



Decarbonization of Public city Transport in Ulaanbaatar, Mongolia

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CONTENTS:

INTRODUCTION: 3

**CURRENT STATUS OF PUBLIC CITY
TRANSPORT IN ULAANBAATAR 4**

**PROJECTS AND MEASURES ARE BEING
IMPLEMENTED
11**

**SUMMARY SHEETS OF DECARBONIZING
OF PUBLIC CITY TRANSPORT
20**

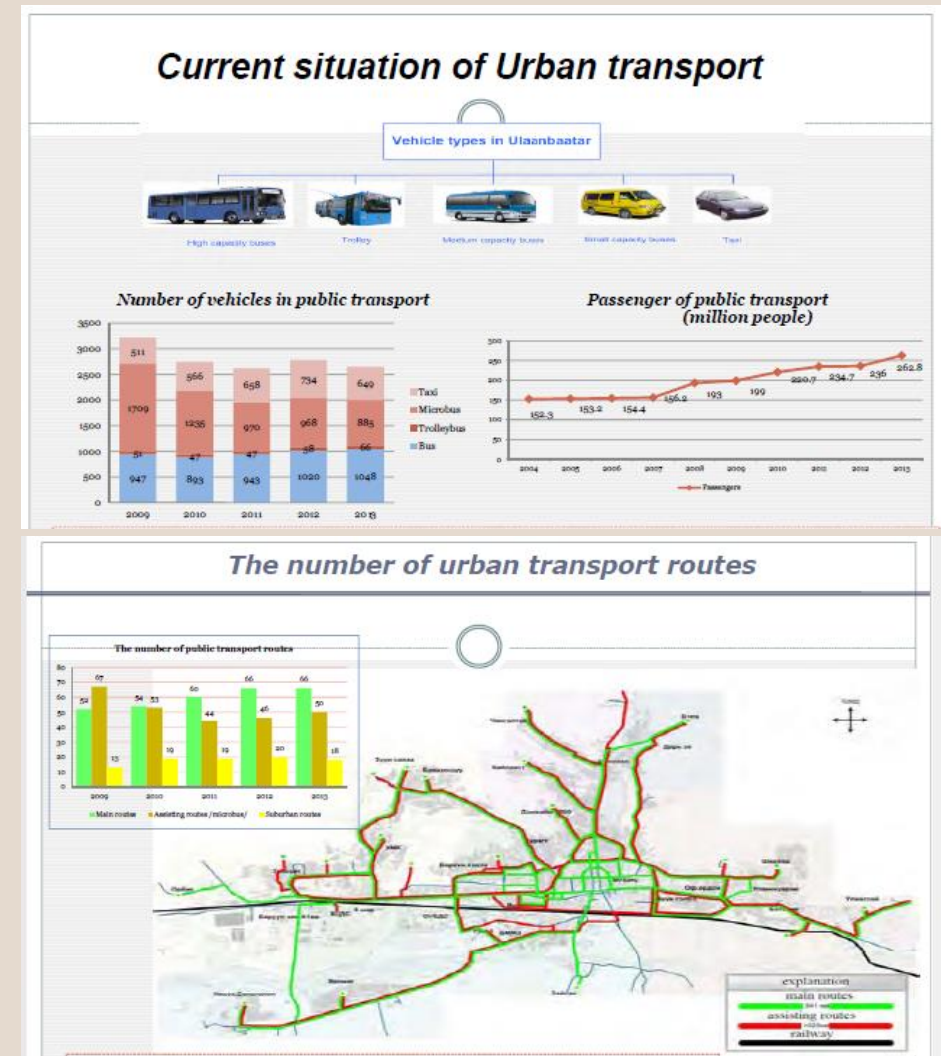
CONCLUSION 26

Introduction

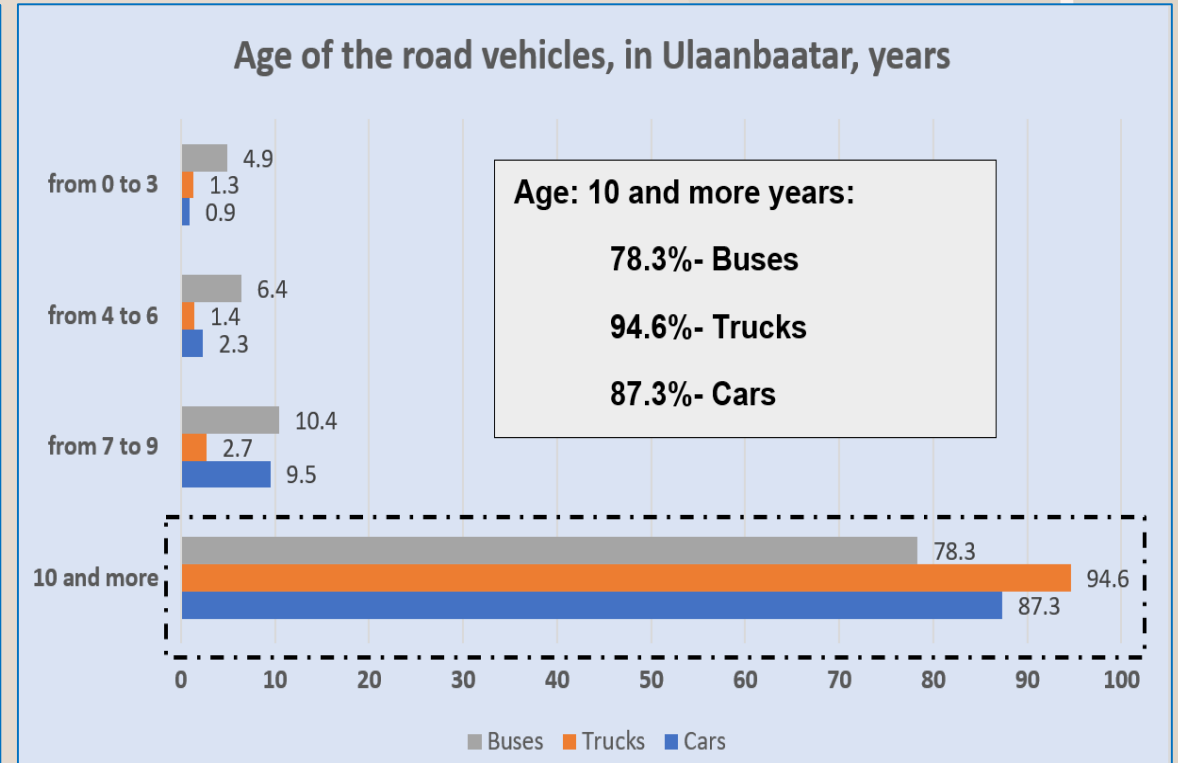
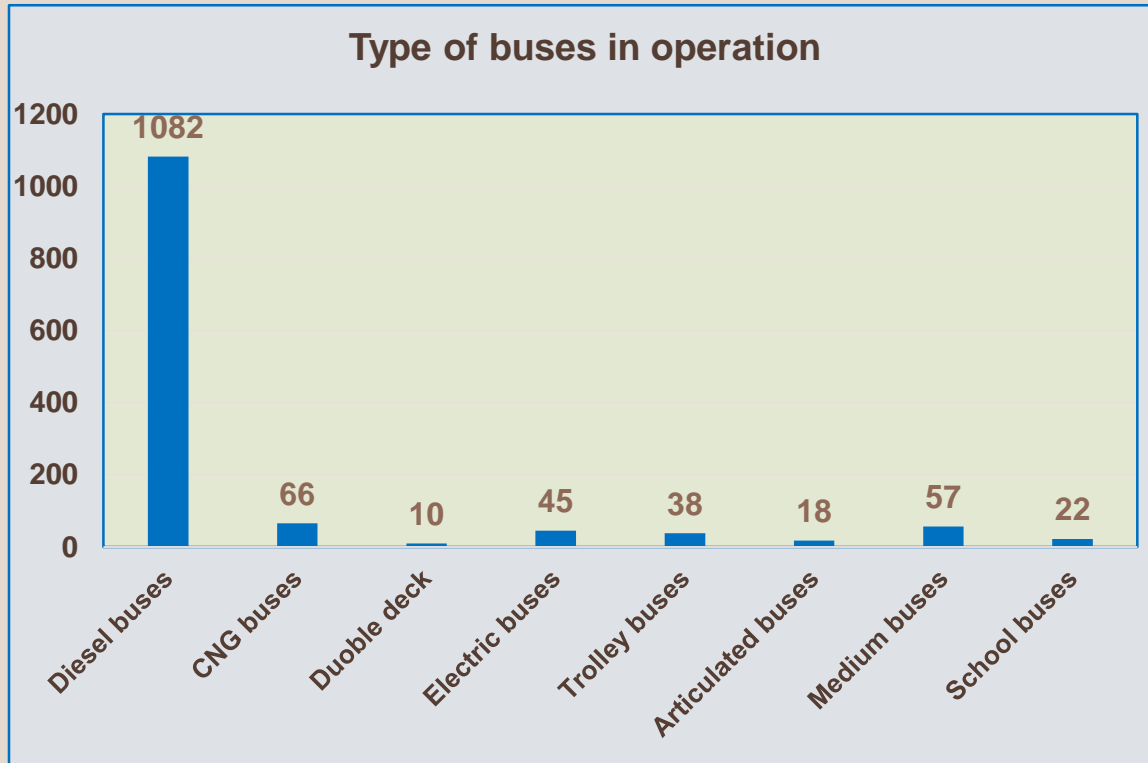
- Now 1.6 million out of 3.4 million population of Mongolia (47%) is concentrated in Ulaanbaatar city.
- Inhabitants of Ulaanbaatar are facing with **air pollution** and **heavy traffic congestion**: every road user or road vehicle driver wastes 2.5 hours for waiting due to congestion a day; average traffic speed in main streets is only 8-12 km/h;
- Decarbonization policy and strategies in Ulaanbaatar city are reflected in the following policy documents such as: “Vision of Mongolia-2050”, “Ulaanbaatar Development Master Plan up to 2040” and other policy documents. For example, “Vision of Mongolia-2050 says: ***Objective 6.4. Develop a low-carbon, productive and inclusive green economy and contribute to international efforts to mitigate climate change.***
- There are several project proposals on introducing New Public transport modes, initiated by the Government of Mongolia and International organizations such as World Bank, Asian Development Bank, Japanese JICA, South Korean KOIKA and others (Feasibility studies and project proposals on introducing BRT, LRT, METRO and etc.)
- Some technical measures were tested. For example, installation of "DPF" (Diesel particulate filter) filters in the diesel buses used in the capital's public transport services within the framework of the "Non-Project Grant" was tested and implemented by the Government of Japan.

Current status of Public transport in Ulaanbaatar

- Currently, 19 bus operators serve in 105 routes with 953 heavy duty buses for 523 thousand passengers a day.

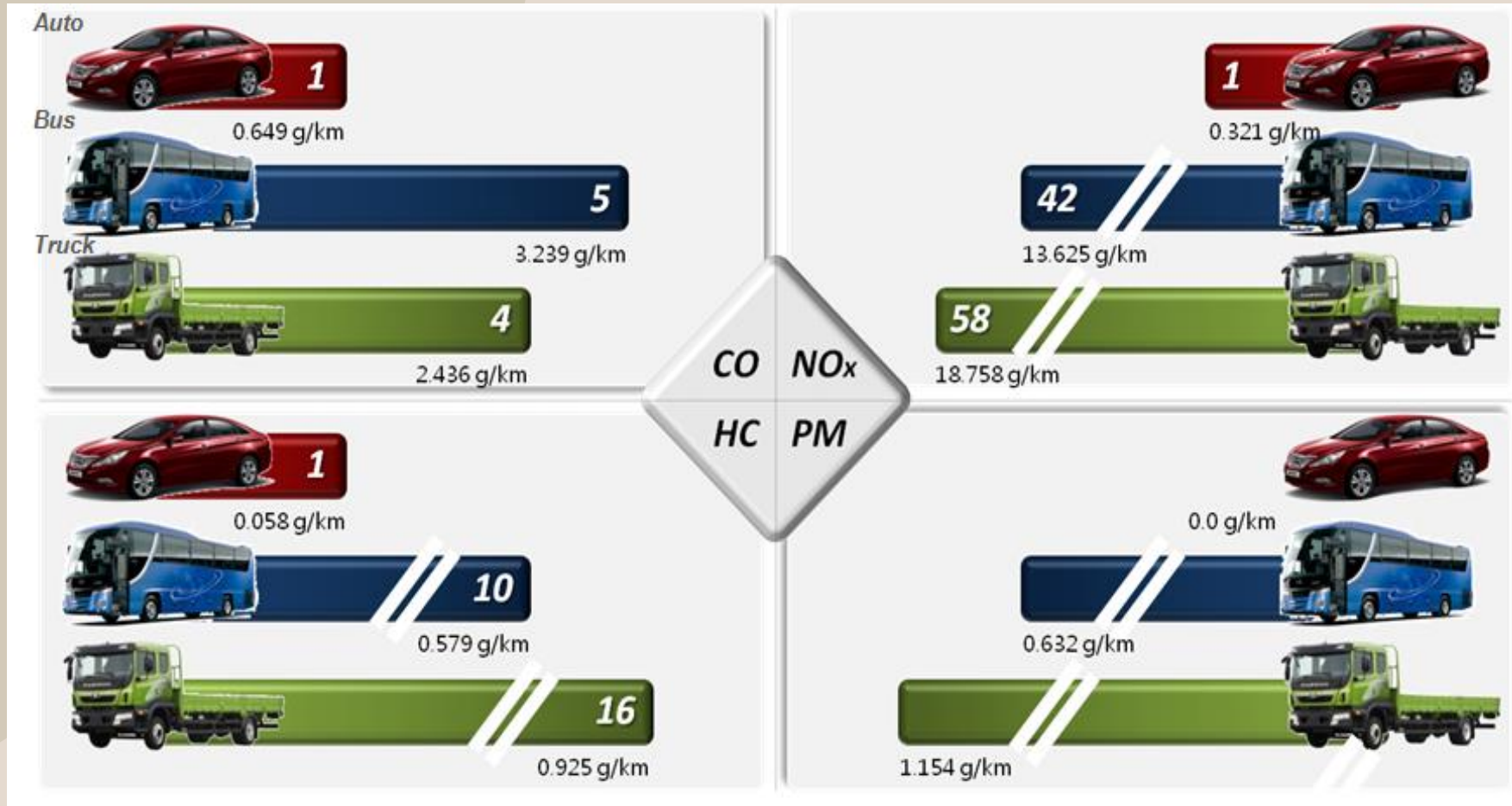


Current status of Public city transport in Ulaanbaatar, Mongolia



Why public transport is essential in Decarbonization?

South Korea (Source: KDI, 2008)



Emission Factors of Air Pollutants from a Diesel Bus

Air Pollutant	Vehicle Age	Equation of Emission Factor ² (g/km)
CO	More than 12 years old	$Y = 86.438 \times V^{-0.7893}$
	More than 8, less than 11 years old	$Y = 49.565 \times V^{-0.6738}$
	Less than 7 years old	$Y = 49.565 \times V^{-0.6738}$
VOC	More than 12 years old	$Y = 13.59 \times V^{0.6682}$
	Less than 11 years old	$Y = 10.158 \times V^{-0.7177}$
NO _x	More than 12 years old	$Y = 79.381 \times V^{-0.8906}$
	More than 10, less than 11 years old	$Y = 56.241 \times V^{-0.4175}$
	More than 8, less than 9 years old	$Y = 46.015 \times V^{-0.4175}$
	Less than 7 years old	$Y = 30.677 \times V^{-0.4175}$
PM	More than 12 years old	$Y = 6.17 \times V^{-0.5844}$
	More than 10, less than 11 years old	$Y = 2.5012 \times V^{-0.5939}$
	More than 8, less than 9 years old	$Y = 1.3896 \times V^{-0.5939}$
	Less than 7 years old	$Y = 0.8337 \times V^{-0.5939}$

<Table> Emission Factors of Air Pollutants from a CNG Bus

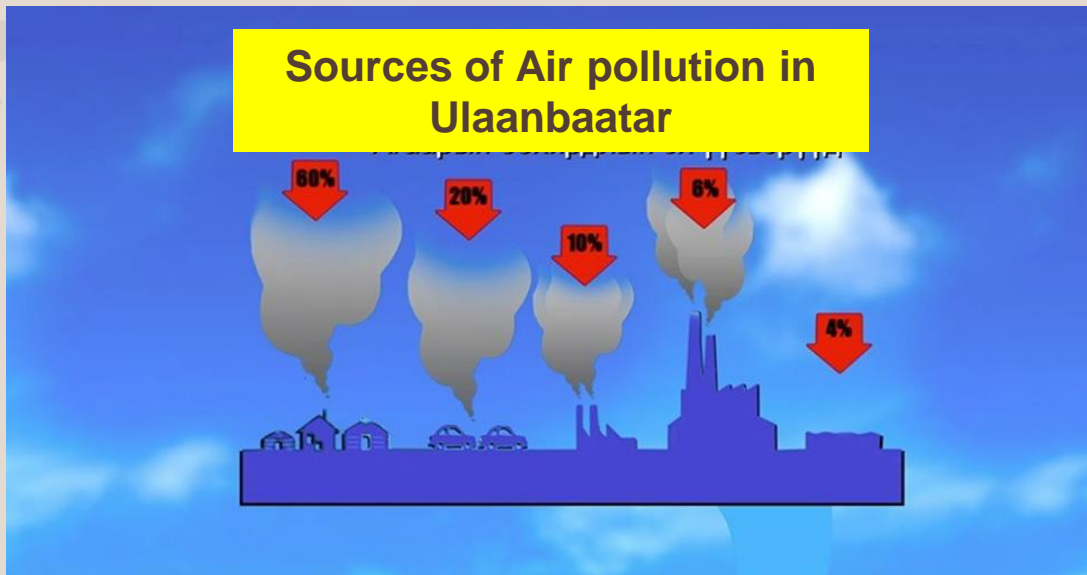
Air Pollutant ¹	Vehicle Age	Equation of Emission Factor ² (g/km)
CO	Less than 13 years old	$Y = 18.238 \times V^{-0.3787}$
NO _x	Less than 13 years old	$Y = 8.6972 \times e^{(-0.0134V)}$
VOC	Less than 13 years old	$Y = 8.0544 \times e^{(-0.01746V)}$

Note: 1) No PM is emitted from CNG buses.

2) V=vehicle speed (km/h), Y=emission factor (g/km)

Source: Korea National Institute of Environmental Research, "Manual for Calculation of Air pollutant Emission", Korean Ministry of Environment, 2007, p.200.

Sources of Air pollution and Targets



Years	2022	2030	2050
Percentage of exhaust gas from Road vehicles in total air pollution in Ulaanbaatar	20%	5%	0

Criteria	Unit	Basic level	Target level		
			2025	2030	2050
Annual average concentration of PM2.5 particles in the air of Ulaanbaatar city	mkg/ M3	64	40	25	0
Annual average concentration of PM10 particles in the air of Ulaanbaatar city	mkg/ M3	141	88	50	0

National standards:

Applicable National Standards on Road vehicle emission:

- 1. Technical requirements for road vehicles, MNS 4598-2011
- 2. Petrol engine vehicles – maximum acceptable level and measuring methods of exhaust emissions. MNS 5013-2009
- **3. Diesel Engine vehicles- Maximum acceptable level and measurement of opacity, MNS 5014-2009**
- 4. Guidelines for carrying out vehicle inspection. General requirements. MNS 5011-2003
- 5. Vehicle inspection Stations. Classification and General Requirements. MNS 5024- 2001.

The Maximum acceptable level of carbon monoxide in the petrol engine exhaust gases

Type of Automobiles	Crankshaft speed frequency	The Maximum acceptable level of carbon monoxide in the petrol engine exhaust gases, %	The Maximum acceptable level of hydrocarbon in the petrol engine exhaust gases, Ppm (million ⁻¹)
Automobiles with Petrol engine, gross weight over 3.5 tones	R pm-min	2.0	800
	Rpm- max	1.5	
Automobiles with Petrol engine, gross weight less than 3.5 tones	R pm-min	1.5	500
	Rpm- max	1.0	
Automobiles with injectors and catalizators for exhaust gases	R pm-min	0.5	250
	Rpm- max	0.3	

The level of Opacity in the exhaust gases of diesel engine vehicle

Type of Automobiles	Maximum acceptable level of Opacity in exhaust gases, %
Cars and trucks with gross weight less than 3.5 tones	35.0
Cars and trucks with gross weight over 3.5 tones	40.0

"VISION 2050"- LONG TERM DEVELOPMENT POLICY OF MONGOLIA



TRANSPORT 2030

LOW-CARBON, PRODUCTIVE AND INCLUSIVE GREEN DEVELOPMENT

Objective 6.4. Develop a low-carbon, productive and inclusive green economy and contribute to international efforts to mitigate climate change.

Results to be achieved:

2. Reduce greenhouse gas emissions and increase carbon absorption in the energy, agriculture, construction, transportation, industry, and waste sectors.

Actions to be taken within the scope of the objectives:

6.4.1. Eco-friendly, economical use and efficient advanced green technologies will be supported by economic incentives.

6.4.4. Adopt eco-friendly advanced techniques and technologies to reduce pollution and waste, save resources, and support clean production and economical consumption with economic incentives.

6.4.9. Strengthen and digitize the capacity of sectors to measure, calculate, inventory, estimate and report greenhouse gas emissions.

TRANSPORT 2050

LOW-CARBON, PRODUCTIVE AND INCLUSIVE GREEN DEVELOPMENT

Objective 6.4. Develop a low-carbon, productive and inclusive green economy and contribute to international efforts to mitigate climate change.

Results to be achieved:

5. Implement comprehensive waste management, introduce zero-waste technology in the construction and road transport sectors, completely recycle and reuse waste.

Actions to be taken within the scope of the objectives:

6.4.18. Creation and development of an electronic system for registration, movement control, registration and information of toxic and dangerous substances.

6.4.21. Environmentally friendly disposal and recycling of solid waste from the construction, road, and transportation sectors will be supported and developed.

PROJECTS AND MEASURES ARE BEING IMPLEMENTED

Years	Natural gas				Electric				Hybrid			
	Car	Truck	Bus	Total	Car	Truck	Bus	Total	Car	Truck	Bus	Total
2021	14,450	165	181	14,796	281	12	96	189	210,364	91	5	210,466
2022- imported	65	4	3	72	15	0	0	15	5,925	0	0	5,925

- As of October 2022, there were 585 electric vehicles in the vehicle registration system of Mongolia.
- Private sector enterprises are charging electric vehicles at 25 stations with a capacity of 20-60 kW in Ulaanbaatar and 10 points in local areas.

PUBLIC-PRIVATE PARTNERSHIP in construction of Electrical charging facilities

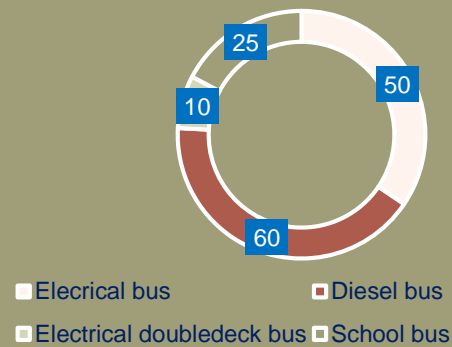
1. When the number of Heavy duty electric buses reaches 300 in 2025, 11 chargers charging 46 heavy duty buses in 3 locations will be added to 100 charging stations in 25 locations to charge 3-5 buses at a time.
2. If the number of cars with electric sources is increased to 30,000 in 2030, the number of normal, medium, and heavy duty chargers for charging the vehicles will be increased 40 times from the current 25, and the number of charging stations will be increased to 1,000 units.
3. The infrastructure of charging facilities for the use of electric buses in public transport services will be established in cooperation with the private sector with the participation of the state.
4. Make a decision to gradually build a point with a normal electric vehicle charging facility for large shopping malls, public and private enterprises with parking spaces for more than 50 vehicles, promote and increase the use of electric vehicles.



Renewal of Bus fleet of Ulaanbaatar



Renewal of bus fleet, 2022



Limitations for electrical buses:

- ✓ Shortage of electrical power supply in Ulaanbaatar to establish charging stations;
- ✓ High price of electrical buses compared with diesel buses (2 times higher)
- ✓ Operational difficulty in harsh winter conditions and battery liquidation issues.

Urban public transport modes

Urban Public Transportation Consists of a variety of Modes, such as:

- **Urban Buses:**

- Heavy duty buses
- Bus rapid transit (BRT)
- Guided bus
- Public light bus
- Shuttle bus
- Transit bus
- Trolleybus
- Express bus

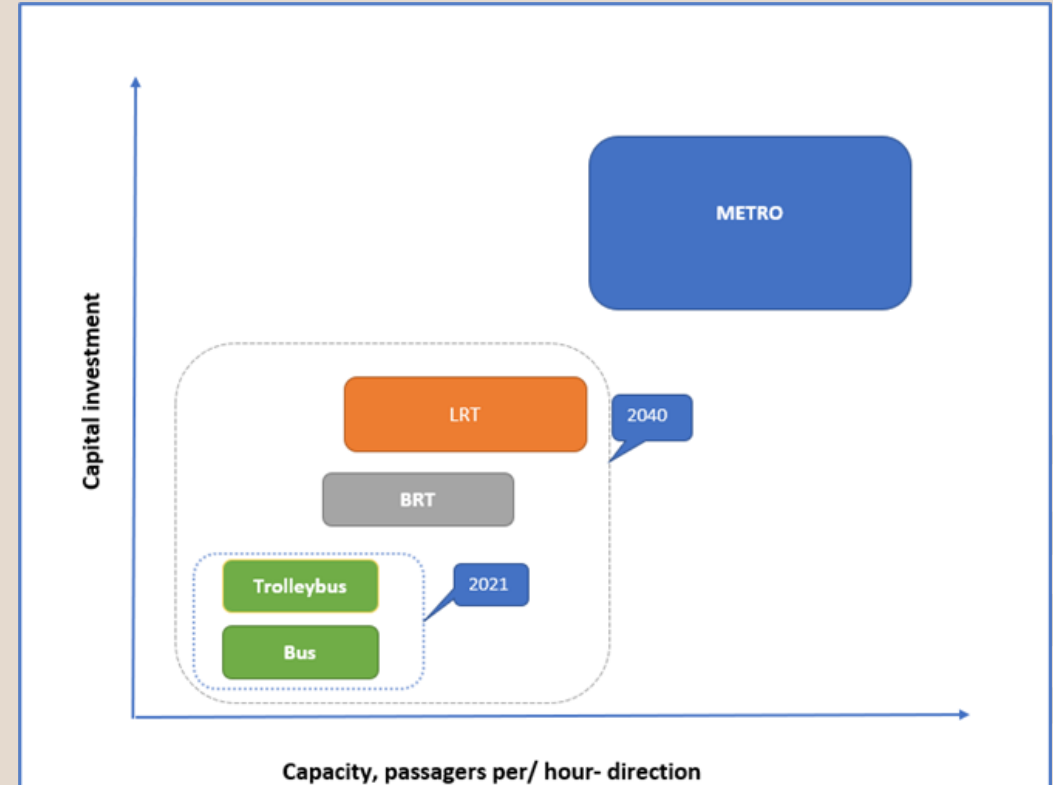
- **Urban rail transit**

- Commuter rail
- **Metro (MRT)**
- Rubber-tired metro
- Light rail (LRT)
- Tram-train
- Tram

- Monorail

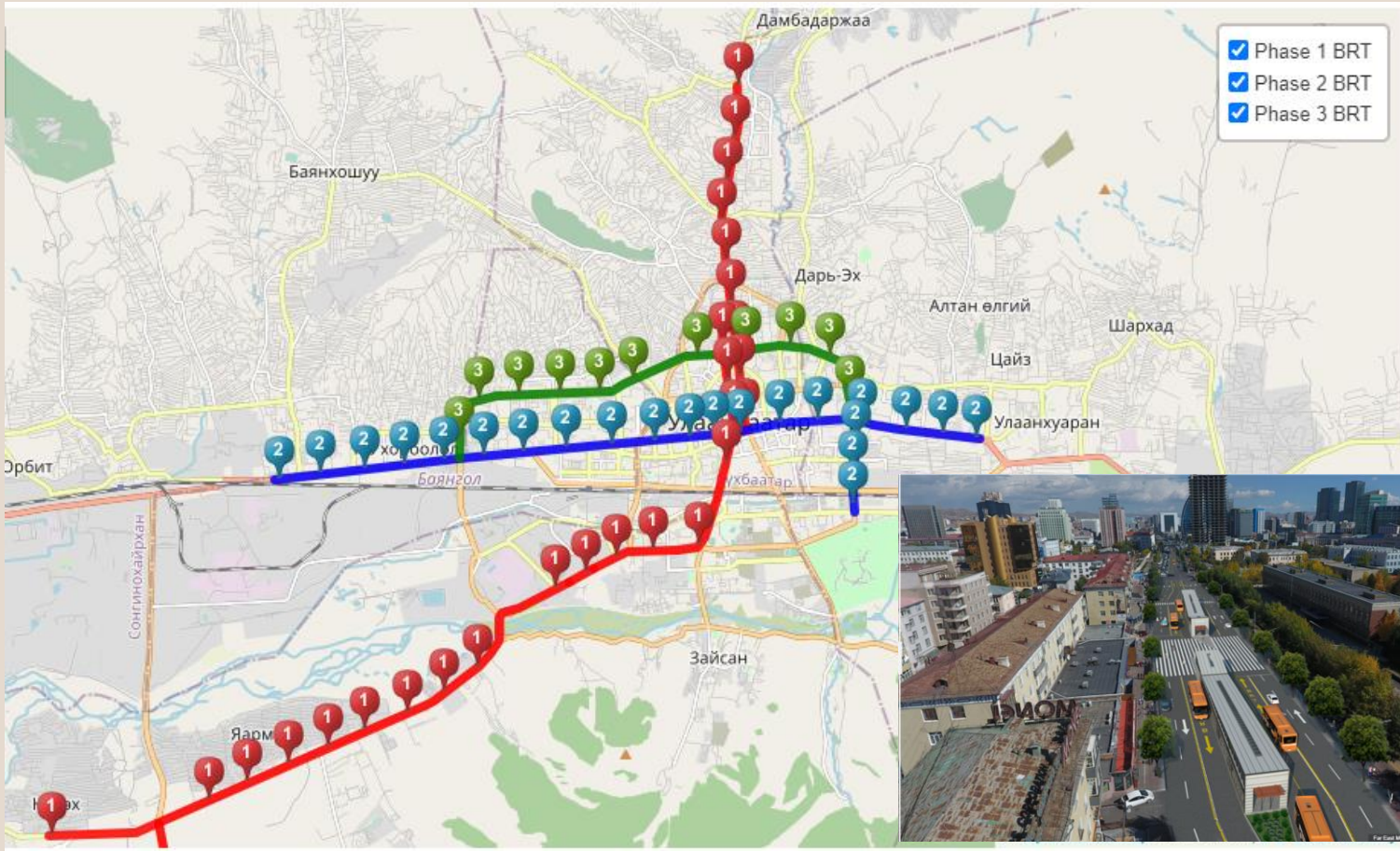
- Cable cars

- Taxi



	Efficiency	Accessibility	Sustainability	Reliability	Safety	Environment
Bus	✓	✓✓	✓	✓	✓	x
Trolleybus	✓	✓✓	✓	✓	✓	✓✓
LRT	✓✓	✓	✓✓	✓✓	✓	✓✓
MRT	✓✓	✓	✓✓	✓✓	✓✓	✓✓

BRT project in Ulaanbaatar (44.9 km)



Planned BRT project

❖ Multi-tranche Financing by ADB - \$ 217.4 million

- ✓ Phase 1 = \$ 59.9 million
- ✓ Phase 2 = \$ 78.0 million
- ✓ Phase 3 = \$ 78.0 million

❖ Project components

- ✓ Package-A. BRT Line-1 Project
- ✓ Package-B. BRT Fleet Expansion Project
- ✓ Package-C. Smart Bus Project (IC-card ticketing system, automatic bus location system)

Planned BRT project

❖ Phase 1:

- ✓ BRT Infrastructure & Vehicles (34 units)
- ✓ Electric wires, feeder cables & substations

❖ Phase 2:

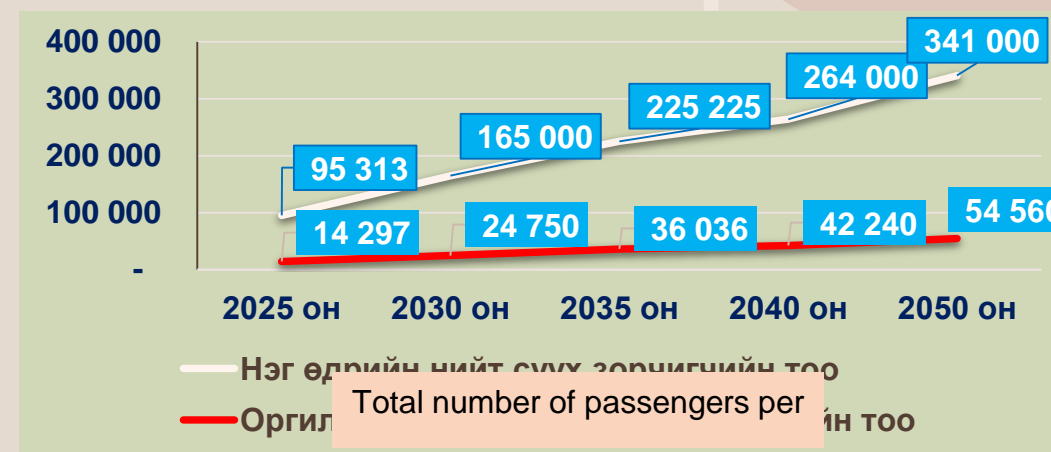
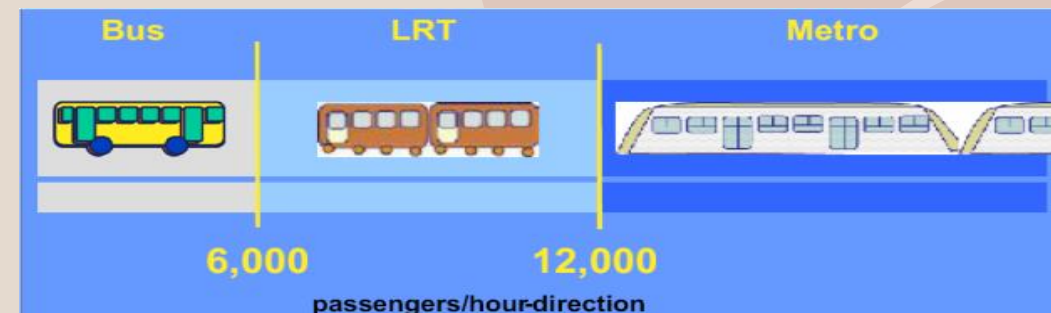
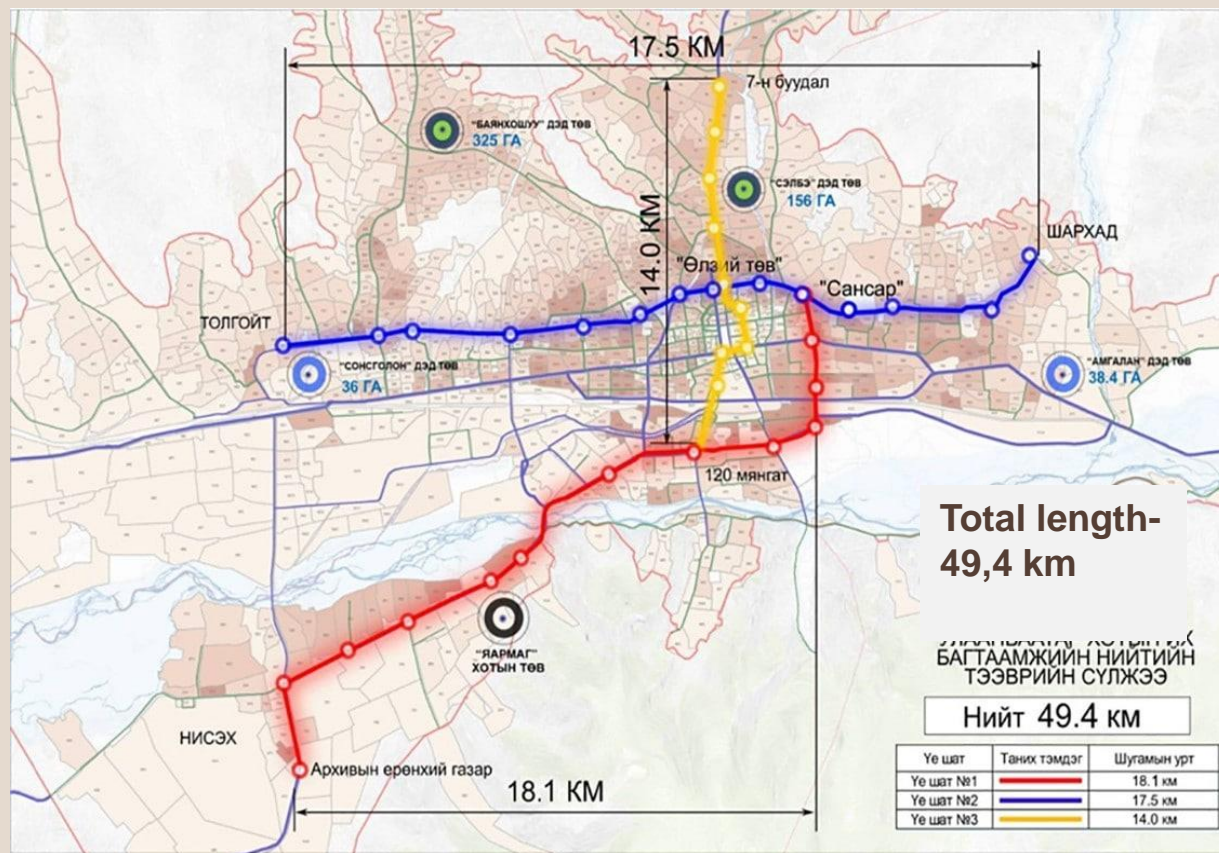
- ✓ Bus depots
- ✓ BRT Fleet Expansion (up to 53 units)

❖ Phase 3:

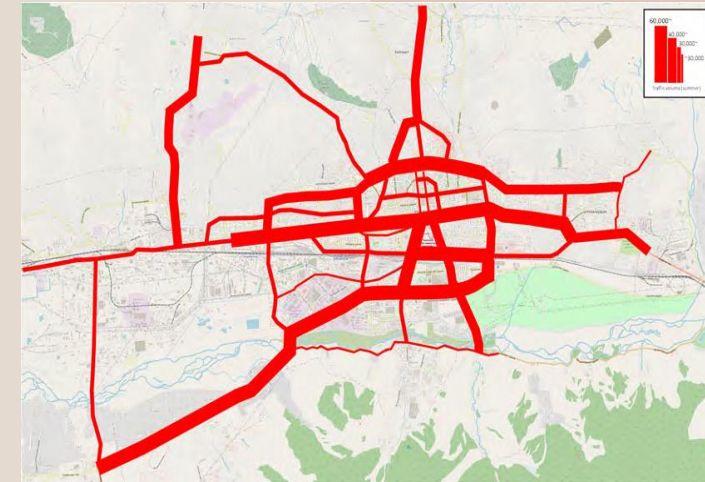
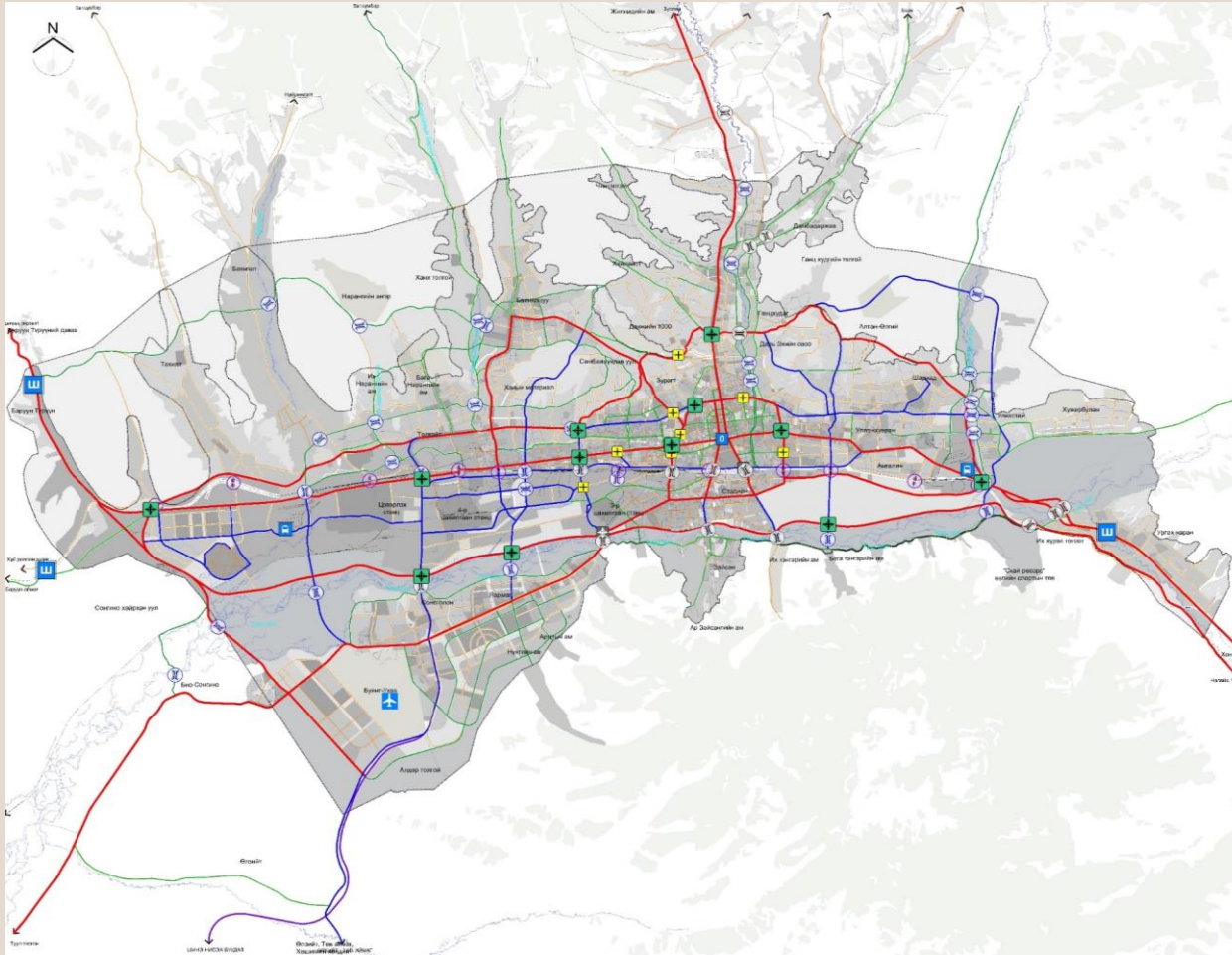
- ✓ Further expansion of BRT system






LRT project

LRT 3 lines with 49.4 km will carry 43.6% of the passenger turnover and average public transport speed will reach up to 30 km/h.



Road network development in Ulaanbaatar



Marking	Categories	Length /km/ 2020	Length /km/ 2040	Growth /km/
	Main road of Category 1	96.4	284.0	187.6
	Main road of Category 2	55.1	118.3	63.2
	Access road of Category 1	112.1	320.8	207.7
	Access road of Category 2	134.8	447.7	312.9
	Road in residential area	455	568.0	113.0
Total		853.4	1738.8	885.4

Green transport

Definition

- A mode of transportation that can reduce energy consumption and carbon dioxide emissions:
 - ❑ Low carb emissions
 - ❑ Optimal use of energy
 - ❑ Low-carbon transportation systems – environmentally friendly, energy-efficient and low-carbon transportation of people and cargo.



Bicycle - Clean vehicles



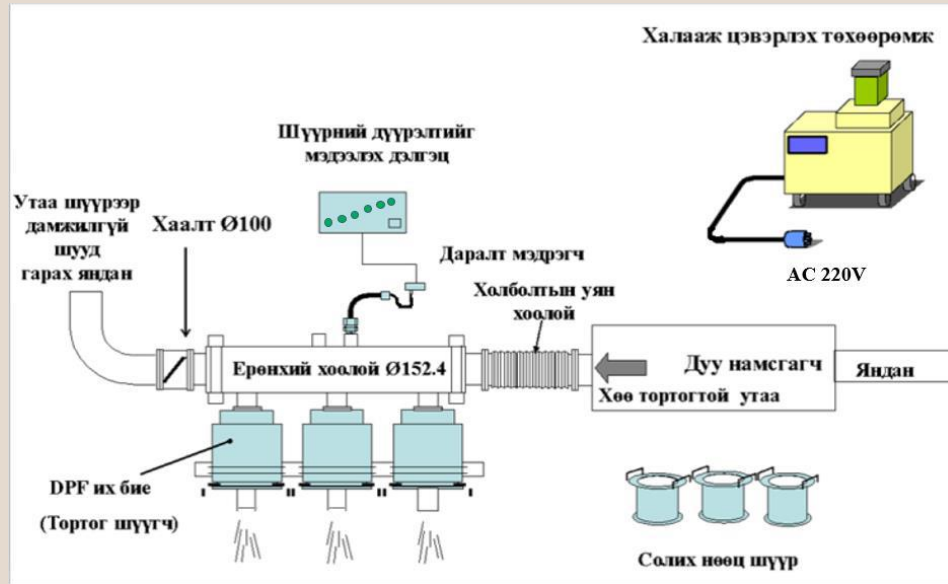
Walking - Pollution-free travel



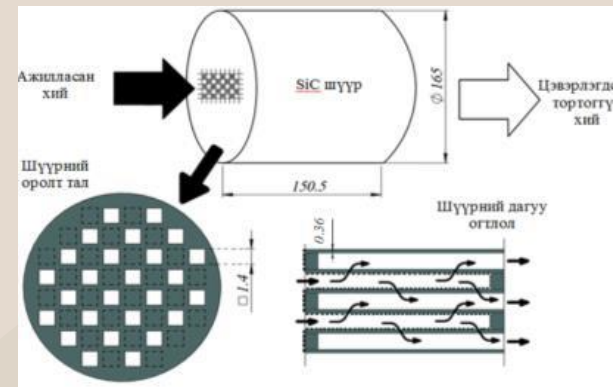
How cities should be designed

DPF- Diesel particulate filter

Installation scheme



Working principle and Cleaning of filters

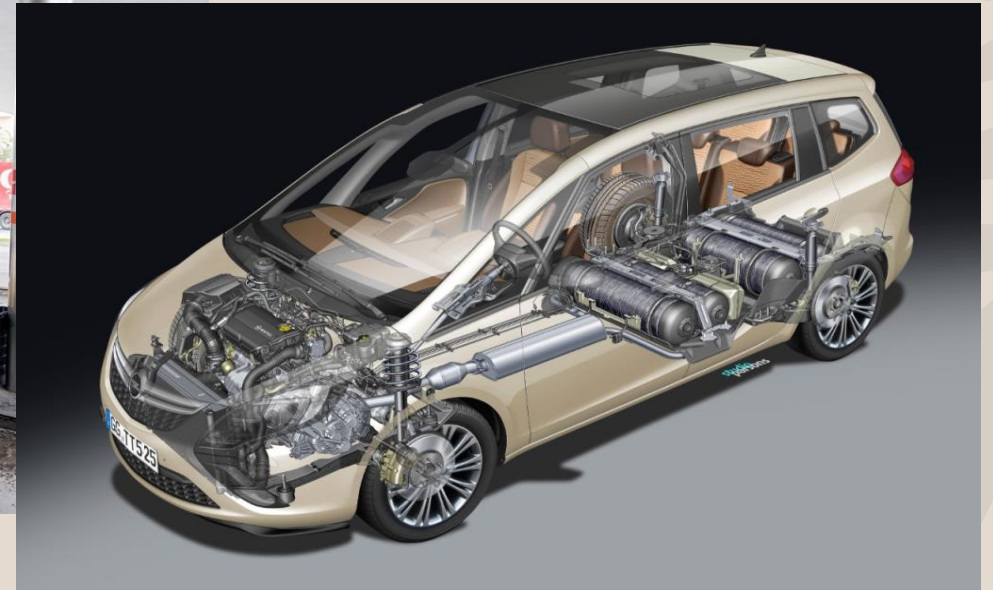


Issues:

- High cost
- Cleaning after work

Mongolia's Standards

- Rule of technical operation of compressor station for charging automobiles with natural gas.
- Road vehicles — Vehicle using compressed natural gas (CNG) and/or liquefied natural gas (LNG). General requirements, terms and definitions.



Summary sheets of decarbonizing of public city transportation

Group of Decarbonizing measures for the Public city transportation in Ulaanbaatar:

- Vehicle technology development (Improvement of vehicle fleet structure)
- Infrastructure expansion
- Public transport promotion
- Shared modes promotion and restriction measures
- Pricing and other measures.

Please see following Summary sheets for each group.

Vehicle technology development (improvement of the vehicle fleet structure) :

Name of Measures	Description of the quantified objective	Base value for 2020	Target level of implementation (2030)	Target level of implementation (2050)	
Technology sales targets for the <u>car</u> fleet	Shares of the different vehicle technologies in private car sales/registrations. (in %)	Gasoline	46% (stock)		
		Gasoline-hybrid	15%	20%	30%
		Diesel	27%		
		Diesel-hybrid	9%		
		LPG/CNG	2%	5%	10%
		Hydrogen	-		
		Hydrogen-hybrid	-		
		Electric	0.04%	30-50% -> 20% (sales)	40-80%-> 40% (sales)
Technology stock targets for the <u>bus</u> fleet	Shares of the different vehicle technologies in bus fleet. (in %)	Gasoline	-		
		Gasoline-hybrid	-		
		Diesel	89%	50% (EURO 5+)	30%
		Diesel-hybrid	-		
		LPG/CNG	5%		
		Hydrogen	-	-	-
		Hydrogen-hybrid	-		
		Electric	4%	50%	70%
Trolleybus	3%				

Infrastructure expansion

Name of Measures	Description of the quantified objective	Base value for 2020	Target level of implementation (2030)	Target level of implementation (2050)
BRT	Total network length. (in km)	0 km	44.9 km	0
LRT	Total network length. (in km)	0 km	18.1 km	31.5 km
Bus corridors (bus lane)	Total network length. (in km)	0 km	13 km	13 km
Suburban rail	Total network length. (in km)	0 km	0	190 km
Bike and pedestrian infrastructure	Network length increase (in km).	364km	1460 km	3000 km

Public transport promotion

Name of Measures	Description of the quantified objective	Base value for 2020	Target level of implementation	Target level of implementation
			2030	2050
Service improvement for buses	Increase in operating speed from optimized stop positioning and service improvement, including ICT. (in %)	-	5%	10%
Public transport priority	Share of the bus network that has priority over other road modes. (in %)	-	5-30% (25km/h speed)	25-50% (30km/h speed) - > 30%
			-> 20%	
Public Transport Fare Integration	Average PT trip cost reduction. (in %)	-	10%	30%
Mobility as a Service	Share of population with a MaaS subscription, which integrates of various forms of transport and transport-related services into a single, comprehensive, and on-demand mobility service (in %)	-	10%	40%

Shared modes promotion and restriction measures

Name of Measures	Description of the quantified objective	Base value for 2020	Target level of implementation (2030)	Target level of implementation (2050)
Shared Modes Promotion				
Car restrictions	Share of cars that will be restricted from circulating within the city. (in %)	0%	5-15% -> 5%	10-20% -> 10%
Restriction measures				
Parking restrictions	Share of the city center that is under (strong) parking restrictions. (in %)	0%	5-10% -> 5%	10-20% -> 10%
Speed limitations	Speed limit reduction. (in km/h)	20 km/h- residential 60 km/h- city area 80 km/h-rural area 100 km/h motorways	15 km/h 50 km/h 80 km/h 100 km/h	-10-30km/h -> -10km/h

Pricing and other measures

Measure name	Description of the quantified objective	Base value for 2020	Target level of implementation (2030)	Target level of implementation (2050)
Road pricing	Increase in vehicle usage costs (per km), excluding fuel cost. (in %)	-	10%	25-30% -> 25%
Parking pricing	Increase in parking costs. (in %)	1000MNT per hour	20-30% -> 20%	30-50% -> 30%
Fuel/Carbon tax	Increase in fossil fuel / emission cost. (in %)	1800MNT - 9500MNT depending on the CO2 emission quantity	2-3MNT / 50% -> 2.2MNT = 50%	3-5MNT / 100% -> 3.6MNT = 150%
Vehicle ownership & purchase tax	Increase in vehicle ownership and purchase cost. (in %)	2000MNT - 720000MNT	50% increase of existing / 20% -> 12000MNT/month	100% increase of existing / 300% -> 16000MNT/month
Other measures				
Teleworking Promotion	Share of active population that regularly teleworks. (in %)	1%	2-30% -> 2%	5-50% -> 5%

Conclusion

- There are some limitations connected with insufficiency of financial and electric power supply sources, problems of winter operation and battery liquidation in Ulaanbaatar that restrict implementation of electrical vehicles.
- Choice of High capacity public transport modes is still problematic in Ulaanbaatar.
- Quality of imported fuel does not meet applicable standards.
- However, decarbonization measures for Public city transportation in Ulaanbaatar will be successfully implemented in order to achieve the goal to develop a low-carbon, productive and inclusive green economy and contribute to international efforts to mitigate climate change.



Thank you!

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