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Sustainable Infrastructure Programme in Asia

DECARBONISING PATHWAYS FOR ULAANBAATAR'S URBAN MOBILITY

Model Manual for the Urban Mobility Model for Ulaanbaatar, Mongolia

September 2023

On behalf of:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

of the Federal Republic of Germany

IKI INTERNATIONAL CLIMATE INITIATIVE

OECD

GOVERNMENT OF MONGOLIA
MINISTRY OF ROAD AND TRANSPORT DEVELOPMENT

НИЙСЛЭЛИЙН ЗАСАГ ДАРГЫН ТАМГЫН ГАЗАР

Disclaimer

The results presented in the model should be regarded as an estimation derived from the best available data and information collected during the project. Its primary value lies in facilitating scenario comparisons rather than providing precise future values for certain indicators.

The ITF warrants the outputs of the default scenarios in the model: Baseline, Current Policies and Climate Ambition. These scenarios are validated by the technical team and the Ministry of Road and Transport Development of Mongolia. The model allows to manually create alternative scenarios by adjusting input; however, the ITF does not endorse the outcomes of this exercise and should not be quoted as the source of any manual scenario results.

The use of the model, its default scenarios and any other elements is free.

Please cite this work as: **ITF (2023), "Urban Mobility Model for Ulaanbaatar", *Sustainable Infrastructure Programme in Asia – Transport*, OECD Publishing, Paris.**

Project overview

As part of SIPA, the Sustainable Infrastructure Programme in Asia, a **national roadmap study** was conducted in **Mongolia**.

It focused on **decarbonising urban passenger transport in Ulaanbaatar**, emphasising the role of public transport.

The main deliverables of this study are the **Findings & Recommendations slide deck**, the **Urban Mobility model for Ulaanbaatar**, and the current **Model Manual**.

This manual aims to **guide users** in utilising the model to support local policy building.

Data collection in cooperation with stakeholders in Mongolia

↓

Consultation with local stakeholders to better grasp the specificities of the urban environment and mobility system in Ulaanbaatar.

↓

Scenario definition with partners in Mongolia: analysis of existing, planned and potential policy measures

↓

Model handover to the Ministry of Road and Transport Development and the City of Ulaanbaatar for supporting local policy building

Access more information and project deliverables

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MODEL OVERVIEW

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General information about the model

The model is built in **Microsoft Excel** (macro-enabled workbooks)

It is based on the **ITF Global Urban Passenger Model**, from which the structure, formulas and initial calibration were extracted

The model covers the administrative boundaries of the **City of Ulaanbaatar** and relies on inputs from local stakeholders and open-source platforms:

- Ministry of Road and Transport Development of Mongolia
- City of Ulaanbaatar (Public Transport Department, Road Development Department, Urban Planning and Research Institute)
- Mongolian University of Science and Technology (MUST)
- UN DESA population data, Intergovernmental Panel on Climate Change (IPCC)

Model purpose

It is a **strategic modelling tool** allowing to assess the impact of CO_2 mitigation measures:

- **Infrastructure Expansion** (e.g. public transport infrastructure improvement)
- **Public Transport Promotion** (e.g. increased frequencies, lower fares)
- **Shared Transport Promotion** (e.g. car sharing, on-demand taxibus services)
- **Restrictive Measures** (e.g. parking restrictions, speed limitations)
- **Pricing Measures** (e.g. road pricing, parking pricing)
- **Vehicle Technology Development** (e.g. technology stock targets for private and public fleets)
- **Other Measures** (teleworking, land use mixture)

The model develops policy scenarios between 2015 and 2050 and evaluates related transport activity and emissions.

Modelling scope – Level of disaggregation

To enhance the representation of urban mobility for different market segments, the model differentiates:

- 14 modes (current and possible in the future)
- 2 genders and 4 age cohorts
- 6 trip distance bins
- 4 fuel types (gasoline, diesel, electric, LPG/CNG)
- 5-year steps from 2015 to 2050

Modelling scope – Transport modes

Non-motorised

- Walk
- Bicycle
- Bike & Scooter sharing

Private vehicles

- Car
- Motorcycle

Public transport

- Bus
- LRT
- BRT
- Cable car
- Suburban rail
- On-demand Taxibus

Shared mobility

- Taxi
- Ride sharing
- Car sharing

Modelling scope – Population and distance categories

8 population categories × **6 trip distance bins**

4 age cohorts

0-4
5-19
20-59
60+

×

2 genders

Female
Male

0 – 1 km
1 – 2.5 km
2.5 – 5 km
5 – 10 km
10 – 20 km
20+ km

Model output

Evolution of mode shares

Evolution of trips

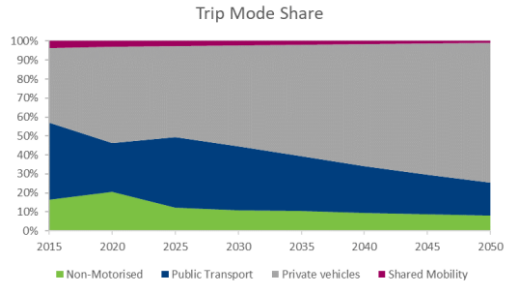
Evolution of passenger demand
(Passenger KiloMetres)

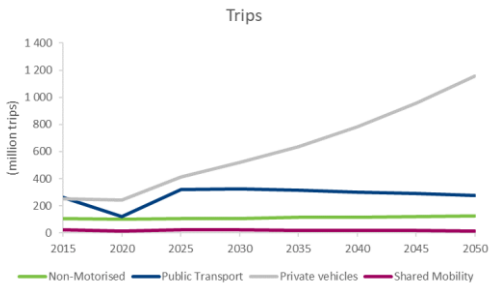
Evolution of vehicle demand
(Passenger KiloMetres)

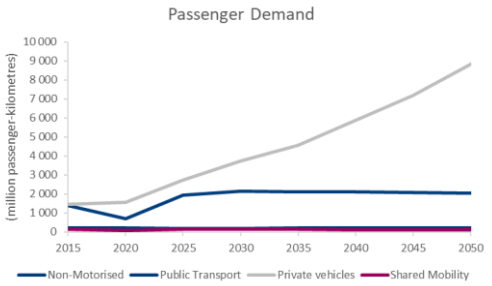
Evolution of CO2 emissions

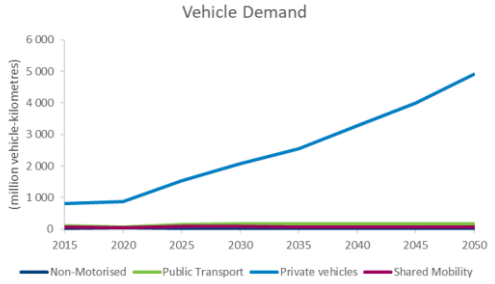
direct Tank To Wheel

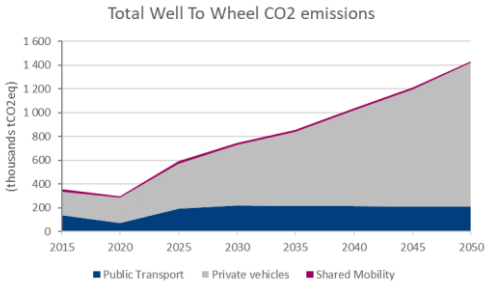
indirect Well To Tank

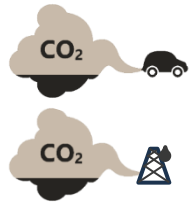




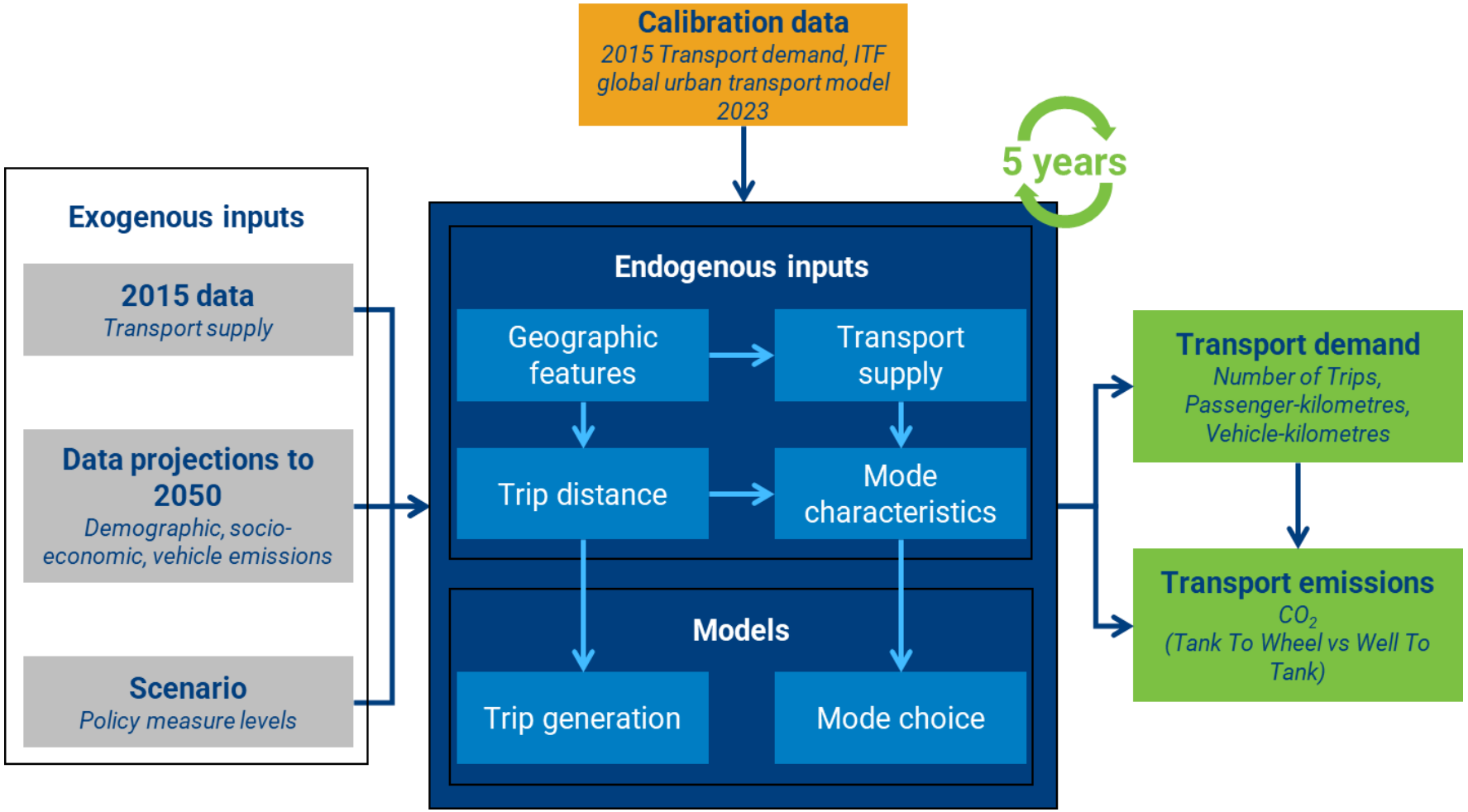








Modelling framework



Principle

Travel demand outputs

Emissions outputs

Number of trips
Average trip distances
Mode shares

→

Passenger kilometres by mode (PKM)

→ Vehicle load factors

Vehicle kilometres by mode (VKM)

→ Fuel/technology mix

CO2 and local pollutants by mode

- By distance bin
- By gender

- By fuel type
- By gender

Modelling tool structure

Main sheets to use for a standard user:

Cover | Scenario setting | Scenario output | Scenario comparison

Other sheets for more advanced users:

Inputs Socio-eco | Supply | Demand

Model-Calibration | City evolution | Fleet | Trip rates & distances | Mode Attributes | Demand_detailed

Modelling tool structure

Main sheets for standard users

- **Cover**: overall model information, disclaimer, description, designers & contacts
- **Scenario setting**: definition of scenarios to test by adjusting each available policy measure
- **Scenario output**: main outcomes of the scenario presented as table and figures
- **Scenario comparison**: comparison of the scenario results with the three scenarios developed by the ITF: *Baseline*, *Current Policies* and *Climate Ambition*

Modelling tool structure

Other sheets for more advanced users:

- **Inputs Socio-eco**: input sheet containing all socio-economic and demographic input data
- **Supply**: input sheet containing all transport supply input data (e.g. fares)
- **Demand**: input sheet containing all transport demand input data (e.g. speed, access/waiting time and occupancy rates)

- **Model Calibration**: lists the formulas used in the model and their related adjustable parameters
- **City evolution**: lists the evolution of the soci-eco-géo-demographic and supply characteristics
- **Fleet**: summarises vehicle fleet assumptions and its evolution for all modes and vehicles
- **Trip rates & distances**: lists the trip generation and trip distance distribution intermediate output
- **Mode attributes**: lists the intermediate mode attributes (e.g. travel time, cost)
- **Demand detailed**: provides all the model output at the most detailed level, for each age, gender and distance category

BASE MANIPULATIONS BEFORE USING THE MODEL

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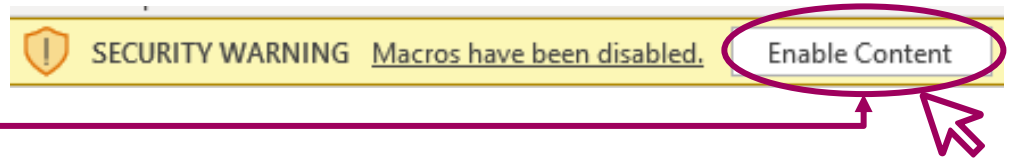
To do when opening the model

1. Enable Macro Content:

Upon opening the .xlsm model file, this small bar should appear:
Click on “Enable Content”



N.B. The interface may be slightly different depending on the version of Microsoft Excel

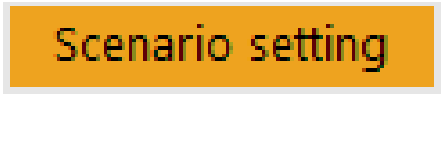
2. Learn key information:

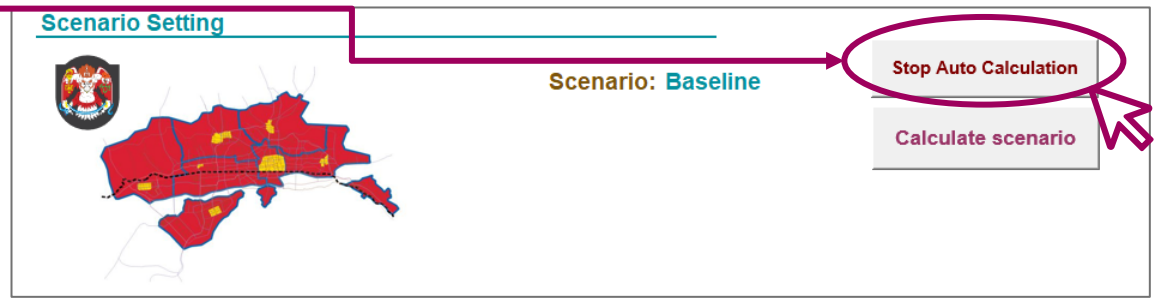
Make sure that you are on the first “Cover” sheet:
Read it all, especially the Disclaimer, Introduction and Model scope sections

3. Disable automated calculation:

If you don’t already know how to do this manually

Switch to the second “Scenario setting” sheet:
On the top right, click the “Stop Auto Calculation” button:





Congratulations, you are now good to start!

USE CASE: STANDARD USER

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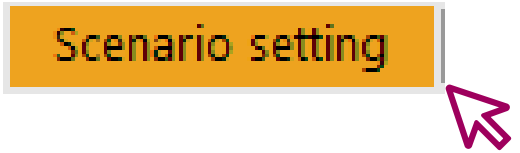
Generating a scenario

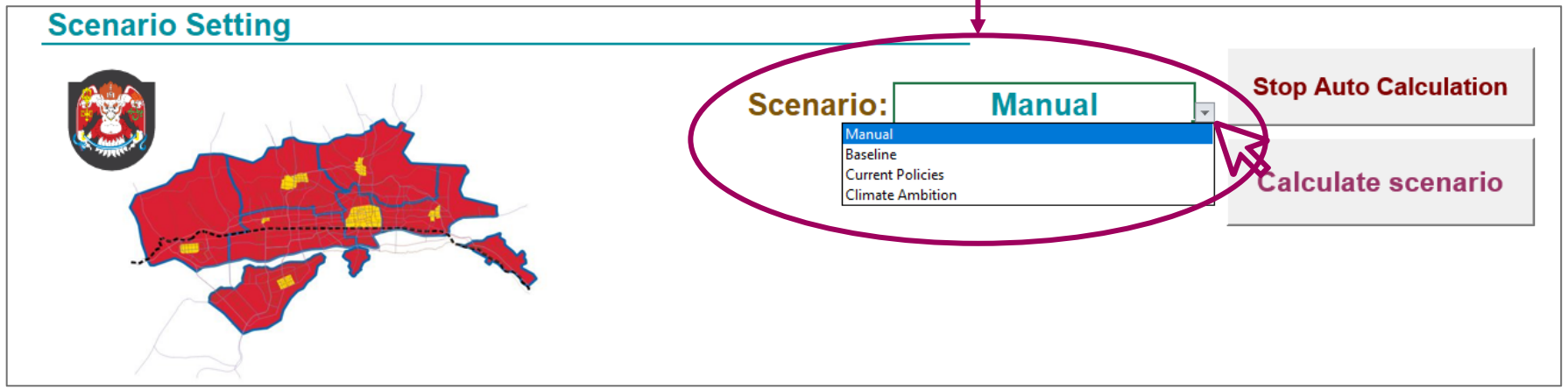
1. Access the “scenario setting” sheet:



2. Choose the scenario that you want to trigger:

There are 4 scenarios to choose from:
Manual – you must define your measure levels and fill the whole sheet, see more details on slide 21
Baseline – Ulaanbaatar city is evolving without any further action and technology development from 2020 on
Current Policies – the policies currently being considered and planned by local authorities are implemented up to 2050
Climate Ambition – more and stronger, yet feasible, measures are implemented to reach climate objectives

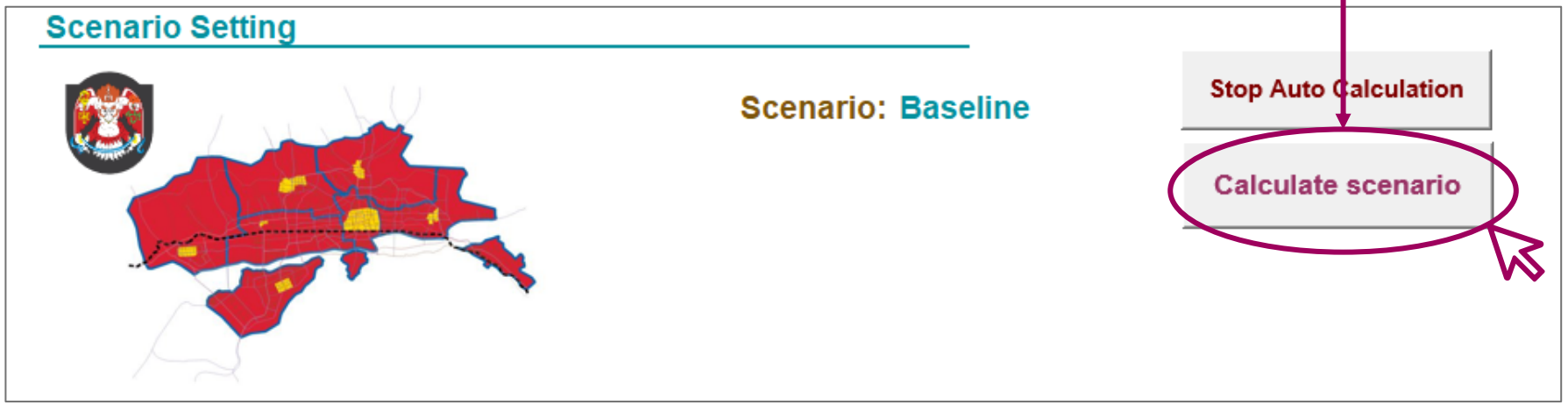
Click on the drop-down menu to select your scenario:



Generating a scenario

3. Generating your scenario:

Click on the “Calculate scenario” button:



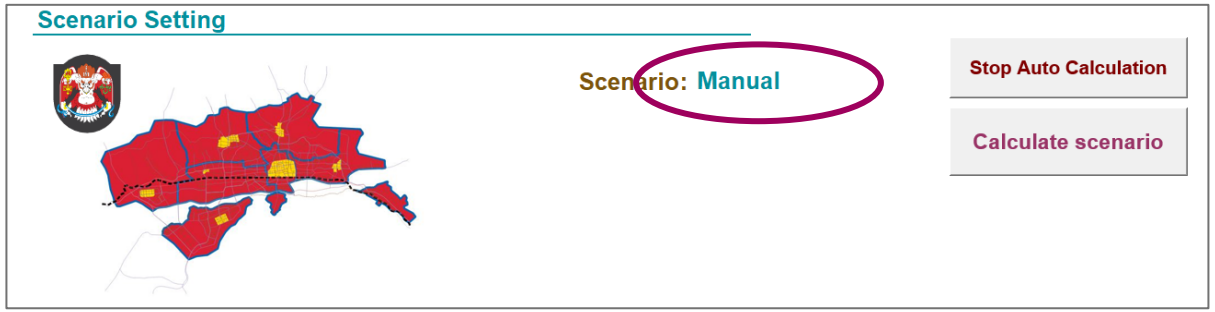
Congratulations, you generated a scenario!

Generating a scenario

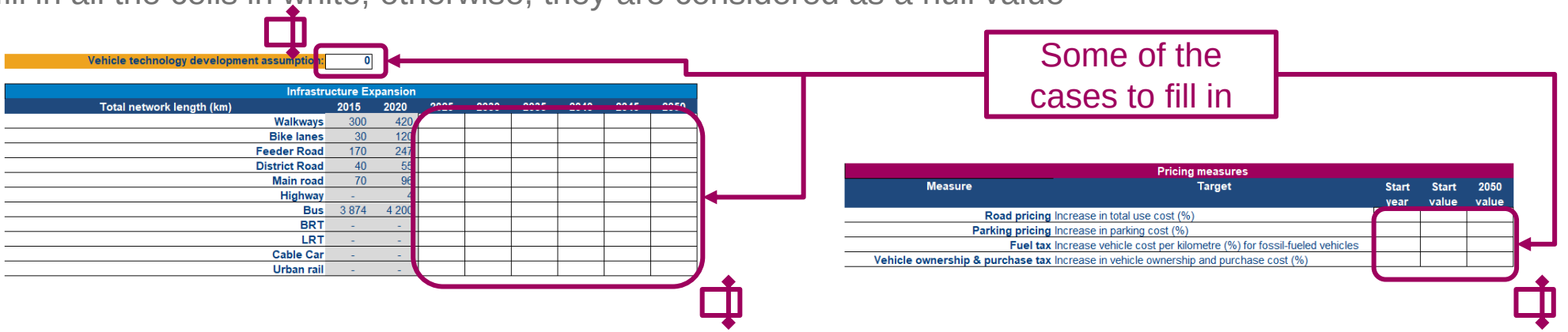
Setting up a manual scenario:

Once the manual scenario is selected:

The different policy measure levels are gathered in 7 sections representing the measure categories:
Vehicle technology assumption, Infrastructure Expansion, Public Transport Promotion, Shared Transport Promotion, Restrictive measures, Pricing measures, Other measures



You must fill in all the cells in white; otherwise, they are considered as a null value



N.B. When there is no drop-down menu, indicative values are provided when selecting a case to fill, error messages are provided when the values are inconsistent, with indications about the consistent range

Reading detailed output

Congratulations, you can now generate your own scenario!

Reading the output

1. Get results for the generated scenario:

Scenario output

Access the “Scenario output” sheet:
Output tables are displayed on the left and figures on the right.

Scenario output - Values are automatically updated based on Inputs and calibration

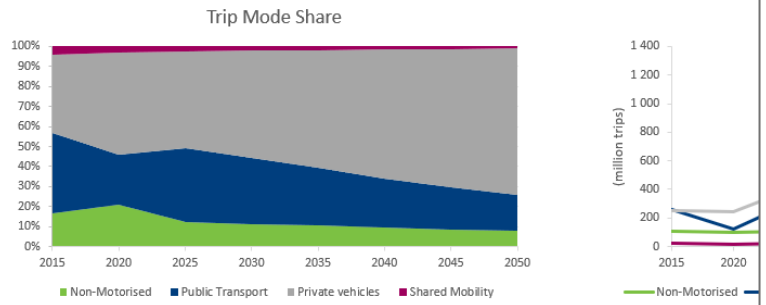
Scenario: Baseline
Run Date: 28/07/2023 14:43

Trip Mode Share

	2015	2020	2025	2030	2035	2040	2045	2050
Non-Motorised	16.4%	20.7%	12.2%	11.0%	10.5%	9.3%	8.7%	8.1%
Private vehicles	39.1%	50.9%	48.1%	53.3%	58.7%	64.4%	69.2%	73.5%
Public Transport	40.7%	25.5%	37.0%	33.5%	29.0%	24.8%	20.9%	17.5%
Shared Mobility	3.8%	2.9%	2.6%	2.2%	1.8%	1.5%	1.2%	0.9%

Trips (million)

	2015	2020	2025	2030	2035	2040	2045	2050
TOTAL	646.3	475.0	858.8	969.8	1 085.3	1 213.8	1 381.0	1 575.6
Non-Motorised	106.0	98.5	105.0	106.6	113.6	113.0	120.2	126.8
Private vehicles	252.8	241.9	413.3	517.2	636.6	781.9	955.9	1 157.7
Public Transport	262.7	120.9	318.1	324.7	315.2	300.9	288.5	276.4



Trip Mode Share

	2015	2020	2025	2030	2035	2040	2045	2050
Non-Motorised	**16.4%**	**20.7%**	**12.2%**	**11.0%**	**10.5%**	**9.3%**	**8.7%**	**8.1%**
Walk	15.4%	18.7%	11.5%	10.4%	9.9%	8.9%	8.3%	7.7%
Bicycle	1.0%	2.1%	0.7%	0.6%	0.5%	0.4%	0.4%	0.3%
Bike and Scooter sharing	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Private vehicles	**39.1%**	**50.9%**	**48.1%**	**53.3%**	**58.7%**	**64.4%**	**69.2%**	**73.5%**
Motorcycle	0.7%	0.5%	0.5%	0.5%	0.4%	0.3%	0.3%	0.2%
Car	38.4%	50.4%	47.6%	52.9%	58.3%	64.1%	68.9%	73.2%
Public Transport	**40.7%**	**25.5%**	**37.0%**	**33.5%**	**29.0%**	**24.8%**	**20.9%**	**17.5%**
Bus	40.7%	25.5%	37.0%	33.5%	29.0%	24.8%	20.9%	17.5%
Bus Rapid Transit	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cable Car	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Light Rail Transit	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Urban Rail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Shared Mobility	**3.8%**	**2.9%**	**2.6%**	**2.2%**	**1.8%**	**1.5%**	**1.2%**	**0.9%**
Taxi	0.5%	0.3%	0.3%	0.3%	0.2%	0.2%	0.2%	0.1%
Ride-sharing	3.4%	2.5%	2.3%	1.9%	1.6%	1.3%	1.0%	0.8%
Car-Sharing	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
On-demand Taxibus	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

It is possible to get access to mode shares disaggregated by mode instead of mode categories by expanding the rows (crosses on the left).

Reading the output

2. Compare the scenario with the pre-defined scenarios:

Scenario comparison

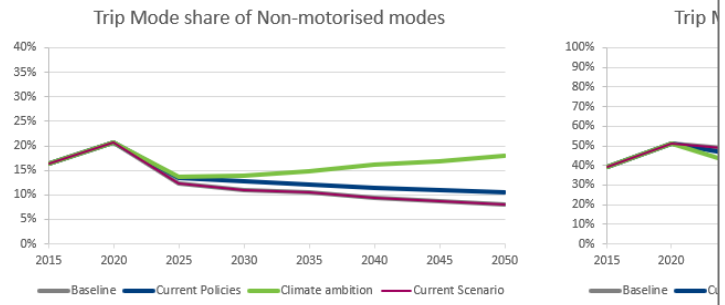
Access the “Scenario comparison” sheet:
The sheet is organised like the previous one: tables are displayed on the left and figures on the right.

Scenario comparison - Values are automatically updated based on Inputs and calibration

Scenario: Baseline
Date: 28/07/2023
14 43

Trip Mode Share

	2015	2020	2025	2030	2035	2040	2045	2050
Non-Motorised	**16.4%**	**20.7%**	**12.2%**	**11.0%**	**10.5%**	**9.3%**	**8.7%**	**8.1%**
Baseline	16.4%	20.7%	12.2%	11.0%	10.5%	9.3%	8.7%	8.1%
Current Policies	16.4%	20.7%	13.4%	12.8%	12.1%	11.4%	10.9%	10.6%
Climate ambition	16.4%	20.7%	13.7%	14.0%	14.9%	16.2%	16.8%	17.9%
Private vehicles	**39.1%**	**50.9%**	**48.1%**	**53.3%**	**58.7%**	**64.4%**	**69.2%**	**73.5%**
Baseline	39.1%	50.9%	48.1%	53.3%	58.7%	64.4%	69.2%	73.5%
Current Policies	39.1%	50.9%	45.3%	44.8%	43.2%	45.8%	44.1%	43.7%
Climate ambition	39.1%	50.9%	40.9%	36.2%	31.2%	28.9%	22.5%	17.8%
Public Transport	**40.7%**	**25.5%**	**37.0%**	**33.5%**	**29.0%**	**24.8%**	**20.9%**	**17.5%**
Baseline	40.7%	25.5%	37.0%	33.5%	29.0%	24.8%	20.9%	17.5%
Current Policies	40.7%	25.5%	38.7%	40.2%	42.9%	41.4%	43.2%	44.0%
Climate ambition	40.7%	25.5%	41.5%	43.4%	48.6%	50.3%	55.4%	59.0%
Shared Mobility	**3.8%**	**2.9%**	**2.6%**	**2.2%**	**1.8%**	**1.5%**	**1.2%**	**0.9%**
Baseline	3.8%	2.9%	2.6%	2.2%	1.8%	1.5%	1.2%	0.9%
Current Policies	3.8%	2.9%	2.6%	2.2%	1.7%	1.4%	1.7%	1.7%
Climate ambition	3.8%	2.9%	3.8%	6.3%	5.2%	4.6%	5.3%	5.3%



More disaggregated data can also be accessible by expanding the rows for Trips, Passenger-kilometres, Vehicle-kilometres and CO_2 emissions sections.

Reading detailed output

Congratulations, you learn how to use the base features of the model!

USE CASE: MORE ADVANCED USER

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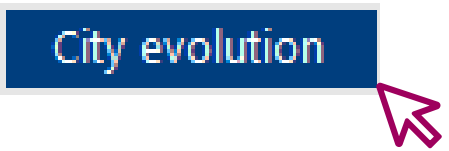
Reading detailed output

1. Looking for data on the evolution of city characteristics:

Access the “City evolution” sheet:
This sheet provides all the information on the evolution of socio-economic, demographic, geographic and transport supply characteristics of the city considered in the model.



City evolution - Values are automatically updated based on Inputs and calibration

			2015	2020	2025	2030	2035	2040	2045	2050
Socio-economic features	Economic	GDP per capita (USD)	6 529	6 257	7 902	9 547	11 584	13 782	16 113	18 595
	Geographic	Urban area (km²)	417	417	417	417	417	417	417	417
		Subcentre area (km²)	18	18	18	18	18	18	18	18
	Population	Population	1 185 219	1 359 521	1 480 113	1 577 135	1 668 703	1 779 189	1 942 700	2 137 496
		Population in subcentres	280 215	297 100	338 181	379 261	420 342	461 422	505 440	549 459
		Share of Women between 0 and 4 (%)	4%	4%	4%	4%	4%	4%	4%	4%
		Share of Women between 5 and 19 (%)	11%	11%	11%	11%	11%	11%	11%	11%
		Share of Women between 20 and 59 (%)	32%	32%	32%	32%	32%	32%	32%	32%
		Share of Women over 60 (%)	3%	3%	3%	3%	3%	3%	3%	3%
		Share of Men between 0 and 4 (%)	5%	5%	5%	5%	5%	5%	5%	5%
		Share of Men between 5 and 19 (%)	11%	11%	11%	11%	11%	11%	11%	11%
		Share of Men between 20 and 59 (%)	30%	30%	30%	30%	30%	30%	30%	30%
		Share of Men over 60 (%)	3%	3%	3%	3%	3%	3%	3%	3%
	Others	Urban density (inhabitant per km²)	2 841	3 258	3 547	3 780	3 999	4 264	4 656	5 123
		Subcentre density (inhabitant per km²)	15 797	16 749	19 065	21 381	23 697	26 013	28 495	30 976
		Land-Use mixture	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
	Road infrastructure	Highway (km)	-	4	4	4	4	4	4	4
		Main road (km)	70	96	119	142	165	188	188	188
		District level main road (km)	40	55	92	130	167	204	204	204
		Feeder road (km)	170	247	378	509	640	771	771	771
		Pedestrian network (km)	300	420	577	735	918	1 102	1 286	1 469
		Bike network (km)	30	120	428	816	1 020	1 224	1 427	1 631
		Parking space (#)	60 303	74 264	88 225	102 186	116 147	130 108	144 069	158 030
	PT infrastructure	Bus network (km)	3874	4200	4100	4100	4100	4100	4100	4100
		LRT (km)	-	-	20.0	39.0	107.7	107.7	107.7	107.7
		BRT (km)	-	-	-	-	-	-	-	-
		Cable car (km)	-	-	-	23.1	23.1	23.1	23.1	23.1

! This sheet <u>should not be edited by the user</u>. Its content is the result of the data input sheets, scenario assumptions and model calibration, it will automatically be updated.

Reading detailed output

2. Looking for data on the vehicle fleet characteristics:

Access the “Fleet” sheet:
This sheet provides all the information on the evolution of the main vehicle fleet characteristics.
It provides the average consumption, emission and occupancy rates for each motorised mode.

Fleet characteristics - Values are automatically updated based on City evolution characteristics and calibration

	Vehicle fleet characteristics	2015	2020	2025	2030	2035	2040	2045	2050
Motorcycle	Electricity consumption (MJ per km)	-	-	-	-	-	-	-	-
	Fuel consumption (L per 100km)	2.11	2.11	2.05	1.99	1.96	1.93	1.88	1.83
	Share of EV vehicles (%)	0%	0%	0%	0%	0%	0%	0%	0%
	TTW emissions (g CO2eq per km)	51.79	51.79	50.17	48.89	47.95	47.21	46.13	44.81
	WTT emissions (g CO2eq per km)	12.00	12.00	11.62	11.32	11.11	10.93	10.68	10.38
	Occupancy rate	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Car	Electricity consumption (MJ per km)	0.59	0.59	0.59	0.58	0.57	0.55	0.54	0.53
	Fuel consumption (L per 100km)	7.97	7.97	8.12	7.65	7.27	6.95	6.72	6.53
	Share of EV vehicles (%)	0%	0%	0%	0%	0%	3%	8%	16%
	TTW emissions (g CO2eq per km)	198.87	198.87	197.94	186.88	177.85	166.07	152.88	136.19
	WTT emissions (g CO2eq per km)	48.38	48.38	46.71	44.26	42.28	40.25	38.08	35.04
	Occupancy rate	1.80	1.80	1.80	1.89	1.91	1.93	1.96	1.98
Bus	Electricity consumption (MJ per km)	4.89	4.89	4.78	4.67	4.56	4.45	4.34	4.23
	Fuel consumption (L per 100km)	39.34	39.34	38.29	37.18	36.30	35.64	34.93	34.16
	Share of EV vehicles (%)	7%	7%	28%	50%	55%	60%	65%	70%
	TTW emissions (g CO2eq per km)	940.96	940.96	687.14	445.99	389.15	336.37	285.02	235.12
	WTT emissions (g CO2eq per km)	282.01	282.01	300.07	286.42	251.28	217.54	188.68	157.44
	Occupancy rate	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Rail	Electricity consumption (MJ per km)	26.17	26.17	22.34	18.52	15.55	14.11	12.08	10.33
	Fuel consumption (L per 100km)	145.45	145.45	142.24	140.65	140.10	140.00	140.00	140.00
	Share of EV vehicles (%)	83%	83%	83%	83%	83%	83%	83%	83%
	TTW emissions (g CO2eq per km)	649.08	649.08	634.78	627.68	625.22	624.80	624.78	624.78
	WTT emissions (g CO2eq per km)	2 492.72	2 492.72	1 778.46	1 254.51	911.54	713.04	553.67	428.52
	Occupancy rate	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
	Derived fleet characteristics								
Taxi	Electricity consumption (MJ per km)	0.53	0.53	0.53	0.52	0.51	0.50	0.49	0.48
	Fuel consumption (L per 100km)	7.18	7.18	7.31	6.89	6.55	6.25	6.05	5.88
	Share of EV vehicles (%)	0%	0%	0%	0%	0%	3%	8%	16%
	TTW emissions (g CO2eq per km)	178.99	178.99	178.14	168.19	160.06	149.46	137.59	122.58

It distinguishes Vehicle and Derived fleet. The Derived fleet is computed based on assumptions regarding the emissions as opposed to the regular Vehicle fleet. For instance, the average emissions of a taxi are estimated as a coefficient times the emissions of private cars, a coefficient which is defined in the “Model-Calibration” sheet.

! This sheet <u>should not be edited by the user</u>. Its content is the result of the data input sheets, scenario assumptions and model calibration, it will automatically be updated.

Reading detailed output

3. Looking for data on the trip and distance characteristics:

Access the “Trip rates & distances” sheet:

Trip rates & distances

This sheet provides all the information on the evolution of the trip characteristics. It indicates the average number of trips per day, the total number of trips and their distribution per distance category.

Trip rates & distances - Values are automatically updated based on City evolution characteristics and calibration

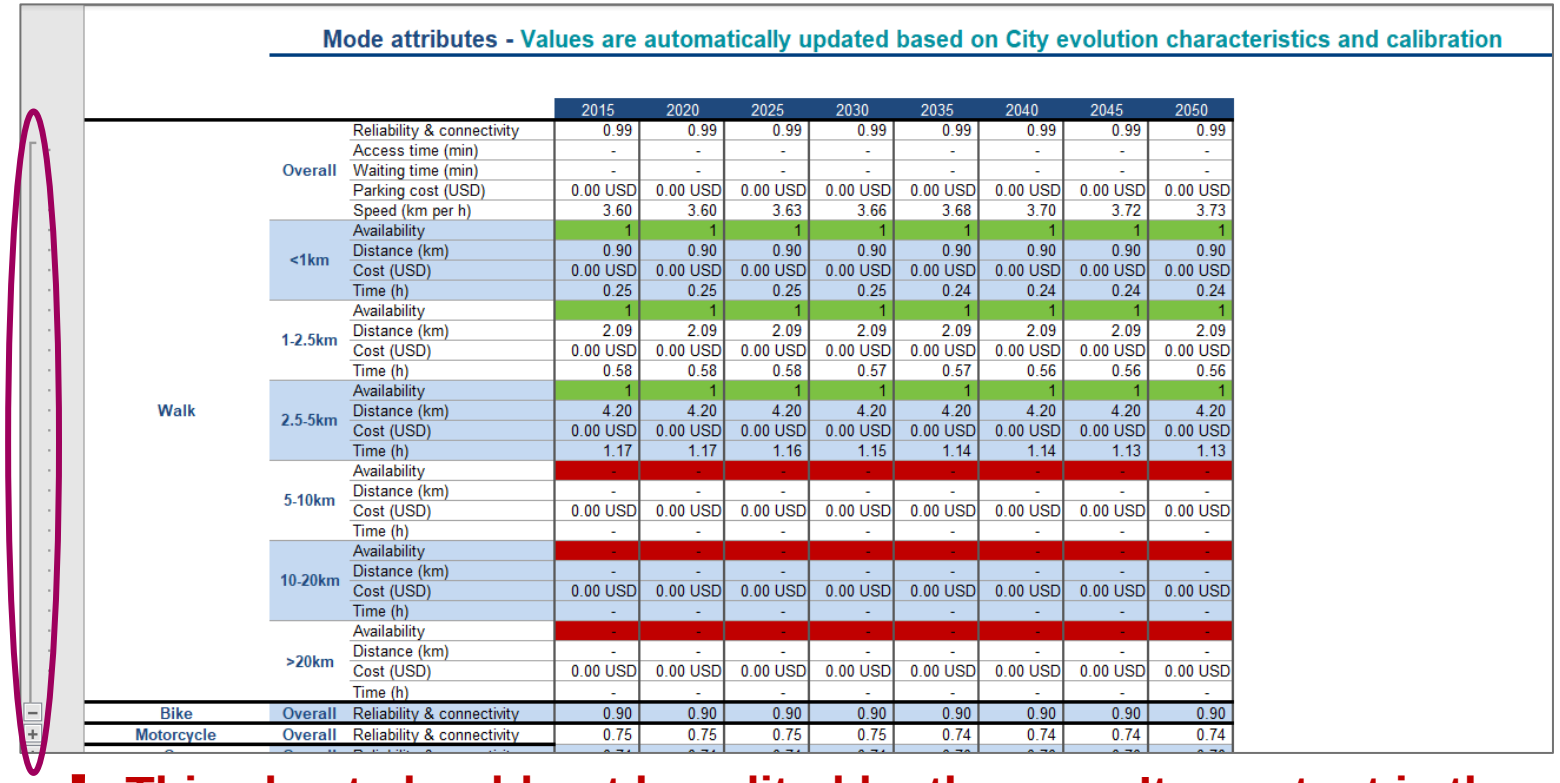
		2015	2020	2025	2030	2035	2040	2045	2050
Trip rates per individual per day	Women between 0 and 4	1.41	0.91	1.50	1.59	1.69	1.77	1.84	1.91
	Women between 5 and 19	1.60	1.03	1.70	1.80	1.91	2.00	2.09	2.16
	Women between 20 and 59	1.83	1.17	1.95	2.07	2.19	2.29	2.39	2.48
	Women over 60	1.44	0.92	1.53	1.63	1.72	1.80	1.88	1.95
	Total: Women	**1.72**	**1.10**	**1.83**	**1.94**	**2.05**	**2.15**	**2.24**	**2.33**
	Men between 0 and 4	1.41	0.91	1.50	1.59	1.69	1.77	1.84	1.91
	Men between 5 and 19	1.68	1.08	1.79	1.90	2.01	2.10	2.19	2.27
	Men between 20 and 59	1.93	1.23	2.05	2.17	2.30	2.41	2.51	2.61
	Men over 60	1.52	0.97	1.61	1.71	1.81	1.90	1.98	2.05
	Total: Men	**1.80**	**1.15**	**1.92**	**2.03**	**2.15**	**2.25**	**2.35**	**2.43**
	Total	**1.76**	**1.13**	**1.87**	**1.98**	**2.10**	**2.20**	**2.29**	**2.38**
Total trip # per day	Women between 0 and 4	74 787	54 962	99 384	112 228	125 587	140 459	159 807	182 326
	Women between 5 and 19	216 515	159 119	287 725	324 907	363 583	406 638	462 653	527 847
	Women between 20 and 59	700 549	514 840	930 951	1 051 258	1 176 395	1 315 704	1 496 944	1 707 881
	Women over 60	56 436	41 475	74 996	84 688	94 769	105 992	120 592	137 585
	Total: Women	**1 048 288**	**770 396**	**1 393 056**	**1 573 081**	**1 760 334**	**1 968 792**	**2 239 996**	**2 555 638**
	Men between 0 and 4	77 299	56 808	102 722	115 997	129 805	145 176	165 174	188 449
	Men between 5 and 19	221 410	162 716	294 229	332 253	371 803	415 831	473 113	539 780
	Men between 20 and 59	690 793	507 669	917 985	1 036 617	1 160 011	1 297 380	1 476 096	1 684 095
	Men over 60	47 007	34 546	62 467	70 540	78 937	88 285	100 446	114 600
	Total: Men	**1 036 509**	**761 740**	**1 377 404**	**1 555 407**	**1 740 555**	**1 946 671**	**2 214 828**	**2 526 924**
	Total	**2 084 797**	**1 532 135**	**2 770 460**	**3 128 488**	**3 500 890**	**3 915 464**	**4 454 825**	**5 082 562**
Total trip # per year	Women between 0 and 4	23 184 122	17 038 213	30 809 081	34 790 557	38 931 875	43 542 174	49 540 173	56 520 966
	Women between 5 and 19	67 119 781	49 326 913	89 194 613	100 721 287	112 710 713	126 057 877	143 422 536	163 632 459
	Women between 20 and 59	217 170 253	159 600 314	288 594 752	325 890 027	364 682 567	407 868 152	464 052 591	529 443 064
	Women over 60	17 495 012	12 857 237	23 248 896	26 253 365	29 378 452	32 857 438	37 383 599	42 651 388
	Total: Women	**324 969 168**	**238 822 677**	**431 847 341**	**487 655 236**	**545 703 606**	**610 325 642**	**694 398 898**	**792 247 877**
	Men between 0 and 4	23 962 775	17 610 453	31 843 823	35 959 020	40 239 426	45 004 565	51 204 011	58 419 258
	Men between 5 and 19	68 637 165	50 442 051	91 211 044	102 998 303	115 258 775	128 907 680	146 664 903	167 331 714
	Men between 20 and 59	214 145 676	157 377 526	284 575 431	321 351 287	359 603 555	402 187 685	457 589 632	522 069 397
	Men over 60	14 572 261	10 709 281	19 364 889	21 867 426	24 470 430	27 368 210	31 138 221	35 525 963
	Total: Men	**321 317 877**	**236 139 311**	**426 995 187**	**482 176 035**	**539 572 186**	**603 468 140**	**686 596 766**	**783 346 332**
	Total	**646 287 045**	**474 961 988**	**858 842 528**	**969 831 271**	**1 085 275 792**	**1 213 793 782**	**1 380 995 664**	**1 575 594 209**
Distribution of distance categories	< 1km	11%	10%	9%	9%	9%	8%	9%	9%
	1 - 2.5km	29%	27%	25%	22%	22%	21%	20%	20%
	2.5 - 5km	39%	35%	32%	30%	29%	27%	27%	27%
	5 - 10km	20%	27%	31%	35%	36%	38%	38%	38%
	10 - 20km	1%	1%	2%	4%	4%	5%	5%	6%
	> 20km	0%	0%	0%	0%	1%	1%	1%	1%

! This sheet <u>should not be edited by the user</u>. Its content is the result of the data input sheets, scenario assumptions and model calibration, it will automatically be updated.

Reading detailed output

4. Looking for data on the mode attributes:

Access the “Mode Attributes” sheet:



Mode attributes - Values are automatically updated based on City evolution characteristics and calibration

			2015	2020	2025	2030	2035	2040	2045	2050
Walk	Overall	Reliability & connectivity	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
		Access time (min)	-	-	-	-	-	-	-	-
		Waiting time (min)	-	-	-	-	-	-	-	-
		Parking cost (USD)	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD
		Speed (km per h)	3.60	3.60	3.63	3.66	3.68	3.70	3.72	3.73
	<1km	Availability	1	1	1	1	1	1	1	1
		Distance (km)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
		Cost (USD)	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD
		Time (h)	0.25	0.25	0.25	0.25	0.24	0.24	0.24	0.24
	1-2.5km	Availability	1	1	1	1	1	1	1	1
		Distance (km)	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09
		Cost (USD)	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD
		Time (h)	0.58	0.58	0.58	0.57	0.57	0.56	0.56	0.56
	2.5-5km	Availability	1	1	1	1	1	1	1	1
		Distance (km)	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20
		Cost (USD)	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD
		Time (h)	1.17	1.17	1.16	1.15	1.14	1.14	1.13	1.13
	5-10km	Availability	-	-	-	-	-	-	-	-
		Distance (km)	-	-	-	-	-	-	-	-
		Cost (USD)	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD
		Time (h)	-	-	-	-	-	-	-	-
	10-20km	Availability	-	-	-	-	-	-	-	-
		Distance (km)	-	-	-	-	-	-	-	-
		Cost (USD)	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD
		Time (h)	-	-	-	-	-	-	-	-
	>20km	Availability	-	-	-	-	-	-	-	-
		Distance (km)	-	-	-	-	-	-	-	-
		Cost (USD)	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD	0.00 USD
		Time (h)	-	-	-	-	-	-	-	-
Bike	Overall	Reliability & connectivity	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Motorcycle	Overall	Reliability & connectivity	0.75	0.75	0.75	0.75	0.74	0.74	0.74	0.74

Mode Attributes

This sheet provides all the information on the evolution of modal attributes of the different modes (i.e. reliability & connectivity, time, cost, availability) for each distance category.

N.B. By default the rows are grouped, but they can be expanded by clicking on the cross on the left.

! This sheet should not be edited by the user. Its content is the result of the data input sheets, scenario assumptions and model calibration, it will automatically be updated.

Reading detailed output

5. Looking for detailed data on the travel demand:

Access the “Demand_detailed” sheet:

Demand_detailed

This sheet provides all the detailed demand output. It gives access to mode shares, trips, passenger-kilometres, vehicle-kilometres, CO_2 emissions (Tank To Wheel vs Well To Tank), for each category of distance, age, gender and for each mode. The “Scenario output” and “Scenario comparison” sheets are summaries of this sheet.

Demand - Values are automatically updated based on City evolution characteristics and calibration

						Trip Mode share							Trip number (yearly)							
Bin cod	Bin	Age cat	Age cat	Gender	code m	Mode	MS2015	MS2020	MS2025	MS2030	MS2035	MS2040	MS2045	MS2050	T2015	T2020	T2025	T2030	T2035	T2040	T2045	T2050	PKM
0		0	0 to 4	Men	1	Walk	72.1%	80.6%	69.2%	69.4%	68.8%	67.8%	65.8%	64.4%	1 875 665	1 411 039	2 055 914	2 178 360	2 440 747	2 578 326	2 884 209	3 250 583	1 6
0	< 1km	0	0 to 4	Men	2	Bicycle	0.9%	1.4%	1.1%	1.4%	1.6%	1.7%	1.8%	2.0%	22 999	23 779	31 935	45 491	56 091	65 178	80 180	99 354	
0	< 1km	0	0 to 4	Men	3	Motorcycle	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	7 465	2 665	7 121	6 680	6 589	6 123	6 023	5 963	
0	< 1km	0	0 to 4	Men	4	Car	13.4%	11.9%	17.3%	17.2%	18.8%	20.6%	22.0%	23.5%	349 516	209 232	514 309	538 758	667 256	782 130	964 432	1 184 101	4
0	< 1km	0	0 to 4	Men	5	Taxi	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	4 601	1 586	4 074	3 745	3 572	3 197	2 997	2 815	
0	< 1km	0	0 to 4	Men	6	PT-Bus	11.6%	5.1%	10.7%	10.5%	9.6%	8.8%	9.2%	8.9%	302 710	88 979	318 500	330 429	338 811	335 327	402 490	450 726	3
0	< 1km	0	0 to 4	Men	7	PT-BRT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	0	0 to 4	Men	8	PT-LRT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	0	0 to 4	Men	9	PT-CableC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	0	0 to 4	Men	10	PT-Rail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	0	0 to 4	Men	11	Bike and S	0.0%	0.0%	0.2%	0.2%	0.2%	0.1%	0.2%	0.2%	-	-	5 307	5 318	5 475	5 267	8 764	11 384	
0	< 1km	0	0 to 4	Men	12	Ride-shari	1.4%	0.8%	1.1%	1.0%	0.8%	0.6%	0.8%	0.9%	36 929	13 639	33 659	30 173	28 172	24 670	37 232	43 988	
0	< 1km	0	0 to 4	Men	13	Car-Sharin	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	0	0 to 4	Men	14	On-deman	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	0	0 to 4	Women	1	Walk	72.7%	81.6%	70.1%	70.4%	70.0%	69.2%	67.2%	65.9%	1 827 586	1 382 289	2 015 680	2 136 952	2 401 964	2 545 185	2 851 652	3 221 335	1 6
0	< 1km	0	0 to 4	Women	2	Bicycle	0.7%	1.1%	0.9%	1.2%	1.3%	1.4%	1.5%	1.7%	18 347	19 072	25 634	36 537	45 194	52 678	64 905	80 613	
0	< 1km	0	0 to 4	Women	3	Motorcycle	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	3 992	1 433	3 832	3 596	3 559	3 317	3 268	3 243	
0	< 1km	0	0 to 4	Women	4	Car	11.9%	10.6%	15.4%	15.3%	16.8%	18.4%	19.7%	21.1%	299 042	179 982	442 774	464 088	576 605	677 957	837 303	1 030 398	3
0	< 1km	0	0 to 4	Women	5	Taxi	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	4 483	1 554	3 994	3 673	3 515	3 155	2 963	2 790	
0	< 1km	0	0 to 4	Women	6	PT-Bus	13.0%	5.7%	12.0%	11.8%	10.7%	9.9%	10.4%	10.1%	325 971	96 333	345 108	358 238	368 494	365 830	439 799	493 647	3
0	< 1km	0	0 to 4	Women	7	PT-BRT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	0	0 to 4	Women	8	PT-LRT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	0	0 to 4	Women	9	PT-CableC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	0	0 to 4	Women	10	PT-Rail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	0	0 to 4	Women	11	Bike and S	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	-	-	4 260	4 271	4 412	4 257	7 094	9 237	
0	< 1km	0	0 to 4	Women	12	Ride-shari	1.4%	0.8%	1.1%	1.0%	0.8%	0.7%	0.9%	0.9%	35 982	13 361	33 001	29 600	27 724	24 353	36 811	43 592	
0	< 1km	0	0 to 4	Women	13	Car-Sharin	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	0	0 to 4	Women	14	On-deman	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	1	5 to 19	Men	1	Walk	72.1%	80.6%	69.2%	69.4%	68.8%	67.8%	65.8%	64.4%	5 372 513	4 041 675	5 888 804	6 239 531	6 991 092	7 385 161	8 261 312	9 310 726	4 8
0	< 1km	1	5 to 19	Men	2	Bicycle	0.9%	1.4%	1.1%	1.4%	1.6%	1.7%	1.8%	2.0%	65 876	68 111	91 471	130 301	160 664	186 692	229 661	284 583	
0	< 1km	1	5 to 19	Men	3	Motorcycle	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	21 382	7 634	20 398	19 133	18 874	17 539	17 251	17 080	
0	< 1km	1	5 to 19	Men	4	Car	13.4%	11.9%	17.3%	17.2%	18.8%	20.6%	22.0%	23.5%	1 001 128	599 308	1 473 147	1 543 178	1 911 239	2 240 274	2 762 445	3 391 650	1 3
0	< 1km	1	5 to 19	Men	5	Taxi	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	13 179	4 543	11 668	10 726	10 231	9 156	8 585	8 064	
0	< 1km	1	5 to 19	Men	6	PT-Bus	11.6%	5.1%	10.7%	10.5%	9.6%	8.8%	9.2%	8.9%	867 059	254 864	912 287	946 454	970 465	960 485	1 152 861	1 291 025	9
0	< 1km	1	5 to 19	Men	7	PT-BRT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	1	5 to 19	Men	8	PT-LRT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	1	5 to 19	Men	9	PT-CableC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	1	5 to 19	Men	10	PT-Rail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	
0	< 1km	1	5 to 19	Men	11	Bike and S	0.0%	0.0%	0.2%	0.2%	0.2%	0.1%	0.2%	0.2%	-	-	15 201	15 233	15 683	15 085	25 103	32 608	
0	< 1km	1	5 to 19	Men	12	Ride-shari	1.4%	0.8%	1.1%	1.0%	0.8%	0.6%	0.8%	0.9%	105 776	39 066	96 411	86 425	80 694	70 664	106 643	125 995	1
0	< 1km	1	5 to 19	Men	13	Car-Sharin	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	

! This sheet should not be edited by the user. Its content is the result of the data input sheets, scenario assumptions and model calibration, it will automatically be updated.

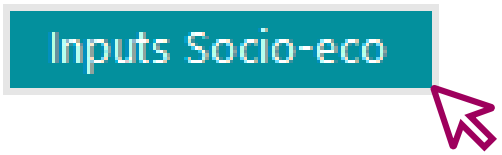
Reading detailed output

Congratulations, you now know how to get more disaggregated data!

Editing model data input

1. Adjusting socio-economic & demographic data:

Access the “Inputs Socio-eco” sheet:



Socio-economic Inputs - Values in this sheet can be modified by the user

Estimations of demographic and Geographic characteristics of the Ulaanbaatar Urban area

		2015	2020	2025	2030	2035	2040	2045	2050
Population by zone	1.Баруун бүс - West zone	235,298	262,187	275,548	284,204	291,617	302,002	309,590	316,108
	2.Баруун өмнөд бүс - South West zone	55,435	79,488	106,888	133,239	159,664	188,588	248,780	326,881
	3.Баруун хойд бүс - North West zone	234,855	274,285	300,161	321,306	341,382	365,379	392,583	420,135
	4.Зүүн бүс - East zone	174,482	212,330	241,296	266,745	291,538	319,978	358,233	399,468
	5.Төвийн бүс - Central zone	296,702	313,737	316,327	313,070	308,066	305,702	297,391	288,157
	6.Хойд бүс - Northern zone	166,909	184,928	193,442	198,622	202,908	209,227	213,268	216,522
	7.Шинэ бүс - New zone	21,537	32,565	46,450	59,949	73,529	88,314	122,855	170,226
	TOTAL	**1,185,219**	**1,359,521**	**1,480,113**	**1,577,135**	**1,668,703**	**1,779,189**	**1,942,700**	**2,137,496**
Population of the subcentre by zone	1.Баруун бүс - West zone	12,209	19,823	32,186	44,550	56,913	69,276	81,639	94,003
	2.Баруун өмнөд бүс - South West zone	1	86	7,602	15,118	22,634	30,150	37,666	45,182
	3.Баруун хойд бүс - North West zone	21,475	28,182	36,983	45,785	54,586	63,387	72,188	80,990
	4.Зүүн бүс - East zone	65,245	65,881	66,523	67,165	67,807	68,449	69,091	69,733
	5.Төвийн бүс - Central zone	152,520	149,523	146,585	143,648	140,710	137,772	137,772	137,772
	6.Хойд бүс - Northern zone	28,742	33,124	38,174	43,224	48,274	53,324	58,374	63,424
	7.Шинэ бүс - New zone	23	481	10,127	19,773	29,418	39,064	48,710	58,356
	TOTAL	**280,215**	**297,100**	**338,181**	**379,261**	**420,342**	**461,422**	**505,440**	**549,459**
Share of the population by age and gender	Women between 0 and 4	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%
	Women between 5 and 19	11.4%	11.4%	11.4%	11.4%	11.4%	11.4%	11.4%	11.4%
	Women between 20 and 59	32.2%	32.2%	32.2%	32.2%	32.2%	32.2%	32.2%	32.2%
	Women over 60	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%
	Men between 0 and 4	4.6%	4.6%	4.6%	4.6%	4.6%	4.6%	4.6%	4.6%
	Men between 5 and 19	11.1%	11.1%	11.1%	11.1%	11.1%	11.1%	11.1%	11.1%
	Men between 20 and 59	30.2%	30.2%	30.2%	30.2%	30.2%	30.2%	30.2%	30.2%
	Men over 60	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%
DP in nbaatar	USD per capita	6,529	6,257	7,902	9,547	11,584	13,782	16,113	18,595

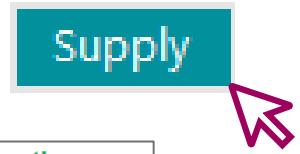
You can adjust all the input values for the population, its distribution into age and gender groups, GDP per capita and area size between 2015 and 2050: you just need to replace the values in the table.

N.B. Cells in grey and columns and raw titles cannot be edited.

Editing model data input

2. Adjusting transport supply data:

Access the “Supply” sheet:



You can adjust all the input values for the vehicle fleet size, the transport services size and the transport fares in 2015 and 2020: you just need to replace the values in the table.

N.B. Cells in grey and columns and raw titles cannot be edited. Blank cells are not considered, and the model automatically makes a linear regression for getting a value.

Transport supply Inputs - Values in this sheet can be modified by the user

Vehicle fleet in the Ulaanbaatar urban area

		2015	2020
Cars	Total number of registered vehicles	315 611	444 086
	Right-hand	52.2%	65.2%
	Left-hand	47.8%	34.8%
Motorcycle	Total number of registered vehicles	5415	9812

Transport services in the Ulaanbaatar urban area

	2015	2020
Taxi fleet (total)	600	600
Share of PT subscription	0%	0%

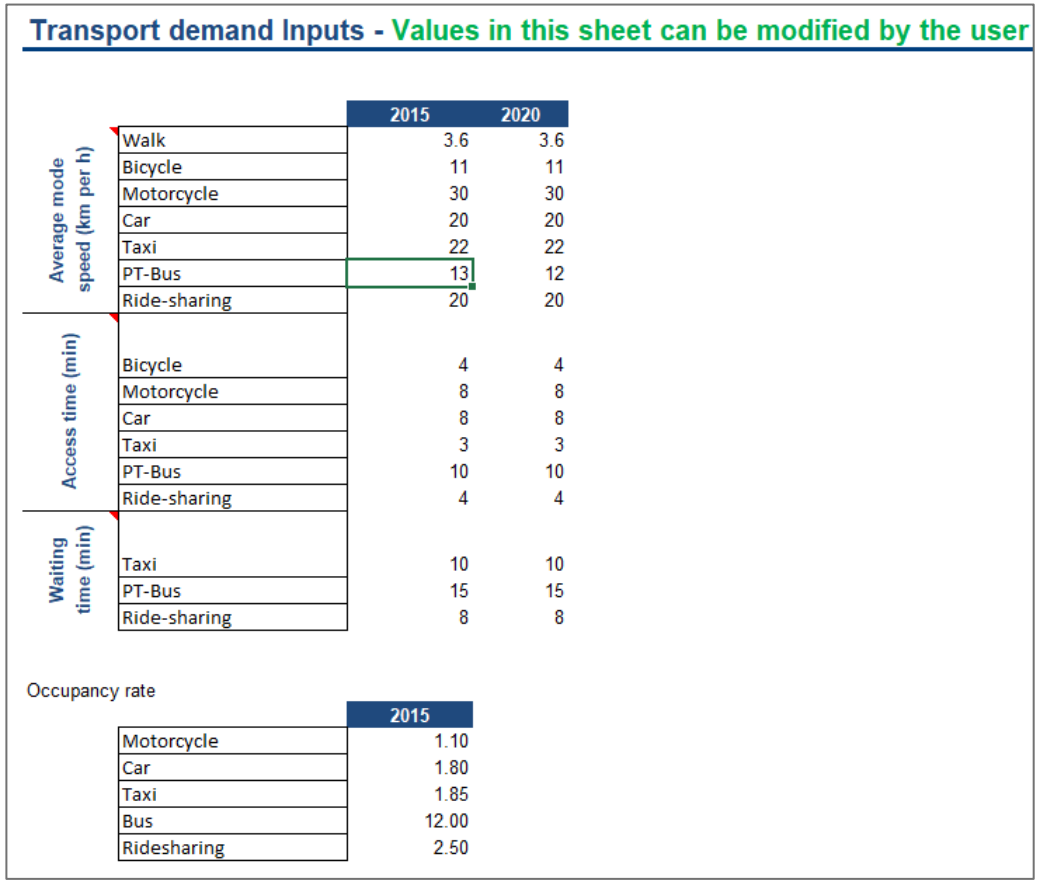
Transport fares in the Ulaanbaatar urban area

		2015	2020
Road Transport	Parking cost (USD per h)		0.36
	Gasoline cost (USD per L)	0.90	
	Electricity cost (USD per MJ)	0.01	0.01
	Taxi: Fixed (USD)	0.42	
	Taxi: Distance (USD per km)	0.35	
	Taxi: Time (USD per h)	7.60	
Public Transport	PT ticket (USD)	0.23	
	Monthly PT subscription (USD)	0.00	0.00

Editing model data input

3. Adjusting transport demand data:

Access the “Demand” sheet:

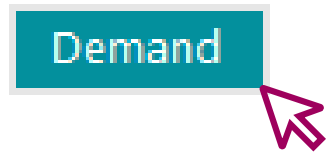


Transport demand Inputs - Values in this sheet can be modified by the user

		2015	2020
Average mode speed (km per h)	Walk	3.6	3.6
	Bicycle	11	11
	Motorcycle	30	30
	Car	20	20
	Taxi	22	22
	PT-Bus	13	12
	Ride-sharing	20	20
Access time (min)			
	Bicycle	4	4
	Motorcycle	8	8
	Car	8	8
	Taxi	3	3
	PT-Bus	10	10
	Ride-sharing	4	4
Waiting time (min)			
	Taxi	10	10
	PT-Bus	15	15
	Ride-sharing	8	8

Occupancy rate

	2015
Motorcycle	1.10
Car	1.80
Taxi	1.85
Bus	12.00
Ridesharing	2.50



You can adjust all the input values for the average mode speed, the access time (time to access the mode, e.g. time to get to a bus stop), and the waiting time (e.g. time waiting for a bus at the bus stop) between 2015 and 2050: you just need to replace the values in the table. Occupancy rate are only provided for 2015.

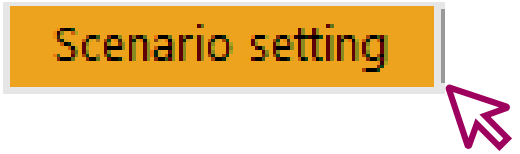
N.B. Cells in grey and columns and raw titles cannot be edited.

Reading detailed output

Congratulations, you now know how to edit the model input data!

Editing model parameters

1. Access the “Model-Calibration” sheet:



2. Read the description of the formulas & regressions:

Make sure that you understand the role of each parameter in the function before trying to adjust them.

3. Edit the parameter values:

Increase or decrease the parameter(s) to reach the expected adjusted effect. It is advised to make minor iteration from the original value.

4. Validate:

Check that the parameter change had the desired effect and update it again if not.

Calibration - Values in this sheet can be modified by the user

Modal Costs

PT Fare, Gasoline and Taxi Models

Future gasoline price is determined by the existing price, as well as the average fuel consumption per kilometer per vehicle , which is influenced by the evolution of population and GDP per capita and average car load factor.

$$cost_{new} = cost_{old} \times (1 + Elasticity \times (\frac{GDPcap_{new}}{GDPcap_{old}} - 1))$$

$$PT\ cost_{new} = PT\ cost_{old} \times (1 + Elasticity \times (\frac{GDPcap_{new}}{GDPcap_{old}} - 1)) \times (1 + \boldsymbol{PT_{FARE}coeff} \times \boldsymbol{PT_{FARE}})$$

Elasticities to GDP per capita increase

	Elasticity	PT_FAREcoeff
Parking cost	1.00	
Gas cost	1.00	
Electricity cost	1.00	
Taxi - fixed cost	1.00	
Taxi - distance cost	1.00	
Taxi - time cost	1.00	

Reading detailed output

Congratulations, you can now edit the modelling assumptions!

International Transport Forum

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Sustainable Infrastructure Programme in Asia

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