwsVl28pdoGoDMZFChpJHVfo2QCZkeawdvs5-jIlOcF2Y6kTsj4QwlaxHFiwHtk8KNJuQmGXGk9edaSi7L3511aftbNp1wnpGeKPlLoD3FqIUyVtZvTP_qxEcMrZ6Aw5VSAKjBcqjIou

Development Projects : Ulaanbaatar Sustainable Urban Transport Project - P174007. (n.d.). World Bank. https://projects.worldbank.org/en/projects-operations/project-detail/P174007

Dnistran, I. (2024, January 19). Here’s why Norway hasn’t had trouble with winter EV charging. *InsideEVs*. https://insideevs.com/news/705338/norway-winter-ev-charging-no-trouble/

Editorial Staff. (2024b, February 20). *Yutong U12 e-bus underwent testing in Norway and Kazakhstan, with dedicated technologies for cold climate*. Sustainable Bus. https://www.sustainable-bus.com/electric-bus/yutong-testing-norway-cold-climate-technologies/

ElaadNL. (2024, July 4). *ELAADNL Outlooks • Projecten • ELAADNL*. https://elaad.nl/projecten/elaadnl-outlooks/

Eldev-Ochir, E. & Asian Infrastructure Research Institute. (2023). *ASSESSMENT OF URBAN MOBILITY: ULAANBAATAR*. https://www.itf-oecd.org/sites/default/files/itf-sipa_mng_dissemination_s3_p3_0.pdf

Electric Autonomy Canada. (n.d.). *Electric Autonomy Canada*. https://electricautonomy.ca/

Electric vehicles - IEA. (2023). IEA. https://www.iea.org/energy-system/transport/electric-vehicles

Elliott, D., Schwartz, M., Scott, G., Haymes, S., Heimiller, D., & George, R. (2001). *Wind Energy Resource Atlas of Mongolia*. https://doi.org/10.2172/787886

Energy Regulatory Comission. (2022). *Data gathered by ERC* [Dataset].

Energy Regulatory Commission. (2021). *Statistics on energy performance Mongolia* [Dataset].

Engel, H., Hensley, R., Knupfer, S., & Sahdev, S. (2018, August 8). *The potential impact of electric vehicles on global energy systems*. McKinsey & Company. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-potential-impact-of-electric-vehicles-on-global-energy-systems

Enkhnaranjav, T. (2022). *Right-hand drive cars are not the cause of traffic congestion*. PressReader. https://www.pressreader.com/mongolia/the-ub-post/20220912/281522229928465

EU: Light-duty: emissions. (n.d.). Transport Policy. https://www.transportpolicy.net/standard/eu-light-duty-emissions/

Getting electricity : System average interruption duration index (SAIDI) (DB16-20 methodology) | Indicator Profile | Prosperity Data360. (2021). https://prosperitydata360.worldbank.org/en/indicator/WB+DB+55

Green Climate Fund. (n.d.). *About GCF*. https://www.greenclimate.fund/about

Global EV Data Explorer – Data Tools - IEA. (2023). IEA. https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer

Hans, F., Nascimento, L., Schiefer, T., Gonzales-Zuñiga, S., Shrestha, H. B., Röser, F., Capacity Development for climate policy in the countries of South East, Eastern Europe, the South Caucasus and Central Asia, Phase III, USAir Force, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, NewClimate Institute, Ministry of Environment and Tourism of Mongolia, & Ministry of Energy of Mongolia. (2020). *The Mongolian electricity sector in the context of international climate mitigation efforts*. https://newclimate.org/sites/default/files/2020/03/Decarbonization_Pathways_Mongolia.pdf

International Bank for Reconstruction and Development. (2020). *TRANSFORMING MONGOLIAN AGRICULTURE THROUGH GROWTH, RESILIENCE, AND COMPETITIVENESS*. International Bank for Reconstruction and Development / The World Bank. https://documents1.worldbank.org/curated/en/894991596007778450/pdf/Policy-Note-for-Mongolia.pdf

International Energy Agency. (2024a). *Trends in electric cars – Global EV Outlook 2024 – Analysis - IEA*. IEA. https://www.iea.org/reports/global-ev-outlook-2024/trends-in-electric-cars

International Energy Agency. (2024b). *Trends in heavy electric vehicles – Global EV Outlook 2024 – Analysis - IEA*. IEA. https://www.iea.org/reports/global-ev-outlook-2024/trends-in-heavy-electric-vehicles

International Federation of Red Cross And Red Crescent Societies (IRFC). (2021, February 2). *Mongolia: Flash Floods - Final Report (Operation n° MDRMN012) - Mongolia*. ReliefWeb. https://reliefweb.int/report/mongolia/mongolia-flash-floods-final-report-operation-n-mdrmn012

Jaeger, J. (n.d.). *These countries are adopting electric vehicles the fastest*. World Resources Institute. https://www.wri.org/insights/countries-adopting-electric-vehicles-fastest#:~:text=China%20is%20by%20far%20the,rest%20of%20the%20world%20combined

JET. (2023). *JET*. https://www.facebook.com/p/%D0%AD%D1%80%D0%B4%D1%8D%D0%BD%D1%8D%D1%82-Jet-100064705747525/?paipv=0&eav=AfYYYuyxp9O6sz1NmNaWF1QbHC_pvOVytHUC5fOcxS2_RkuZbj4N1BCBovHuQyqN6H8&_rdr

Klesty, V. & Reuters. (2024). *Tesla extends lead in Norway sales, EVs take 82% market share*. https://www.reuters.com/business/autos-transportation/tesla-extends-lead-norway-evs-take-record-82-market-share-2024-01-02/

Kyung-don, J. (2013, January 20). *Taxi industry slugs it out over which fuel to use*. https://koreajoongangdaily.joins.com/2013/01/20/socialAffairs/Taxi-industry-slugs-it-out-over-which-fuel-to-use/2965784.html

Lkhagva, J. & Energy Regulatory Commission. (2019). *RENEWABLE ENERGY POLICY IN MONGOLIA Feed-in tariff to Auction*. https://events.development.asia/system/files/materials/2019/09/201909-renewable-energy-policy-mongolia-feed-tariff-auction-en-and-cn.pdf

McMahon, J. (2019, May 30). More electric cars mean fewer mechanical jobs. *Forbes*. https://www.forbes.com/sites/jeffmcmahon/2019/05/30/more-electric-cars-fewer-manufacturing-jobs/

Ministry of Energy. (2017). *Energy sector of Mongolia, Policies and challenges*. https://eneken.ieej.or.jp/data/7391.pdf

Ministry of Energy. (2021a). *Mongolia's transmission map*.

Ministry of Energy. (2021b). *Ulaanbaatar's distribution map*.

Model E12 – Yutong Eurobus Scandinavian AB. (n.d.). https://yutongeurobus.se/products/model-e12-2/#tab-id-2

Mongolia: Provinces, cities & urban settlements - population statistics, maps, charts, weather and web information. (n.d.). https://www.citypopulation.de/en/mongolia/cities/

Mongolia's clean Energy transition: a pathway to sustainable and inclusive development. (n.d.). UNDP. https://www.undp.org/mongolia/blog/mongolias-clean-energy-transition-pathway-sustainable-and-inclusive-development

Mongolian Ministry of Foreign Affairs. (2024). *Vehicle Data* [Dataset].

Motoaki, Y., Yi, W., & Salisbury, S. (2018). Empirical analysis of electric vehicle fast charging under cold temperatures. *Energy Policy*, *122*, 162–168. https://doi.org/10.1016/j.enpol.2018.07.036

MRTD. (2024). *Increase the use of electric cars, electricity on the establishment of car charging centers*. Mongolian Ministry of Road and Transport Development.

MSM. (2024). *Mongolian Customs data* [Dataset].

MUB PTD. (2023). *Response to study team's data request*.

Munkhzul, A. (2020). *Air pollution reportedly reduced by 49.6 percent*. MONTSAME News Agency. https://montsame.mn/en/read/211671

National Automotive Vehicle Centre. (2023). *Vehicle Import Data* [Dataset].

National Statistics Office. (2024). *NUMBER OF REGISTERED VEHICLES , by age, by region, aimags and the Capital, by year* [Dataset]. https://www.1212.mn/en/statistic/statcate/573059/table-view/DT_NSO_1200_013V4

Ochirjamaa, B. (2020). *Global Motors averts plan to install 20 EV charger*. https://www.pressreader.com/mongolia/the-ub-post/20200608/281565177991064

Odontuya, A. (2016). *Common traffic rules of UB*. gogo.mn. https://mongolia.gogo.mn/r/152456

OECD. (2019). Taxing Energy Use 2019: Country Note – Korea. In *Taxing Energy Use 2019*. https://www.oecd.org/content/dam/oecd/en/topics/policy-sub-issues/carbon-pricing-and-energy-taxes/taxing-energy-use-korea.pdf

People's Daily Online. (2024). *China accelerates pace of second-hand car exports - People's Daily Online*. http://en.people.cn/n3/2024/0229/c98649-20138843.html#:~:text=Since%20the%20launch%20of%20a,about%2015%2C000%20units%20in%202021.

Pmanifold, A. (n.d.). *All EV segments are Green: A myth or reality? – Pmanifold*. https://www.pmanifold.com/blogs/all-ev-segments-are-green-a-myth-or-reality/

Real-world usage of plug-in hybrid vehicles in Europe: A 2022 update on fuel consumption, electric driving, and CO2 emissions - International Council on Clean Transportation. (2022, November 8). International Council on Clean Transportation. https://theicct.org/publication/real-world-phev-use-jun22/

Segway-Ninebot. (n.d.). *MAX G2 e*. United Kingdom - English. https://uk-en.segway.com/products/ninebot-kickscooter-max-g2e-powered-by-segway

South Korea: electric vehicles market share 2023 | Statista. (2024, March 28). Statista. https://www.statista.com/statistics/1099571/south-korea-electric-vehicles-market-share/

State Great Hural. (n.d.). VISION-2050" LONG-TERM DEVELOPMENT POLICY OF MONGOLIA. In *Annex 1 to Resolution 52, 2020*. https://cabinet.gov.mn/wp-content/uploads/2050_VISION_LONG-TERM-DEVELOPMENT-POLICY.pdf

Statista. (2023, April 24). *Household electricity prices APAC 2022, by country*. https://www.statista.com/statistics/1378957/apac-household-electricity-prices-by-country/

Statista. (2024, August 1). *Electricity sector carbon intensity APAC 2022, by country*. https://www.statista.com/statistics/1299708/apac-carbon-intensity-power-sector-by-country/

The causal effect of wrong-hand drive vehicles on road safety. (2017). In *CEPIE Working Paper* [Working Paper]. https://www.econstor.eu/bitstream/10419/170527/1/1001186524.pdf

The Economist. (2023, April 16). How Japan is losing the global electric-vehicle race. *The Economist*. https://www.economist.com/asia/2023/04/16/how-japan-is-losing-the-global-electric-vehicle-race

The World Bank. (2021). Ulaanbaatar Sustainable Urban Transport Project (P174007). In *Project Information Document (PID)* (Report No. PIDA31171; Appraisal Stage, pp. 1–17). https://documents1.worldbank.org/curated/en/708891618997774951/pdf/Project-Information-Document-Ulaanbaatar-Sustainable-Urban-Transport-Project-P174007.pdf

The World Bank Group. (2019). *Global Solar Atlas 2.0*. https://globalsolaratlas.info/map?c=46.156922,104.010315,8&m=site

Tips for using an EV in cold weather. (n.d.). Connected Kerb. https://connectedkerb.com/stories-and-reports/tips-for-using-an-ev-in-cold-weather/

¿Transmilenio por la séptima?: verdades y mentiras del corredor verde de Claudia López. (2020, November 24). *RTVC*. https://www.canalinstitucional.tv/noticias/corredor-verde-septima-claudia-lopez-transmilenio

Trends in electric light-duty vehicles – Global EV Outlook 2023 – Analysis - IEA. (2023). IEA. https://www.iea.org/reports/global-ev-outlook-2023/trends-in-electric-light-duty-vehicles

Ulaanbaatar Projects. (n.d.). https://www.fareast.mobi/en/projects/Ulaanbaatar

Ulan Bator Climate, Weather by month, Average Temperature (Mongolia) - Weather Spark. (n.d.). Weather Spark. https://weatherspark.com/y/117604/Average-Weather-in-Ulan-Bator-Mongolia-Year-Round

Under-Frequency load shedding in Mongolia: Simulation assessment considering inertia scenarios. (2020, June 1). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/document/9152584

U.S. DEPARTMENT of STATE — BUREAU of CONSULAR AFFAIRS. (n.d.). https://travel.state.gov/content/travel/en/international-travel/International-Travel-Country-Information-Pages/Mongolia.html

Why are electric truck prices so high? (n.d.). Resources for the Future. https://www.resources.org/common-resources/why-are-electric-truck-prices-so-high/

Wikipedia contributors. (2024, May 24). *Darkhan (city)*. Wikipedia. https://en.wikipedia.org/wiki/Darkhan_(city)

Wikiwand - Trolleybuses in Ulaanbaatar. (n.d.). Wikiwand. https://www.wikiwand.com/en/Trolleybuses_in_Ulan_Bator

Witchalls. (2018). *Power poverty: the new paradigm for social and economic inequality of electric vehicles*. https://www.stantec.com/en/ideas/power-poverty-the-new-paradigm-for-social-and-economic-inequality-of-electric-vehicles

Zenobē. (2022, November 2). *£0.5m per 100 buses per year: the impact of e-bus driver performance on operational costs - Zenobē*. https://www.zenobe.com/insights-and-guides/0-5m-per-100-buses-per-year-the-impact-of-e-bus-driver-performance-on-operational-costs/

Б.Анхтуяа. (2022, June 21). *Reckless teens riding electric dirt bikes cause crashes on roads - News.MN*. News.MN - the Source of News. https://news.mn/en/797627/

Appendices

Appendix 1: E-bus charging devices in UB

Appendix 1: 240kw e-bus charging device specification

Electrical input	Input size	400 V +/- 15%, 3-phase, 400 A (max)
	Number of phases and wires	3-phase / L1, L2, L3, PE
	Voltage factor	>0.98
	Current/THD	<5%
	Efficiency	>95%
Electrical output	Output power	240 kW
	Output voltage	200 V – 750 V DC
Protection	Protection	Current surge, voltage drop, surge, residual current, surge protection, short circuit, overheat, ground fault
User panel & controls	Management screen	10.1-inch touch screen
	Language selection	English (can be changed upon request)
	Charging mode	Can be changed for a period of time, on request, by use, by payment
	Size of the charger	2 nozzles (GB/T)
	Payment method	Card or PayPal
Connectivity	Network mode	Ethernet (standard); Wi-Fi, 4G (optional)
Environmental	Operating temperature	-45°C to 55°C (decreasing performance above 55°C)
	Storage temperature	-50°C to 70°C
	Moisture	<95% humidity, non-condensing
	Altitude	Up to 2,000 m (6,000 feet)
Mechanical	Electrical component protection	IP54 (An IP54 rating means that your product will be protected against contamination from limited amounts of dust and other particles. Additionally, you can be confident that it will be protected from water sprays from all directions.)
	Relief	Air defence
	Dimensions (W*D*H)	1200 mm*750 mm*1750 mm
	Weight	450 kg
Regulation	Certification / Adjustment	GB/T 20234, GB/T 27930

Appendix 2: TCO model input assumptions

Appendix 2: Vehicle segment-wise inputs for TCO analysis

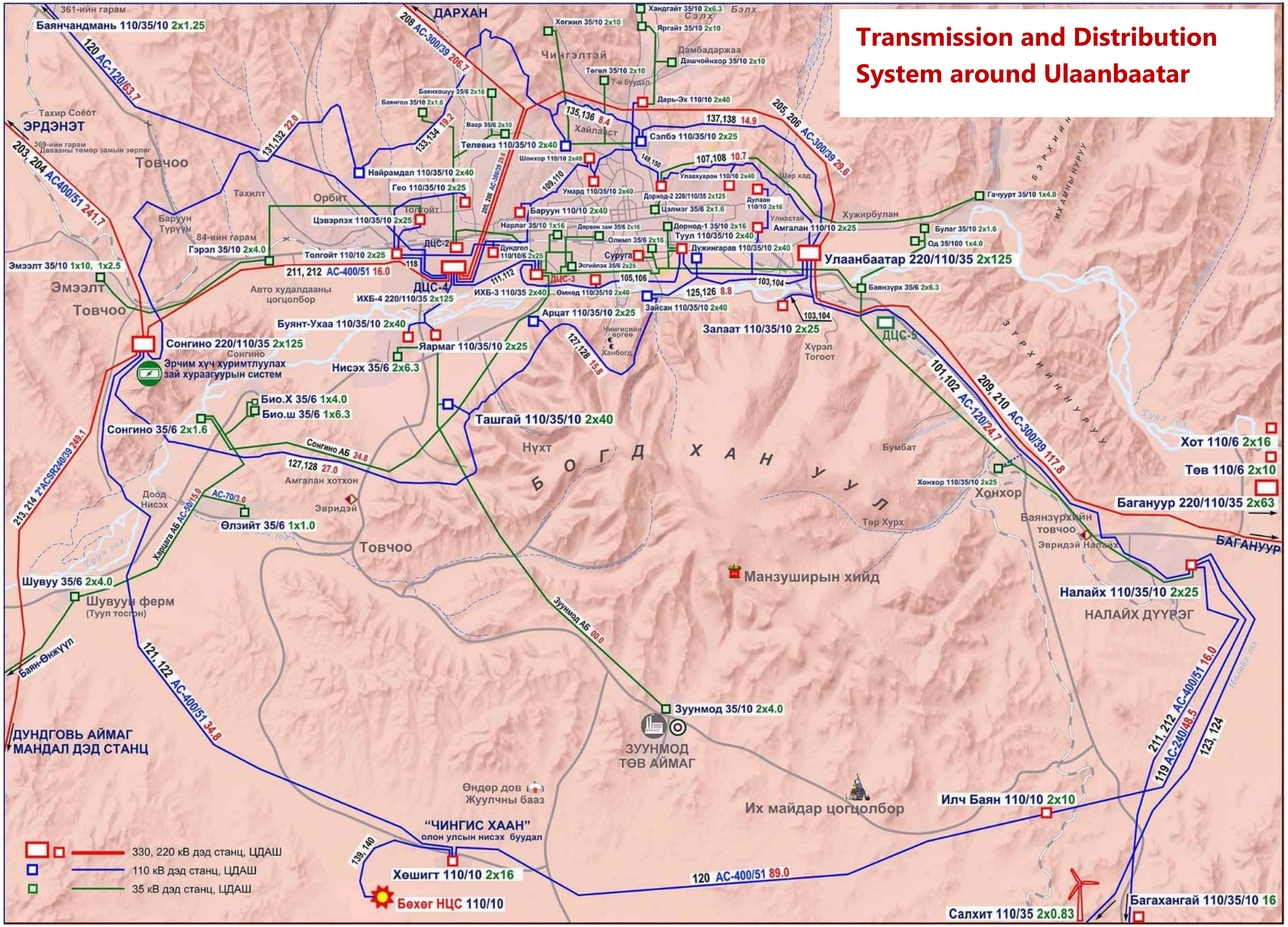
Vehicle segment	Input	ICEV	Hybrid	EV
Mass Market Car (used) And Commercial Taxi (Car)	Model	Toyota Corolla	Toyota Prius 20	Nissan Leaf (with 40 kWh battery capacity)
	Purchase cost (USD)	7,600 Custom Duty: 225 Excise Duty: 2,000 VAT: 673	7,390 Vehicle cost: 3,350 Custom Duty: 168 Excise Duty: 1,697 VAT: 521 Battery cost: 1,452	19,532 Vehicle cost: 10,800 Custom Duty: 540 Excise Duty: 232 VAT: 1,157 Battery cost: 6,600
	Avg. vehicle efficiency	0.1099 Litres/km	0.0566 Litres/km	0.2296 kWh/km
	Charger size and life	--	--	6.6 kW; 7 yrs
Mid- Range Market Car	Model	Lexus NX 300h AZ10	Toyota Harrier XU60	BAIC EU5 (with 48 kWh battery capacity)
	Purchase cost (USD)	18,800 Excise Duty: 3,000 VAT: 1,691 Custom Duty: 663	17,350 Vehicle Cost: 12,900 Excise Duty: 725 VAT: 1,427 Custom Duty: 645 Battery cost:1,452	24,100 Vehicle Cost: 12,600 Excise Duty: 109 VAT: 1,460 Custom Duty: 1,890 Battery Cost: 7,970
	Avg. vehicle efficiency	0.1099 Litres/km	0.0566 Litres/km	0.1616 kWh/km
	Charger size and life	--	--	6.6 kW; 10 years

Notes: *ICEV and Hybrid vehicles are assumed to be non-operational 1 day per week due to circulation restriction. Interest rate fixed at 10% for all vehicle segments and powertrains.

Vehicle segment	Inputs	ICE	EV
New Car segment And Premium Taxi Car segment	Model	Mercedes Benz C class	BYD Han (With 88 kWh battery capacity)
	Purchase cost (USD)	52,000 Excise Duty: 500 VAT: 4670 Custom Duty: 2200	69,000 Vehicle cost: 42,850 Excise Duty: 109 VAT: 4939 Custom Duty: 6428 Battery cost: 14,520
	Avg. vehicle efficiency	0.06 Litres/km	0.2296 kWh/km
	Avg. kms run per day	50 Km	50
	Operational days per year	283	330
	Vehicle life	15 years	15 years
	Charger Size (kWh)	-	6.6
Light freight Vehicle	Model	Ford Transit Van	BYD T3 (With 149 kWh battery capacity)
	Purchase cost (USD)	43,300 Excise Duty: 500 VAT: 4599 Custom Duty: 2166	45,300 Vehicle cost: 28,900 Excise Duty: 109 VAT: 3334 Custom Duty: 4335 Battery cost: 8,250
	Avg. vehicle efficiency	0.06 Litres/km	0.2296 kWh/km
	Avg. kms run per day	180 km	180 km
	Operational days per year	283	330
	Vehicle life	15 years	15 years
	Charger Size (kWh)	-	6.6
Intraurban bus	Model	Yutong ZK6108HGH Diesel	Yutong E12 (With 374 kWh battery capacity)
	Purchase cost (USD)	89,000	2,70,000 Vehicle cost:180,000 Battery cost:90,000
	Avg. vehicle efficiency	0.35 Litres/km	1.26 kWh/km
	Avg. kms run per day	246 km	220 km
	Operational days per year	310	310
	Vehicle life	12 years	12 years
	Charger Size (kWh)	-	240
Minibus	Model	Mercedes-Benz Sprinter	Altas Novus Ecoline
	Purchase cost (USD)	1,42,000 Excise Duty: 500 VAT: 12,800 Custom Duty: 6,095	2,25,500 Vehicle cost:170,000 Excise Duty: 109 VAT: 3334 Custom Duty: 4335 Battery cost: 27,830
	Avg. vehicle efficiency	0.13 Litres/km	0.33 kWh/km
	Avg. kms run per day	180 km	180 km
	Operational days per year	283	310
	Vehicle life	15 years	15 years
	Charger Size (kWh)	-	120

Appendix 3 – Map of Mongolia’s energy system

Appendix 4- Transmission and distribution grid around Ulaanbaatar



Appendix 5: Renewable energy potential

Wind Energy

8.6 Mongolia's wind power potential is estimated at 1,100 GW, with significant resources in the south-east. The distribution of this potential is indicated Figure A1 per energy system[124]. From here it is evident that CES and the SES has the highest potential for wind generation and WES having the lowest. Current installed wind capacity is around 320 MW. In context of EVs, wind energy will play a significant role in further lowering the carbon intensity of EVs on a grid-wide scale.

Table A1 Wind potential per energy system

Energy system	Wind potential (% of total)
CES	66%
SES	18%
WES	3%
AUES	7%
EES	7%

Challenges special to Mongolia include:

- Complex grid connections for wind generation located in remote areas. In some regions access to the transmission grid is limited.
- Constructability and operational challenges due to harsh climate conditions in the winter. Requiring special selection of wind turbine technology.

Solar Energy

8.7 The installed solar capacity in Mongolia, as of 2022, is 145 MW, with most of the central-southern region ranging from around 0.7 – 8 kWh / m^2[125]. The Central region of Mongolia receives around 2,800 hours of annual sunshine, ranking in the top 25% of countries for practical solar potential[126], while other more developed EV countries are

[124] Based on analysis found in "Wind Energy Resource Atlas of Mongolia, NREL (2021)"
Elliott, D., Schwartz, M., Scott, G., Haymes, S., Heimiller, D., & George, R. (2001). *Wind Energy Resource Atlas of Mongolia*. https://doi.org/10.2172/787886
[125] Assuming 1 kWp takes up 6.25 m^2 of PV-module area.
[126] According to The World Bank Group. (2019). Global Solar Atlas 2.0

within the last 20%. In the context of EVs, apart from the grid scale benefits, PV integration into charging stations can serve as a profitable solution for local decarbonization (as shown in Figure A2).

Figure A1 Mongolia's wind electric potential[124]

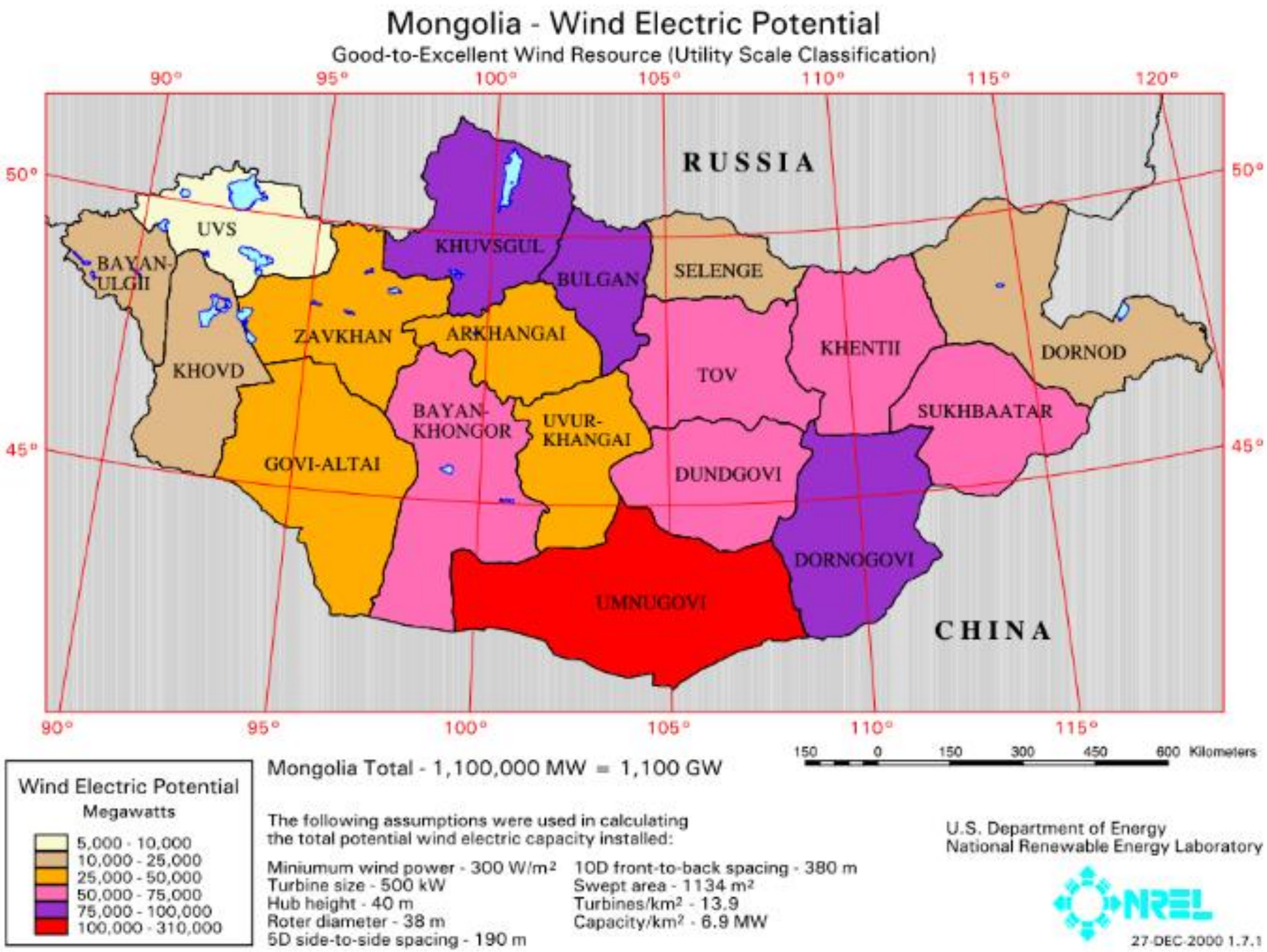
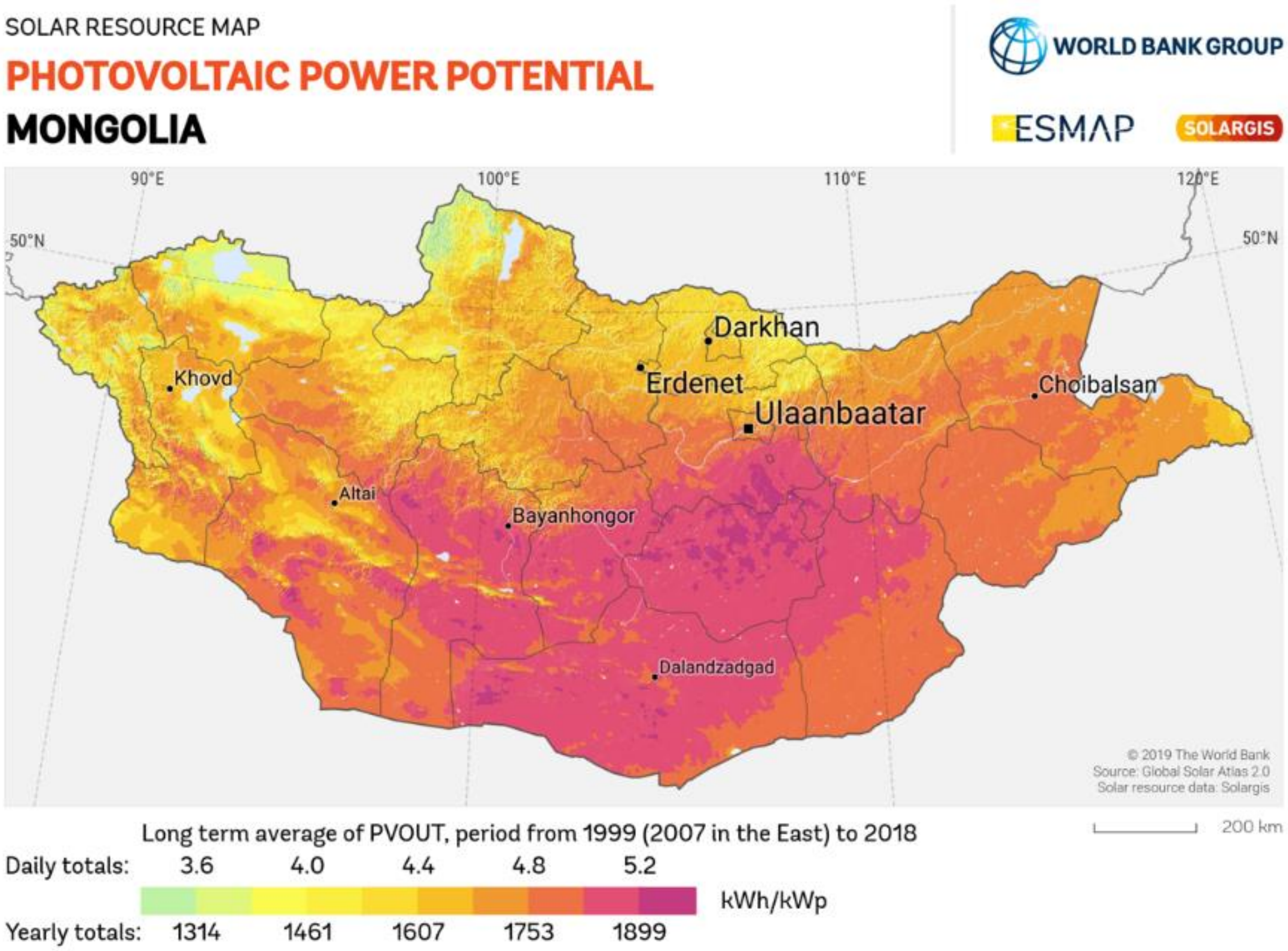


Figure A2 Solar PV power potential in Mongolia[127]



[127] The World Bank Group. (2019). *Global Solar Atlas 2.0*. https://globalsolaratlas.info/map?c=46.156922,104.010315,8&m=site

8.8 Main challenges include:

- Reduced efficiency due to harsh climate conditions (winter).
- Reduced efficiency due to dust accumulation. Mongolia has desert terrains and significant air pollutants in the capital city (high vehicle number and several power plants located in the city).
- Complex grid connections for PV generation located in remote areas. In some regions access to the transmission grid is limited.

Hydro-electric Energy

8.9 The theoretical potential of hydro generation in Mongolia is estimated around 6.2 GW with around 1 GW having been identified[128], as shown in Figure A3. This potential is mostly concentrated in the north-western regions. In context of EVs, hydro generation will serve in further lowering the carbon intensity of EVs on a grid-wide scale.

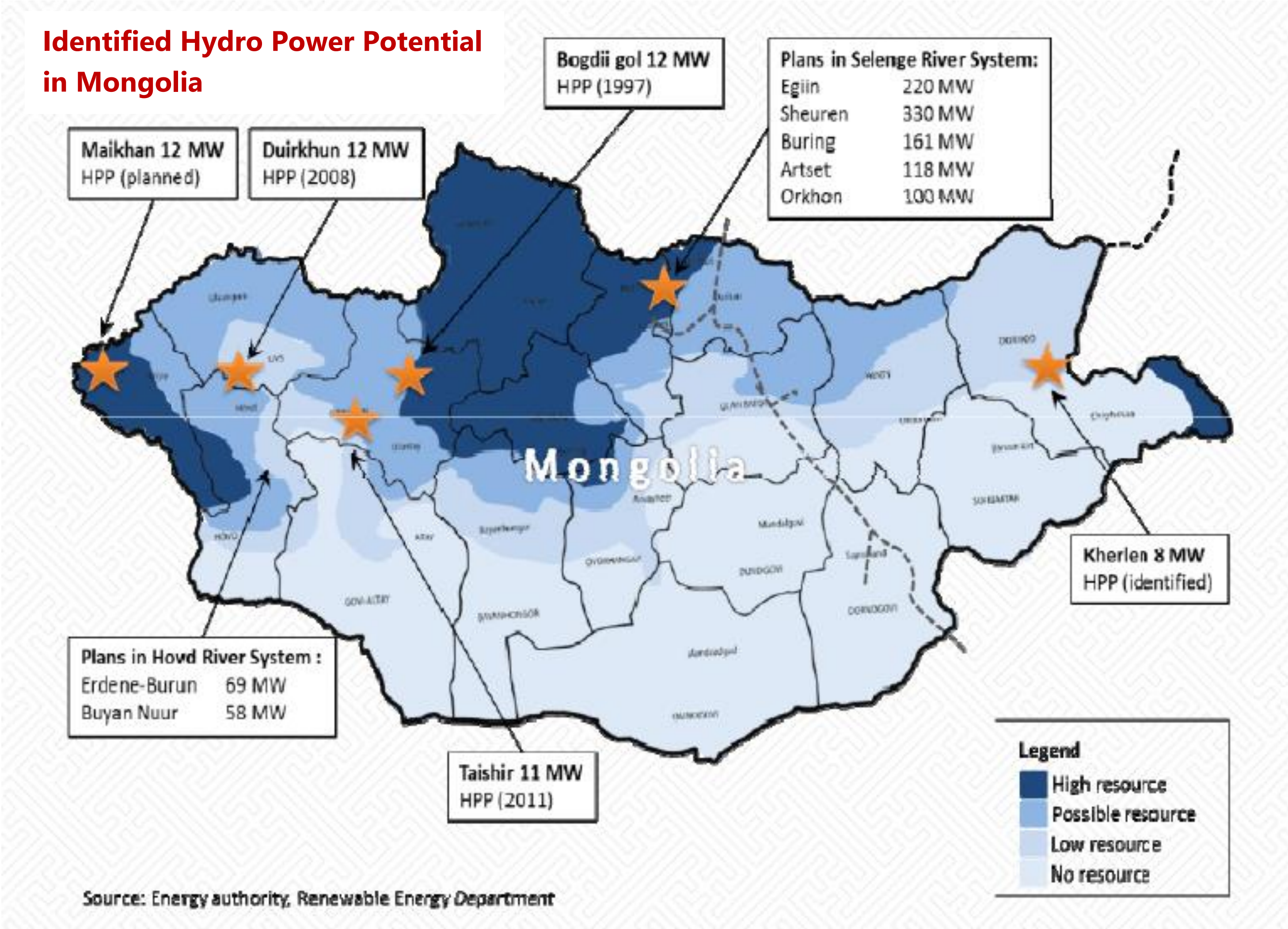
8.10 Hydropower capacity in Mongolia reached 123 MW by 2023.

8.11 Main challenges consist of:

- Environmental impacts of creating reservoirs behind dams
- Resource and capital intensive to realize in Mongolia's rugged terrain and harsh climate conditions.
- Water resource concerns due to river's flowing across international borders

[128] Ministry of Energy. (2017). *Energy sector of Mongolia, Policies and challenges*. https://eneken.ieej.or.jp/data/7391.pdf

Figure A3 Mongolia's identified hydro generation potential



Nuclear Energy

8.12 Mongolia possesses tremendous mineral resources, with a particular focus on its potential in the nuclear energy sector. The nation's uranium reserves are predominantly concentrated in the eastern region, as indicated on Figure A4. At present, approximately 70 percent of Mongolia's total land area has undergone exploration for uranium reserves. Preliminary assessments suggest that Mongolia possesses an impressive 1.5 million tons of uranium resources, a figure that would position it as the world's 10th largest repository of uranium.

Figure A4: Mongolia's Uranium resources

8.13 In a bid to reduce its dependence on fossil fuels and Russian energy imports, Mongolia is currently exploring the feasibility of establishing a nuclear power plant in collaboration with international players. One such initiative on going in 2023 involves discussions and the potential development of a nuclear power plant in collaboration with France.

8.14 Nonetheless, the prospects for nuclear power in Mongolia are clouded by public resistance and scepticism. This opposition is rooted in the collective memory of Soviet-era nuclear tests and lingering recollections of the Fukushima nuclear catastrophe, which continue to influence public sentiment and perception regarding nuclear energy within the country.

Energy Storage Systems

8.15 Energy storage systems play a crucial role in mitigating the challenges associated with curtailed renewable energy and smoothing out fluctuations resulting from the intermittent nature of renewable sources. Presently, there is an active initiative, supported by funding from the Asian Development Bank (ADB), in Western Ulaanbaatar that is poised to become Mongolia's first utility-scale energy storage system. This project consists of an 80 MW/200 MWh BESS with the potential to provide approximately 58.5 GWh of clean peaking power on an annual basis. It is anticipated to commence operations by end of 2023. In context of EVs, energy storage systems will play a significant role in further lowering the carbon intensity of EVs both on grid-wide scale and local scale.

Appendix 6: Catalytic converters and filters used in Diesel and Gasoline ICE vehicles

Figure A5: Catalytic converter and filters used in Diesel and Gasoline ICE

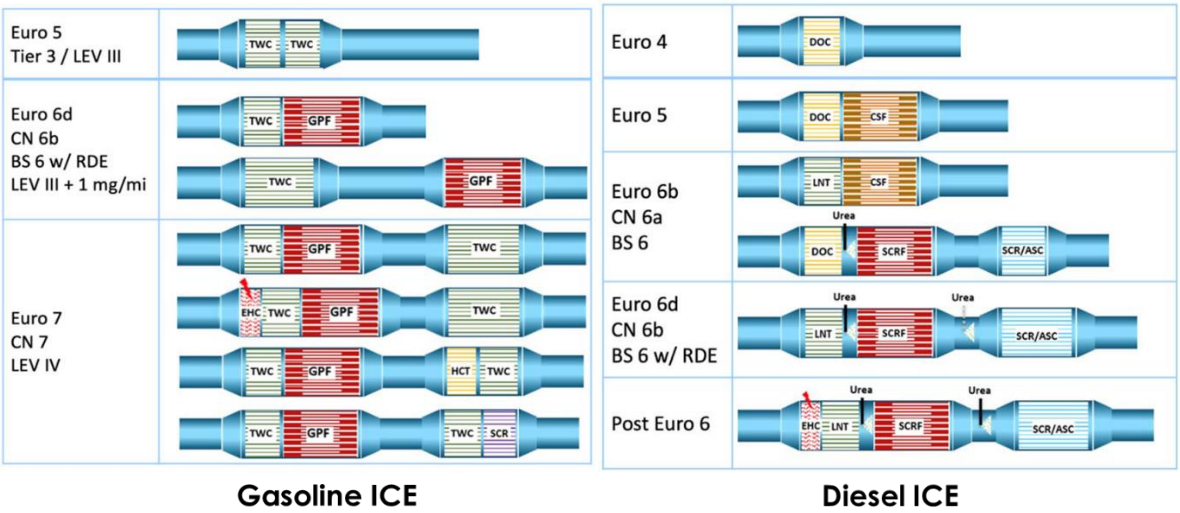


Table A1: Catalytic Converter and Particulate Matter Filters Brief

Catalytic converter / filter Type	Description
1. Diesel Oxidation Catalyst (DOC)	Converts harmful gases such as carbon monoxide (CO) and unburned hydrocarbons (HC) into less harmful emissions. Primarily used in diesel engines to reduce emissions.
2. Catalyzed Soot Filter (CSF)	Captures and burns particulate matter (soot) generated by diesel engines, reducing harmful emissions. Primarily used in Diesel engine exhaust systems.
3. Lean NOx Trap (LNT)	Reduces nitrogen oxides (NOx) emissions by trapping and converting them into nitrogen gas under lean-burning conditions. Primary application is reducing NOx emissions in gasoline and diesel engines.
4. Selective Catalytic Reduction on Filter (SCRF)	Combines particulate matter filtration with selective catalytic reduction to reduce both soot and NOx emissions. Used in modern diesel engines to meet stringent emission standards.
5. Selective Catalytic Reduction (SCR)	Reduces NOx emissions by using a chemical reductant (usually urea) to convert NOx into nitrogen and water in diesel and some gasoline engines.
6. Ammonia Slip Catalyst (ASC)	Captures and converts excess ammonia (NH3) that may escape from the SCR system, preventing

	ammonia emissions. Used in conjunction with SCR systems in diesel engines.
7. Electrically Heated Catalyst (EHC)	Rapidly heats the catalytic converter to operating temperature during cold starts, reducing emissions during warm-up. Aids in improving emission control in internal combustion engines, particularly in cold climates.
8. Three-Way Catalytic Converter (TWC)	Converts carbon monoxide (CO), unburned hydrocarbons (HC), and nitrogen oxides (NOx) into carbon dioxide (CO_2), water (H_2O), and nitrogen (N_2). Primarily used in Gasoline engine exhaust systems to reduce multiple pollutants.
9. Gasoline Particulate Filter (GPF)	Captures and reduces particulate matter (soot and tiny particles) emitted from gasoline engines. Used in gasoline-powered vehicles to meet stricter emissions regulations, especially in Europe.

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