Decarbonising Transport in Emerging Economies (DTEE) - Azerbaijan

Baku urban passenger model training session

Recalling the context

- The ITF team has worked with the Azerbaijan Ministry of Digital Development and Transport and the Baku Transport Authority to build 3 tools that allow to assess the impact of policy measures on transport demand and related emissions to 2050.
- The 3 tools are MS Excel-based and cover:
  - Passenger transport in Baku **[FOCUS OF THIS PRESENTATION]**
  - Passenger transport in Azerbaijan (excl. Baku)
  - Freight transport in Azerbaijan
- The tools (incl. training material) are made available to any interested stakeholders

Recalling the context

- The tools should **help policy makers put in place efficient policy measures** to reduce carbon emissions from transport.
- Results may feed national or international policy documents (e.g. national transport plans or updates of Azerbaijan's NDC).

- The tools were developed in the context of the Decarbonising Transport in Emerging Economies project (www.itf-oecd.org/dtee)

Goal of the user manual

Present the modelling tool for Baku in detail, explain its structure and how its components interact

Objectives:

- Model users are able to understand and use the tool for scenario analysis
- Model "handlers" are able to update modelling assumptions
- Use this presentation as a manual for future users

This training presentation should be used together with the model methodology note

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 2020, from which the structure, formulas and initial calibration were extracted

The model covers Greater Baku area and relies on inputs from local sources:

- State Statistical Committee of the Republic of Azerbaijan
- Baku Transport Agency

Model uses

It is a **strategic modelling tool** allowing to assess the impact of CO2 mitigation measures, including:

- **Pricing policies** (e.g. parking pricing, carbon pricing)
- **Restrictive measures** (e.g. parking restrictions)
- **Shared modes promotion** (car sharing, on-demand bus, etc.)
- **Public Transport promotion** (various PT improvements and MaaS)
- **Soft modes and low emission vehicles promotion**
- **Exogenous scenario variables** (e.g. autonomous vehicles, teleworking)

It allows developing policy scenarios to 2050 and assessing related transport activity and related emissions

1. Introduction
2. **Model components**

    Scope

    Modelling structure

    Main functions

    Input data

    Sub-Models

    Detailed outputs

Level of disaggregation

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

- 18 modes (current and possible future ones)
- 2 genders and 5 age cohorts
- 6 trip distance bins
- 5 fuel types (gasoline, diesel, electric, methane, H2)
- 5 years step from 2015 to 2050

18 transport modes

Active modes

- Walking
- Biking
- Scooter sharing
- Bike sharing

Private vehicle modes

- Motorcycle
- Car

Public transport modes

- Light Rail
- Rail
- Metro
- Bus
- BRT

Paratransit modes

- Informal Bus
- Informal 3-wheelers

Shared mobility modes

- Taxi
- Private ride sharing
- Motorcycle sharing
- Car sharing
- Minibus sharing ("Taxi bus")

Population and Distance Categories

10 population categories **X**

5 age cohorts **X** **2 genders**

5 age cohorts	2 genders
0-19	Female
20-29	Male
30-49	
50-64	
65+	

6 trip distance bins

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

Geographic scope

The study area corresponds to the **City of Baku area**
(12 districts, plus city of Khirdalan and city of Sumgayt)

Area, population and gender shares are based on Baku General Plan 2040, Explanatory Memorandum *(`Baku Masterplan`)*

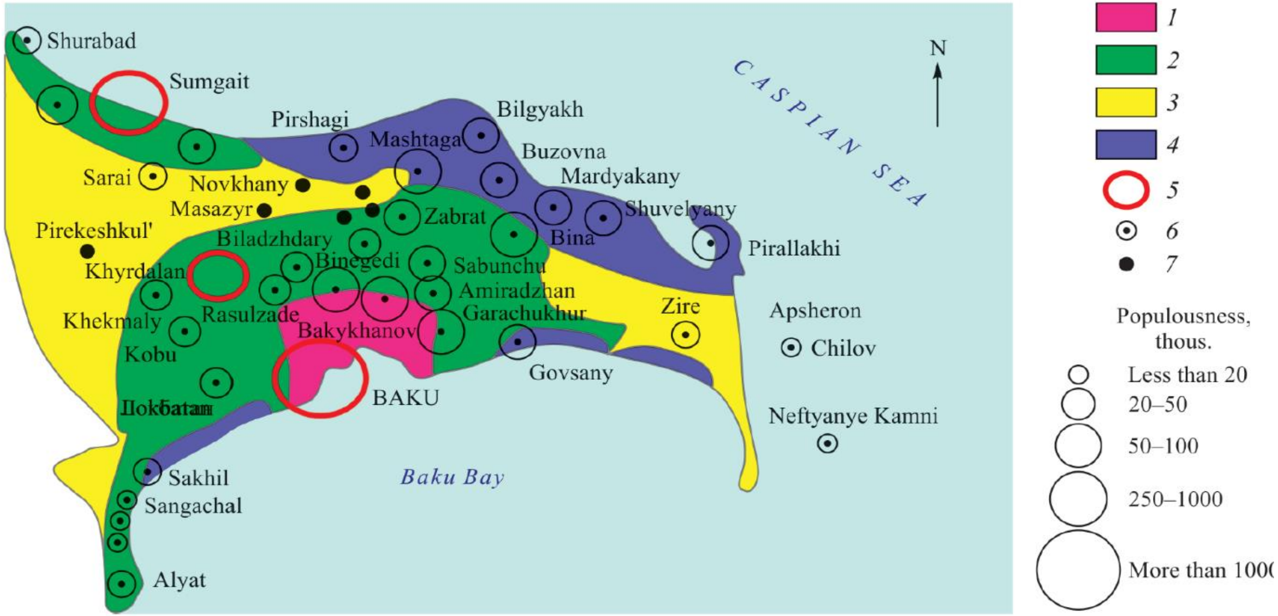
data for the City of Baku for years 2020, 2027, 2040.

Growth rates were derived from this data and applied for each five year interval from 2015 to 2050.

Missing data extrapolated to Sumgayt and Khirdalan.

base year values (2015) for these two cities were obtained from the State Statistical Committee of the Republic of Azerbaijan.

Geographic scope



Schematic map of regionalization of the Baku urban agglomeration.
Zones: *1* – core, *2* – industrial, *3* – industrial-agricultural, *4* – recreational. Settlements: *5* – cities, *6* – villages, *7* – rural settlements.

The City Centre: two scenarios

The city centre for years 2015 – 2020:

6 Baku districts (Sabail, Yasamal, Nasimi, Narimanov, Nizami and Khatai) + cities of Sumgayt and Khirdalan.

2025 – 2050 the city centre structure develops according to two scenarios:

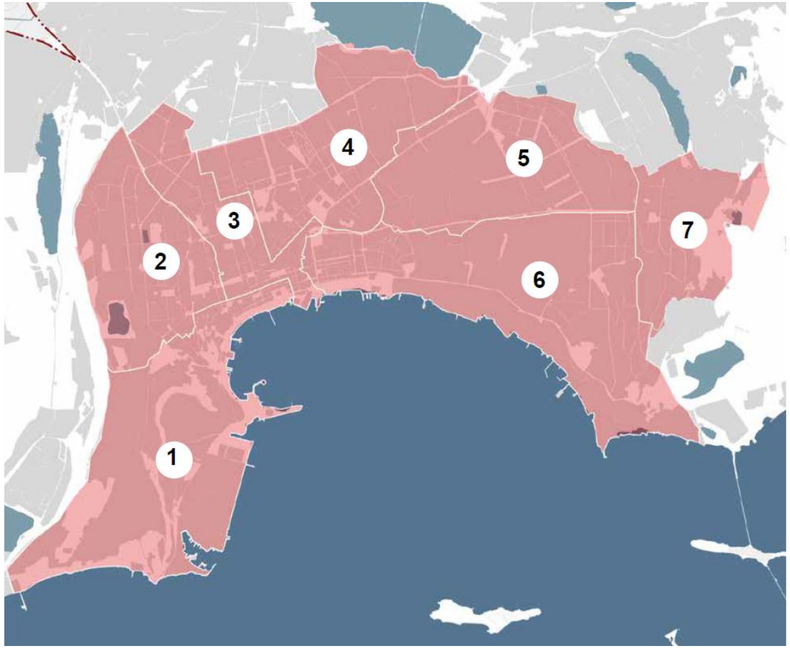
- Base year city centre + settlement of Garachukhur (`Baseline city centre development scenario`).
- Polycentric structure according to '*Baku Masterplan*' ('Polycentric scenario')

The City Centre: Baseline scenario

# on the map	District	2020	2040
1	Sabail	113.007	117.268
2	Yasamal	273.335	303.829
3	Nasimi	239.05	243.488
4	Narimanov	197.567	266.838
5	Nizami	213.687	300.972
6	Khatai	318.312	417.741
7	Garachukhur	96.235	113.134

+ Khirdalan + Sumgayt

Source: Baku General Plan 2040, Explanatory Memorandum (`*Baku Masterplan*`)



The City Centre: Polycentric scenario

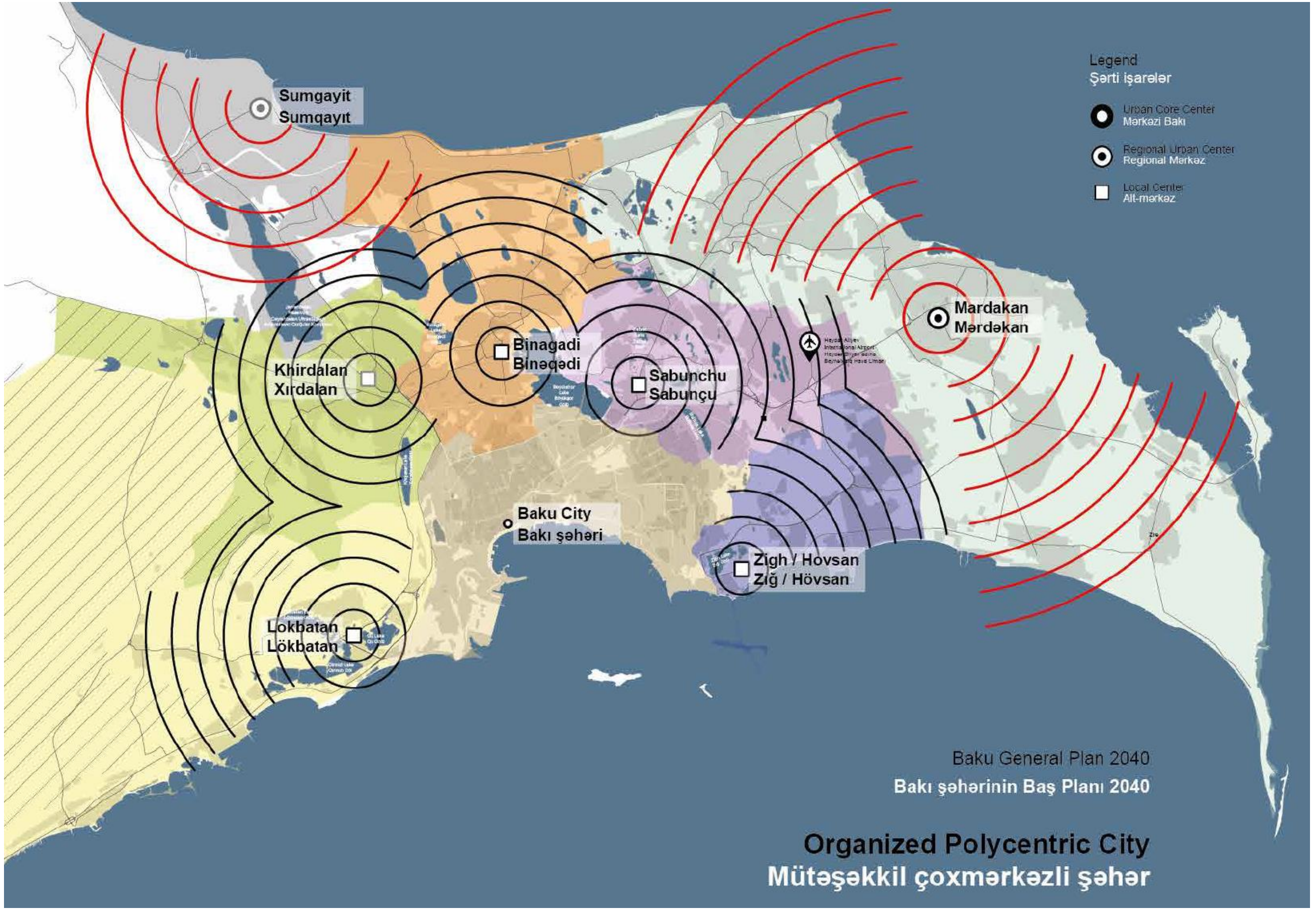
Several settlements around Baku will become additional local centres.

Additional parts of the future city centre are settlements which

- have considerably higher population density (compared to the rest of its region)
- will have considerably high population in 2040 according to the 'Baku Masterplan' (compared to the rest of its region)

The City Centre: Polycentric scenario map

Source: Baku General Plan 2040, Explanatory Memorandum (`Baku Masterplan`)



Polycentric scenario, example of settlements choice

Mardakan Catchment Area Mərdəkanın əhatə dairəsi			Population 2020 Əhali 2020	Residential Capacity of Development Areas until 2040 [1] 2040-cı ilə qədər yeni inkişaf ərazilərində yaşayacaq əhalinin sayı [1]
1	Mardakan	Mərdəkan	33.809	-
2	Kurdakhani	Kürdəxanı	11.240	+ 237
3	Nardaran	Nardaran	25.182	-
4	Bilgah	Bilgəh	10.162	-
5	Mashtaga	Maştağa	52.008	+ 18.839
6	Buzovna	Buzovna	35.541	+ 13.924
7	Shagan	Şağan	4.123	-
8	Gala	Qala	7.163	+ 40.168
9	Shuvelan	Şüvəlan	24.081	-
10	Turkan	Türkan	12.023	-
11	Zira	Zirə	12.604	+ 7.204
12	Gürgan	Gürgən	1.396	-
13	Pirallahi	Pirallahı	17.084	-
-	Chilov	Çilov	1.704	-
-	Neft Dashlari	Neft daşları	400	-
	Population 2020 [1]	**Əhali 2020 [1]**	**248.520**	
	Planned Population 2040 [1] • Planlaşdırılan əhali 2040 [1]			**328.889**

Source: Baku General Plan 2040, Explanatory Memorandum (*`Baku Masterplan`*)

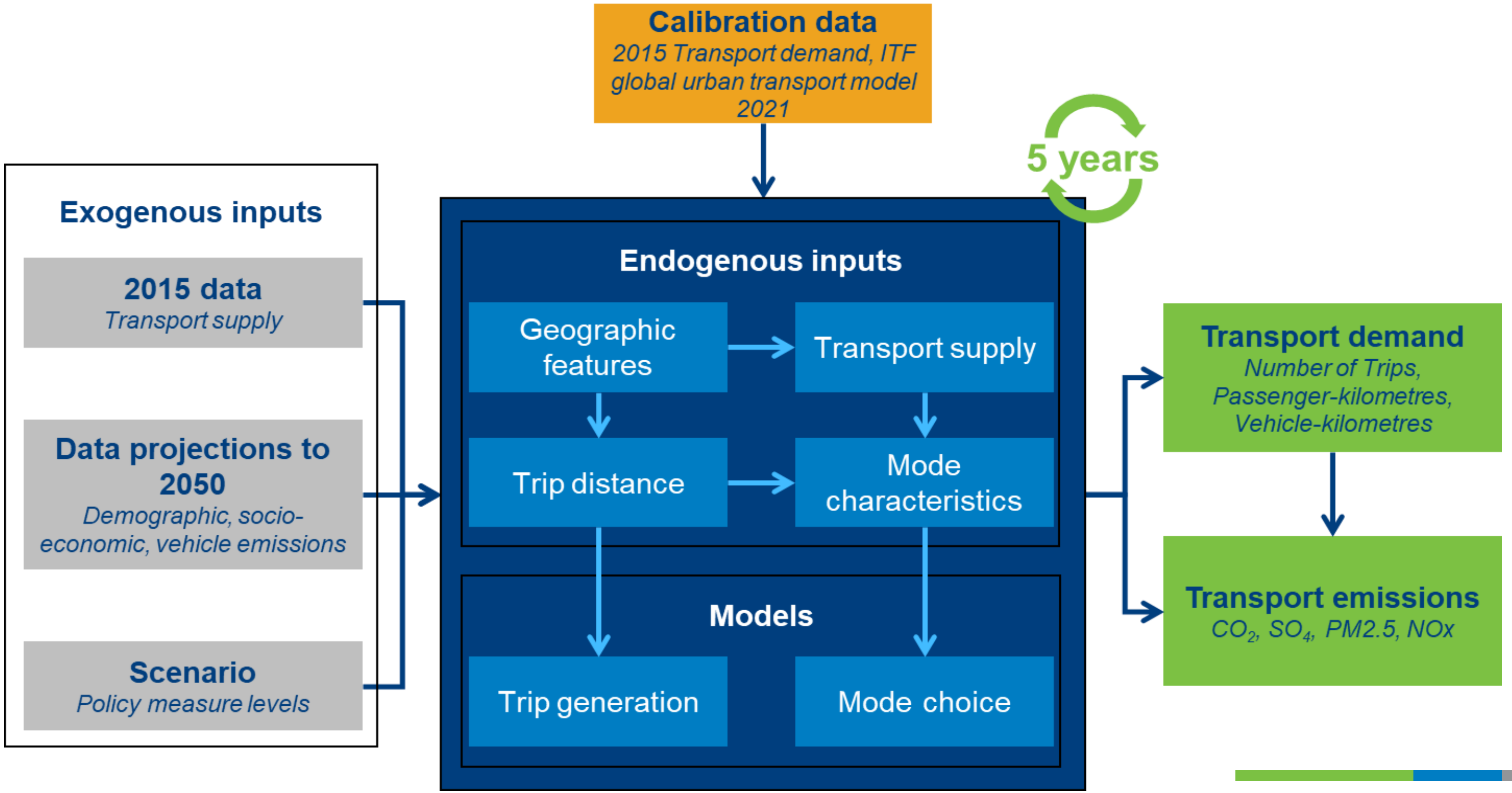
The City Centre:
Polycentric scenario additional settlements

The additional **regions**/settlements are:

- **Mardakan**: Mardakan, Mashtaga, Buzovna, Shagan, Gala, Shuvelan
- **Alat**: Alat + Gobustan
- **Lokbatan**: Lokbatan
- **Khirdalan**: Khirdalan + Khojahasan
- **Binadi**: Binagadi, Biladjari, M. A. Rasulzade

1. **Introduction**
2. **Model components**
   - Scope
   - **Modelling structure**
   - Main functions
   - Input data
   - Sub-Models
   - Detailed outputs

Modelling framework



Main Model Sections

- Cover
- Data explorer
- Scenario & Results
- Model Inputs
- Intermediate Steps
- Model Outputs

Scenario & Results -->

Scenario Setting

Main Results | Saved Results | Results Comparison

Screenshot of the Scenario Template

Scenario Setting

Return to Data Explorer

Please enter/correct manual values in the table below

Cells to fill - **required** | Cells to fill - **optional**

Scenario measures

Measure code	Measure name	Description/Explanation of value to be provided	Insert your values into this column: Anticipated 2050 values — Measure yes	Reference values: 2015 — Base Year Value	Reference values: 2050 — 'Baseline" scenario values as defined by the ITF
Pricing Measures					
Rp	Road pricing	Percentage increase in vehicle usage costs (per km), and, more specfcially, by applying this increase to 2015 vehicle maintenance costs. E.g. 300% of the value of this parameter will correspond to the vehicle usage cost being 20% of the total cost of a vehicle (with being the rest 80% attributed to fuel cost)	0%	Vehicle maintenance cost per vkm: 0.18 USD/km	0%
PKp	Parking pricing	Percentage increase in parking costs to 2015 value.	0%	0.2 USD / hour	0%
Cp	Carbon pricing	Tax levied on tank-to-wheel carbon emissions (in USD/tCO2).	0 USD	0 USD	150 USD
Shared Modes Promotion					
Csi	Car sharing incentives	Number of car sharing vehicles per 1000 capita (if the value entered is less than the one specified in column H (2050 "Baseline" scenario values as defined by the ITF), or left empty, the model takes for 2050 the value specified in column H)	0	0 vehicles per thousand capita	0 vehicles per thousand capita
Csi_moto	Motorcycle sharing incentives	Number of motorcycle sharing vehicles per 1000 capita (if the value entered is less than the one specified in column H (2050 "Baseline" scenario values as defined by the ITF), or left empty, the model takes for 2050 the value specified in column H)	0	0 vehicles per thousand capita	0 vehicles per thousand capita
RSi	Incentives for car-based ride sharing	Number of car-based ride sharing vehicles per 1000 capita (if the value entered is less than the one specified in column H (2050 "Baseline" scenario values as defined by the ITF), or left empty, the model takes for 2050 the value specified in ...	0	0 vehicles per thousand capita	0 vehicles per thousand capita

Filling in the template: general

Insert your values into this column
Anticipated 2050 values
Scenario Name

The user changes the values in *column E*

- The cells to be filled in are highlighted in yellow
- The user is allowed to input values for 2050 or for each year
- Each policy measure has a measure code to refer to (See Measure Code *column B*)
- If a yellow cell is empty, the model considers it equal to zero, with an exception of TECH_car and TECH_bus policy measures (see further)
- To test absence of any measures you can consider having all zeroes besides PTiL_metro, which has to remain constant over time
- Entering the Scenario Name allows to track the scenario in the results sheets

Filling in the template: sales targets for low-emission vehicles

Policy measures: TECH_car, TECH_bus

Setting values here allows overwriting the pre-defined `default` values for the vehicle technology scenarios (set up in the TECH measure, see the IEA NPS/SDS scenarios description in the Methodology Note).

Provide % shares of the different vehicle technologies for 2050 private car sales or registrations / bus fleet.

Make sure the sum of the shares is 100%, otherwise the default IEA NPS/SDS shares will be used.

Make sure to put realistic future values: e.g. if gasoline and electric exist in future, gasoline-hybrid should not be zero

Insert your values into this column	Reference	
Anticipated 2050 values	2015	
Scenario Name	Base Year Value	
5%	Gasoline	87%
	Gasoline-hybrid	0%
5%	Diesel	12%
35%	Diesel-hybrid	0%
	LPG/CNG	1%
5%	Hydrogen	0%
	Hydrogen-hybri	0%
50%	Electric	0%
100%	**Total**	**100%**

Filling in the template: PT infrastructure Improvement

Fill in the total network length in km for each mode and year

Make sure the following years are non-zero once the value becomes non-zero for a certain mode. See an example below

Measure code	Measure name	Description/Explanation of value to be provided	Insert your values into this column Anticipated 2050 values Scenario Name	20 Base Ye
PTiI_LRT	Public transport infrastructure improvement. LRT	LRT total network length (in km). Please fill in all the cells or left all empty/zeroes.	0.0	2015
			0.0	2020
			0.0	2025
			20.0	2030
			20.0	2035
			25.0	2040
			30.0	2045
			30.0	2050
PTiI_metro	Public transport infrastructure improvement metro	Metro total network length (in km). Please fill in all the cells or left all empty/zeroes.	36.6	2015
			36.6	2020
			36.6	2025
			36.6	2030
			36.6	2035
			36.6	2040
			36.6	2045
			36.6	2050

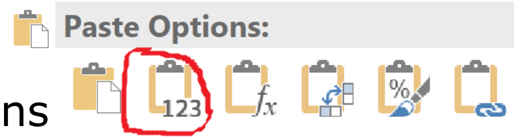
The results

Aggregated results can be found in sheet Main Results

Detailed results are in section Model Outputs -->

To compare aggregated results, please follow the steps:

- Set scenario name and values for scenario 1 in sheet Scenario Setting
- After the calculation is finished, select the results in Main Results and copy the selection (avoid selecting the sheet title)
- Paste the selection to Saved Results as values.
  To do that: right click on the cell, where the copied data is to be pasted, chose `123` under Paste Options sub-menu. Make sure you pasted the data to the same cells as in the `Main Results` sheet

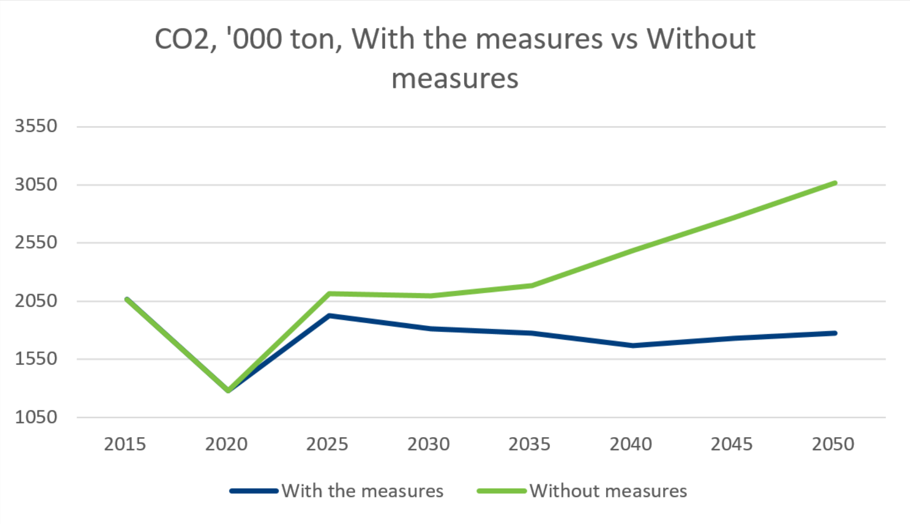


- Set scenario name values for scenario 2 in sheet Scenario Setting
- See the results comparison in sheet Results Comparison

Example: testing the BNA scenarios

	With the measures	Without measures
2015	2065.6836	2065.6836
2020	1280.5874	1280.5874
2025	1922.2717	2115.8618
2030	1810.2988	2096.7667
2035	1772.7378	2185.3802
2040	1664.2569	2481.9386
2045	1730.6257	2769.6949
2050	1774.0883	3067.2530

Change of CO_2 in 2050 between the scenarios: -42.16035260%



Model Inputs -->

Socio-econ. Inputs | Transport Ind. 2015 | Vehicle technology

Model Inputs

The model is initialised with different data inputs:

- base year data from 2015: supply + demand
- external/exogenous projections depicting the evolution of the urban area (e.g. demographics, socio-economics development, vehicle technologies) up until 2050
- scenario inputs: set of policy measures and assumptions either predefined in the model or freely set by the users

Base Year (2015) Inputs: Supply

Transport infrastructure supply

- OpenStreetMaps [www.openstreetmap.org]

(e.g. total lengths of roads by type, Public Transport (PT) infrastructure)

Mode attributes

- as provided by BNA (e.g. travel times, waiting times etc.)

Assumptions where required:

- Mainly based on urban areas with similar characteristics where data is available (e.g. regional data on the CO_2 emissions for the vehicle stock model)

✓ The user can modify the data in this section

Socio-demographic data

Population by age group & gender, area

Base year (2015) and projections until 2050

Calculations based on Baku General Plan, 2040 and 2020 AZE statistics

- The data sources are **color-coded**
- Based on the available data **growth rates** are calculated
- The rest of the cells are calculated based on the growth rates

✓ To modify the data in this sheet the user should be very well familiar with the model

Vehicle data

Vehicle fuel/technology mix, CO_2 and load factors from IEA Mobility Model (MoMo), 4 main tables, including **2 IEA scenarios**

Load factors for private car are updated based on the BNA data

Fuel composition for private car and bus comes from Scenario Setting if specified by the user

Local pollutants emissions: the ICCT Transport Roadmap Model

✓ To modify the data in this sheet the user should be very well familiar with the model

Agenda

1. **Introduction**
2. **Model components**
   - Scope
   - Modelling structure
   - Main functions
   - Input data
   - **Sub-Models**
   - Detailed outputs

Intermediate steps -->

Scenario parameters | Socio-eco Projection

Urban Area descriptors | Sub-models calibration

Vehicle-Stock Model

Trip Rates & Distances | Modal Attributes | Mode Share Utilities

Evolution of scenario parameters

The sheets calculates the evolution of the parameters between the base year and 2050, for which the user defined the value in Scenario Setting

The evolution may follow various paths depending on the parameter

- Linear growth
- Values calculated based on the growth rate between the initial value and 2050
- The parameter can be constant over time representing a corresponding multiplier plugged into the model

The values for 2020 are in most cases are equal to the base year (2015)

✓ <u>The user is not recommended to modify this sheet</u>

Socio-economical projections to 2050

Socio - demographic data is summarized here from Socio-econ. Inputs

- The data is available every 5 years, for 17 age categories, aggregated further into 5 categories, to be used in the subsequent modelling steps

Economic data (= GDP at city level)

- National GDP 2015-2050 from OECD Economics Department
- GDP at the city level based on redistribution of national GDP via distribution maps obtained from LANDSAT program (2010)

✓ The user can modify the economic data in this section while all modifications of the socio-demographic data should be in Socio-econ. Inputs

Sub-models

The sheet contains description of each sub-model and its coefficients

The sheets includes several sections

- **Activation of new modes** – thresholds triggering appearing of new modes
- **Mode choice module** – mode choice model coefficients, base modal attributes, COVID impact coefficients, modes availability/applicability by distance bin
- **Mobility patterns** - trip distance and distance category distribution models, trip rate model
- **Transport supply** – road length models, pt length / reference speed model
- **Modal costs** – PT fare, gasoline and taxi cost models, parking cost update model
- **Vehicle stocks / ownership** – mobility tool ownership models for various modes
- **Other parameters** – autonomous vehicles, carpooling, etc.

✓ The user can modify the parameters in this section to change modal shares, distance bins split, sensitivities to costs, etc. It is recommended to keep a copy of the initial parameters.

Sub-models example: adjusting the mode shares

The model shares can be changed by modifying the mode choice model coefficients. The results are shown in Mode Share

Increasing/decreasing ASC (alternative-specific constant) allows to increase/decrease the mode utility → increase/decrease its share, independently of the modal attributes values.

Changing other coefficients allows making modes more 'sensitive' to changes in modal attributes.

Changes of the model coefficients is not recommended without having good data to validate the changes.

Mode Choice Model

Coefficients of the calibrated multinomial logit mode choice model, used to compute the

$$Utility^m = \sum_i \boldsymbol{Parameter^m}_i * vari$$

Mode	Code	ASC	Reliability
Walk	0	-0.60	0.00
Bicycle	1	-3.00	1.00
Motorcycle	2	-2.80	0.15
Car	3	-0.80	0.14
Taxi	4	-3.63	1.00

Sub-models example: adjusting the distance bins shares

The shares of trips falling into each distance bin can be changed by modifying the distance bin choice model coefficients. The results are shown in Trip Rates & Distances

Increasing/decreasing ASC (alternative-specific constant) allows to increase/decrease the distance bin utility → increase/decrease its share, independently of the attribute values (such as Area, Density, etc.)

Changing other coefficients allow making distance bins more 'sensitive' to changes in their attributes.

Changes of the model coefficients is not recommended without having good data to validate the changes.

Coefficients of the multinomial logit **Distance Category Distribution model**,

$$Utility^d = \mu * (\sum_i \boldsymbol{Parame}$$

The variables are slightly transformed to include thresholde effects, and the im

Distance bin choice model coefficients

Bin	Asc	Area core	Area
0	-11.5000	0.0010	-0.0
1	-9.0000	0.0006	-0.0
2	-1.7608	-0.0007	-0.0
3	0.0002	-0.0016	-0.0
4	8.0000	0.0000	0.0
5	5.0000	-0.0019	0.0

Sub-models example:
adjusting the trip rates gender differences

Increase/decrease of the value of the coefficient for a gender (0 – female) in the Trip Rate Model leads to increase/decrease of the trop rates by this gender for all age categories

The results are in Trip Rates & Distances

Trip Rate Model

Trip Rate Model estimates the average number of trips per person per d

$Trip\ rate = \log(GMPcap * GMP\ per\ capita) * \exp(Constant + Po$

Variable	Trip rate Category	Value
Constant	A	-0.796
GMPcap	M	0.005
Pop_cat	1	0.443
Pop_cat	2	1.212
Pop_cat	3	0.841
Pop_cat	4	0.056
Pop_cat	5	0.026
GDP_cap	1	0.710
GDP_cap	2	0.610
GDP_cap	3	0.476
GDP_cap	4	0.164
GDP_cap	5	0.057
Gender	0	-0.050
Gender	1	0.106
Age_group	0-18	0.136

Characteristics of area and its transport system

The evolution of the area and its transport system characteristics between 2015 and 2050, based on the input data and sub-models

The sections in this sheet are

- Socio-economic and geographic characteristics
- Transport infrastructure supply
- Transport fares
- Transport service supply
- Reference indicators

✓ The user is not recommended to modify this sheet

Vehicle-Stock Model: summary

This sheet uses IEA projected fuel efficiency to 2050 for new vehicles sold

It combines this data with sales assumptions coming from Scenario Setting

Stock composition for year 2015 is based on data coming from Baku

Fuel efficiency towards 2050 follows the evolution of the IEA estimates on the base year value or evolves based on the growth rates to reach values specified in Scenario Setting

Old vehicles exit the fleet based on the survival curve

Average annual VKM by age group were calculated to match fleet average VKM resulting by the model outputs and the vehicle stock inputs

- this is calculated with delay of 5 years to avoid circular referencing and to reflect the inertia of buyers to changing transport situation

All the cells that can be updated by the user in this sheet are highlighted in green

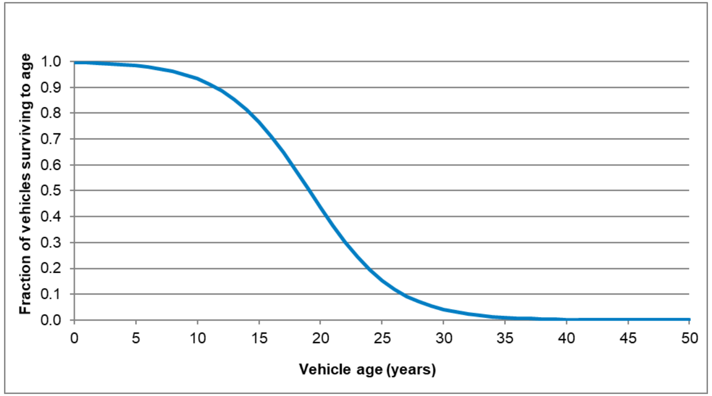
International Transport Forum

Vehicle-Stock Model

Vehicle-Stock Model: vehicle survival curve

Gives information on the likelihood of a vehicle remaining in the car fleet for at least one more year after having reached a certain age.

Can be adjusted by the user



Survival curves

			Private cars
aggregated values survival curve cars		Veh Age	
Age	**Survival pro**	0	**0.99881805**
0-5	0.99381918	1	**0.99699559**
5-10	0.97214089	2	**0.99459539**
10-15	0.95012728	3	**0.99143043**
15-20	0.77871925	4	**0.98725646**
20-25	0.35404895	5	**0.98175685**
25-30	0.07709194	6	**0.97452554**
30-35	0.02045135	7	**0.96504906**
35-50	0.05259612	8	**0.95269077**
		9	**0.93668224**
		10	**0.91613042**
		11	**0.89005281**
		12	**0.85745544**
		13	**0.81746690**
		14	**0.76953081**
		15	**0.71363584**
		16	**0.65052777**
		17	**0.58181887**
		18	**0.50991107**
		19	**0.43770272**
		20	**0.36814048**
		21	**0.30375550**
		22	**0.24633112**
		23	**0.19678261**
		24	**0.15523504**

Vehicle-Stock Model: fleet by year

Fleet distribution by year:

The values are assigned to match the BNA statistics data on shares of vehicles by age in 2020:

< 5 years old - 6.6%

5 – 10 years old – 24.2%

> 10 years old – 69.2%

vehicle	manufacture	number	share
40	1975	62	0.0001
39	1976	62	0.0001
38	1977	124	0.0002
37	1978	124	0.0002
36	1979	186	0.0003
35	1980	186	0.0003
34	1981	248	0.0004
33	1982	248	0.0004
32	1983	310	0.0005
31	1984	310	0.0005
30	1985	310	0.0005
29	1986	372	0.0006
28	1987	372	0.0006
27	1988	621	0.001
26	1989	1055	0.0017
25	1990	1365	0.0022
24	1991	1862	0.003
23	1992	7447	0.012

Vehicle-Stock Model: annual km by age group

Share of annual km per vehicle by age group

Should be equal to 1

Average annual vkm by age group						
	Age	Annual km	Result fleet average	Target resulting by VKM/total fleet	Calculated fleet average	Share of Annual km per vehicle
0	5	13 899	10978	60 428.97	10978	0.23
5	10	12 690				0.21
10	15	10 877				0.18
15	20	9 669				0.16
20	25	9 064				0.15
25	50	4 230				0.07

Vehicle-Stock Model: emissions

If there are data on CO2 emissions per VKM of private cars in Azerbaijan, the zeroes can be substituted with the actual values

CO2 per VKM									
		2015	2020	2025	2030	2035	2040	2045	2050
	fleet average CO2 following BNA data	0	0	0	0	0	0	0	0
		2 015	2 020	2 025	2 030	2 035	2 040	2 045	2 050
	fleet average CO2 following IEA data	183.8	180.6	175.2	166.1	156.8	149.8	143.9	138.1

Then '1' should be set in the cell highlighted in light-green in the table below, so the model uses the BNA data instead of the IEA ones

CO2 per VKM									
To use BNA data, write value 1 in cell M7; To use IEA data, write value 0.									
	IEA								
	0	2 015	2 020	2 025	2 030	2 035	2 040	2 045	2 050
	fleet average CO2 following IEA data	183.79	180.59	175.16	166.13	156.75	149.79	143.86	138.14

Vehicle-Stock Model: annual km by age group

Percentage of new / 5-10 year old / 10 -15 year old car sales reflect the sales of second-hand cars. For other car ages the number of sold vehicles is assumed to be negligible.

Multiplier for annual km reduction reflects assumption that the average annual VKM by age group reduces with time (for all age groups).

Vehicle-Stock Model

Return to Data Explorer

			2020	2025	2030
		percentage of new cars sales	0.13	0.14	0.16
		percentage of 5-10 year old cars sales	0.65	0.64	0.63
		percentage of 10-15 year old cars sales	0.22	0.22	0.21
Total stock by Vehicle age		**multiplier for annual km reduction**	0.95	0.75	0.9

		2015	2020	2025	2030
0	5	27 307	21 845.40	20 753.1315	54 427.4600
5	10	160 365	122 284.74	139 958.2083	255 018.8621
10	15	230 246	179 839	158 135.2146	228 068.3146
15	20	142 119	188 708	147 395.4445	129 606.7793
20	25	54 614	64 615	85 797.1385	67 014.1417
25	50	5 958	12 014	14 315.2669	18 974.5555
		620 608	**589 306**	**566 354**	**753 110**

Vehicle-Stock Model: main outputs

Total number of private cars per year

Total stock by Vehicle age		multiplier for annual km reduction	0.95	0.75	0.9
		2015	2020	2025	2030
0	5	27 307	21 845.40	20 753.1315	54 427.4600
5	10	160 365	122 284.74	139 958.2083	255 018.8621
10	15	230 246	179 839	158 135.2146	228 068.3146
15	20	142 119	188 708	147 395.4445	129 606.7793
20	25	54 614	64 615	85 797.1385	67 014.1417
25	50	5 958	12 014	14 315.2669	18 974.5555
		620 608	**589 306**	**566 354**	**753 110**

Car ownership

Carownership	Year		
	2015	2020	2025
total pop	2 927 848	3 072 044	3 217 722
car ownership per 1000 capita	212	192	176
increase	1.0	0.9	0.9

Intermediate calculations

The three sheets in the end of this section present some intermediate calculations

- Trip Rates & Distances contains the trips rates by gender and five age categories, and the shares of trips falling in each distance bin
- Modal Attributes presents attributes of each mode (explained in the methodology note), for some of them with the variation depending on the distance bin
- Mode Share Utilities contains the values of the modes utility functions, calculated based on the mode choice parameters from Sub-models calibration (this sheet is hidden).

✓ The user is not recommended to modify these sheet

Model Outputs -->

Mode Share	Trips	PKM	VKM

WTT_CO2	TTW_CO2	NOx	PM2.5	SO4

Model Outputs

- **Number of trips**
- **Average trip distances**
- **Mode shares**

→ **PKM by mode**

Vehicle load factors ↓

VKM by mode

Fuel/technology mix, vehicle fuel economy & emission factors ↓

CO2 and local pollutants by mode

All the outputs are available for 2015 – 2050 by gender

Model Outputs

- **PKM by mode**
- **VKM by mode**
- **Number of trips**
- **Average trip distances**
- **Mode shares**

By distance bin

By gender

- **CO_2 by mode**
- **Local pollutants by mode**

By fuel type

By gender