MODELLING APPROACH AND DATA REQUIREMENTS: CASE OF BAKU URBAN MOBILITY MODEL

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SIPA
Sustainable Infrastructure Programme in Asia

On behalf of:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

of the Federal Republic of Germany

IKI INTERNATIONAL CLIMATE INITIATIVE

International Transport Forum

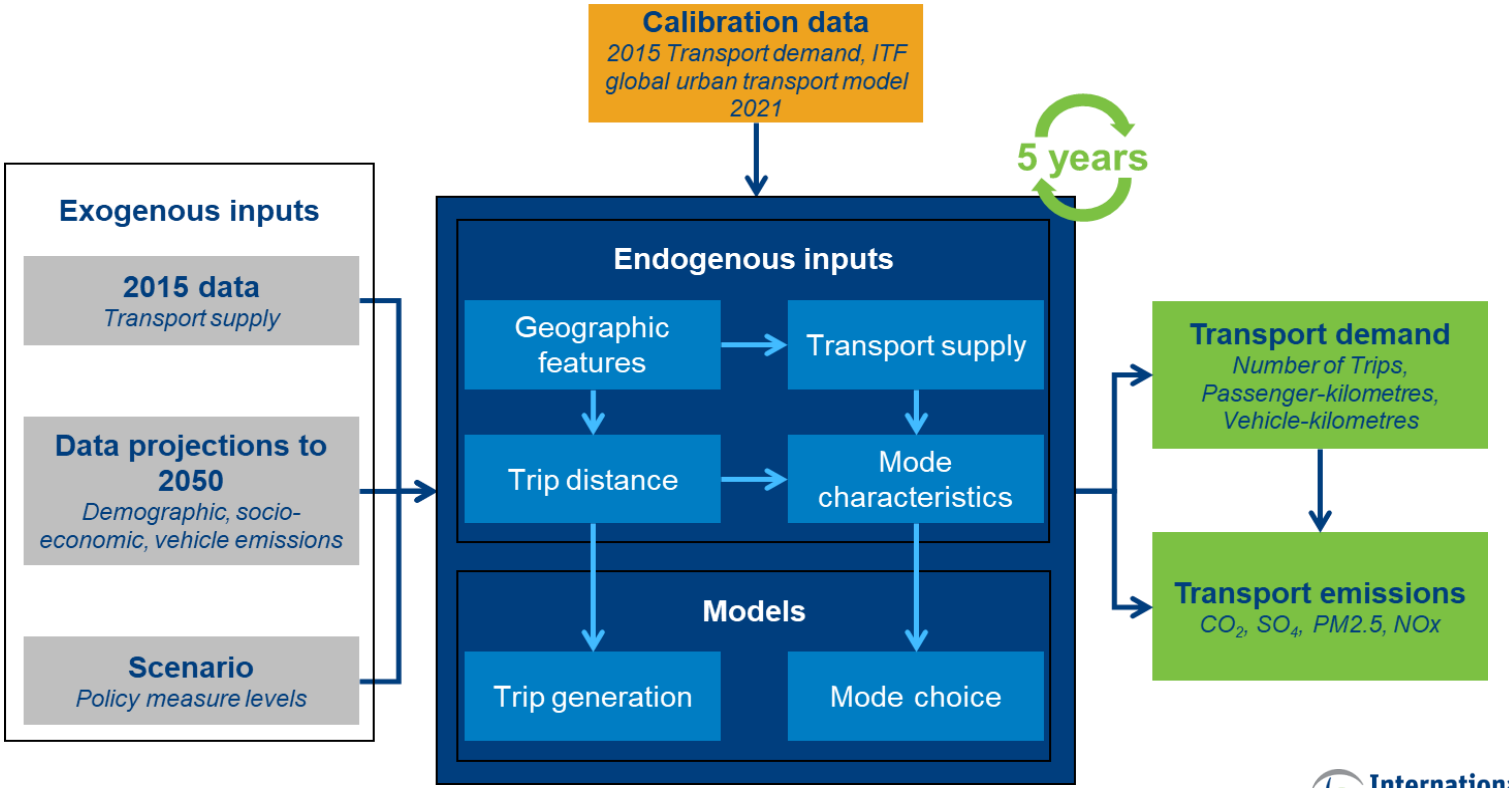
General information about the model

- **The model is built in Excel**, should be used in macro enabled workbooks
- The model is developed based on the **ITF Global Urban Passenger Model**, using from that model the dependencies between variables and parameters
- The model covers the **Greater Baku area** and uses several inputs from local sources
  - State Statistical Committee of the Republic of Azerbaijan
  - Baku Transport Agency
  - ITF Global Urban Passenger Model

Model functions

- The model is a **strategic modelling tool** that allows 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 (e.g. car sharing, on-demand bus)
  - Public transport promotion (various PT improvements and MaaS)
  - Soft modes and low emission vehicles promotion
  - Exogenous scenario variables (e.g. autonomous vehicles, teleworking)
- Allows the user to develop **different policy scenarios** up to 2050 and assess resulting **transport activity and related emissions**

Modelling framework



Level of disaggregation

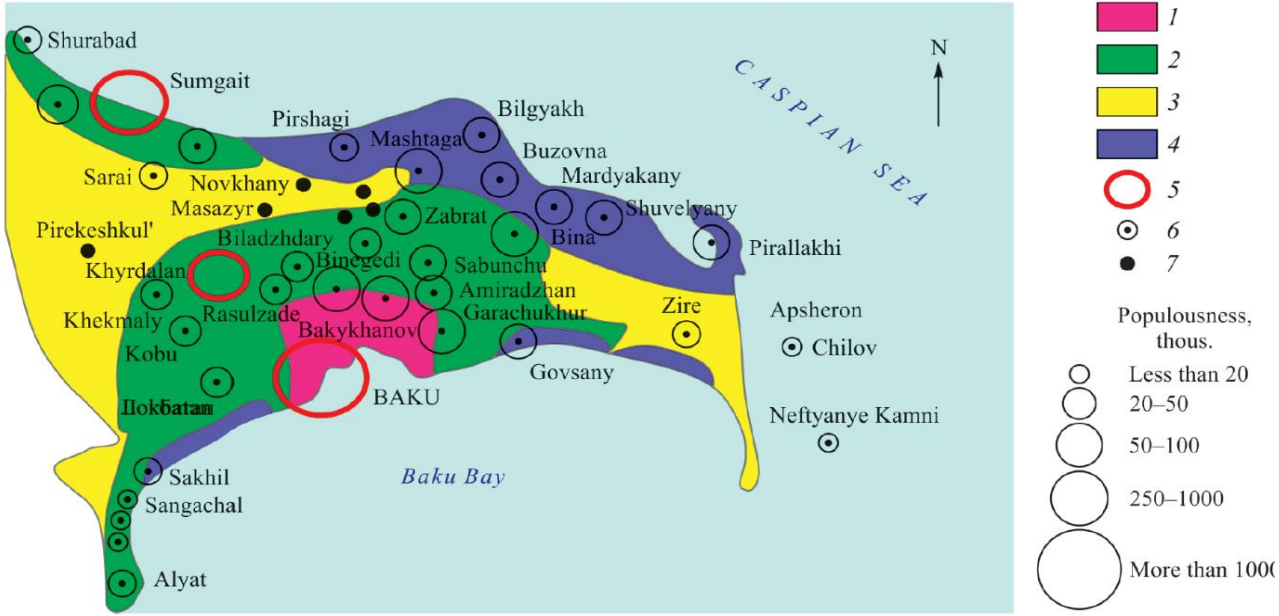
To enhance the representation of the urban mobility for different market segments, the model differentiates:

- **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**

Geographic scope

- The study area corresponds to the **City of Baku area**, consisting of 12 districts, plus the **City of Khirdalan** and the **City of Sumgayt**
- The area, population and gender shares are calculated based on the **Baku General Plan 2040, Explanatory Memorandum ("Baku Masterplan")**
  - Data for the City of Baku for years 2020, 2027, 2040
- Based on these data, the **growth rates are calculated** and applied for each five years from 2015 to 2050
- These growth rates are **extrapolated to Sumgayt and Khirdalan**
  - The base year values (2015) for these two cities are 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.

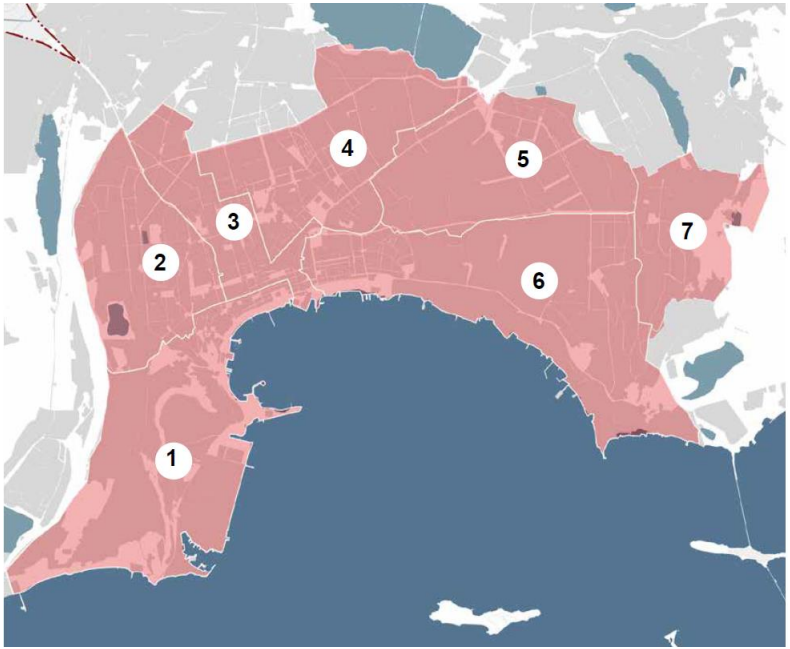
The city centre: two scenarios

- **The city centre for years 2015-2020**
  - 6 Baku districts (Sabail, Yasamal, Nasimi, Narimanov, Nizami and Khatai)
  - Cities of Sumgayt and Khirdalan
- **In 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)
  - In the Polycentric scenario, several settlements around Baku will become additional local centres (settlements with considerably large population and higher population density)

The city centre: Baseline development scenario

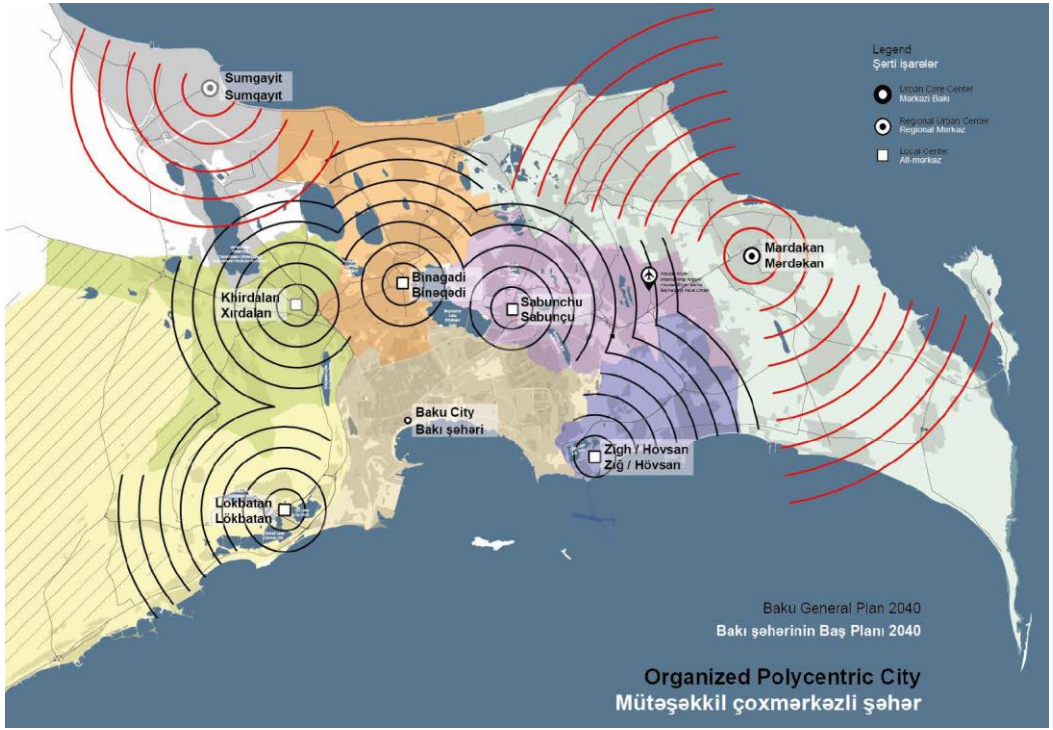
# on the map	District	2020	2040
1	Sabail	113.007	117.268
2	Yasamal	273.335	303.829
3	Nasimi	239.05	243.488
4	Narimanov	197.567	266.838
5	Nizami	213.687	300.972
6	Khatai	318.312	417.741
7	Garachukhur	96.235	113.134

+ Khirdalan + Sumgayt



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

The city centre: Polycentric scenario

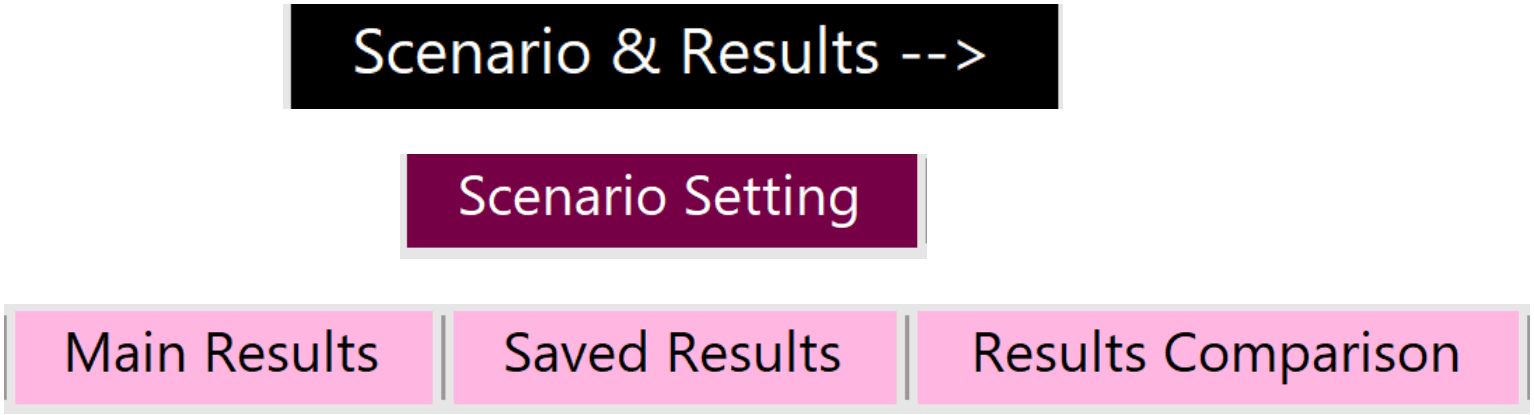


Source: Baku General Plan 2040, Explanatory Memorandum ("Baku Masterplan")

Main model sections

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

Scenario and results



Scenario setting

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 specifcially, 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

Scenario setting

Scenario Setting

While the tool aims to be as comprehensive as possible in the set of policies and measures which can be tested, the four following elements are of particular interest:

- **Urban transport investment** policies (including public transport and NMT)
- Policies related to **urban sprawl and land-use** (teleworking, densification, polycentric structure)
- **Demand management** policies, such as pricing of car ownership and car use or parking policies
- **Vehicle technology, shared mobility**

Model results

- **Aggregated results** can be found in sheet

  Main Results

- **Detailed results** are in section

  Model Outputs -->

- **Results of one scenario can be saved** in the sheet

  Saved Results

- Afterwards, **two scenarios can be compared** in

  Results Comparison

Model inputs

Model Inputs -->	Socio-econ. Inputs	Transport Ind. 2015	Vehicle technology

The model is initialised with different **data inputs**:

- **Base year data** from 2015: supply + demand
- **External/exogenous projections** that depict the evolution of the urban area (e.g. demographics, socio-economic development, vehicle technologies) until 2050
- **Scenario inputs** - a set of policy measures and assumptions either predefined in the model or freely set by the users

Socio-economic inputs

Socio-econ. Inputs

- **Population by age group & gender, area**
- **Base year (2015) and projections until 2050**
- Calculations are based on the **Baku General Plan 2040 and AZE statistics data for 2020**
  - The data sources are color-coded
  - Growth rates are calculated based on the available data
  - The rest of the cells are calculated based on the growth rates

Transport inputs for Base Year (2015)

Transport Ind. 2015

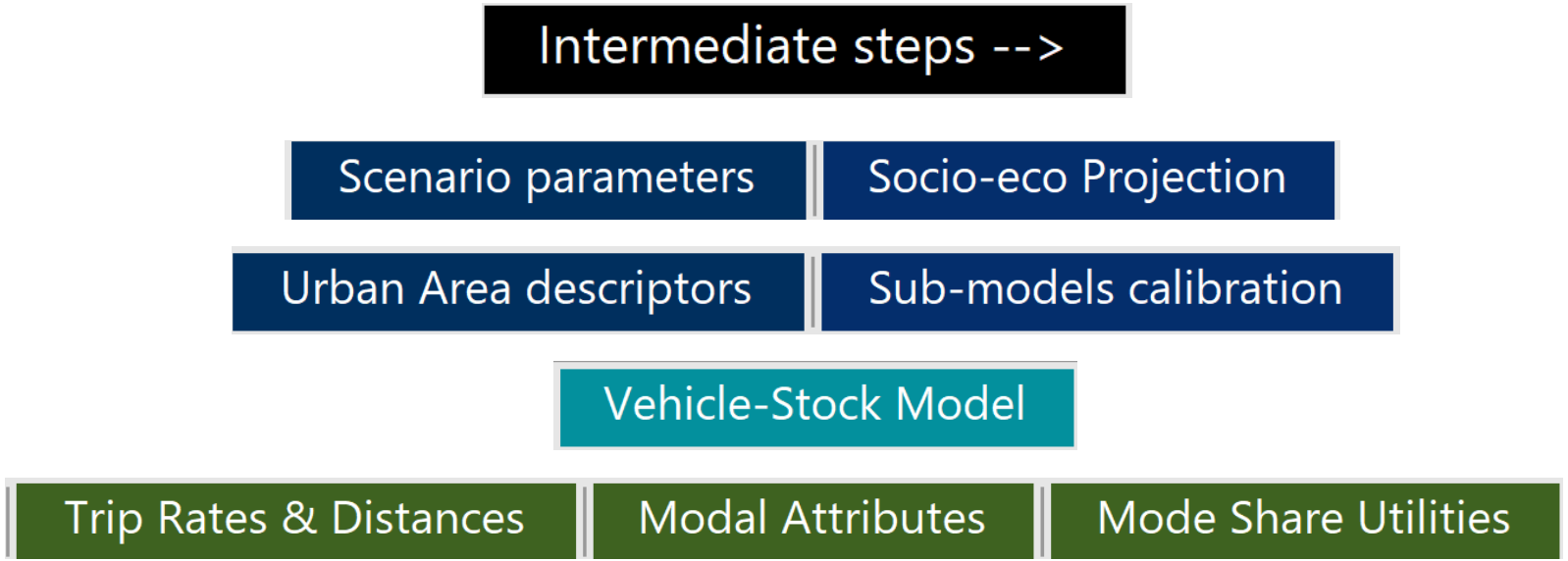
- **Transport infrastructure supply**
  - OpenStreetMaps [www.openstreetmap.org] (e.g. total lengths of roads by type, public transport infrastructure)
- **Mode attributes**
  - As provided by BNA (e.g. travel times, waiting times, etc.)
- **Assumptions where required**
  - Mainly based on urban areas with similar characteristics where data is available (e.g. regional data on the CO2 emissions for the vehicle stock model)

Vehicle technology data

Vehicle technology

- **Vehicle fuel/technology mix, CO2 and load factors** from the 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** are taken from the ICCT Transport Roadmap Model

Intermediate steps



Evolution of scenario parameters

Scenario parameters

- The sheet calculates **the evolution of the parameters** between the base year and 2050, for which the user defined the values 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 equal to the base year (2015)

Characteristics of the area and its transport

Urban Area descriptors

- 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

Socio-economic projections to 2050

Socio-eco Projection

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

Sub-models

Sub-models calibration

- 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.

Vehicle stock model: summary

Vehicle-Stock Model

- This sheet uses the **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 are calculated to match fleet average VKM resulting by the model outputs and the vehicle stock inputs

Vehicle stock model: main outputs

Vehicle-Stock Model

- 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

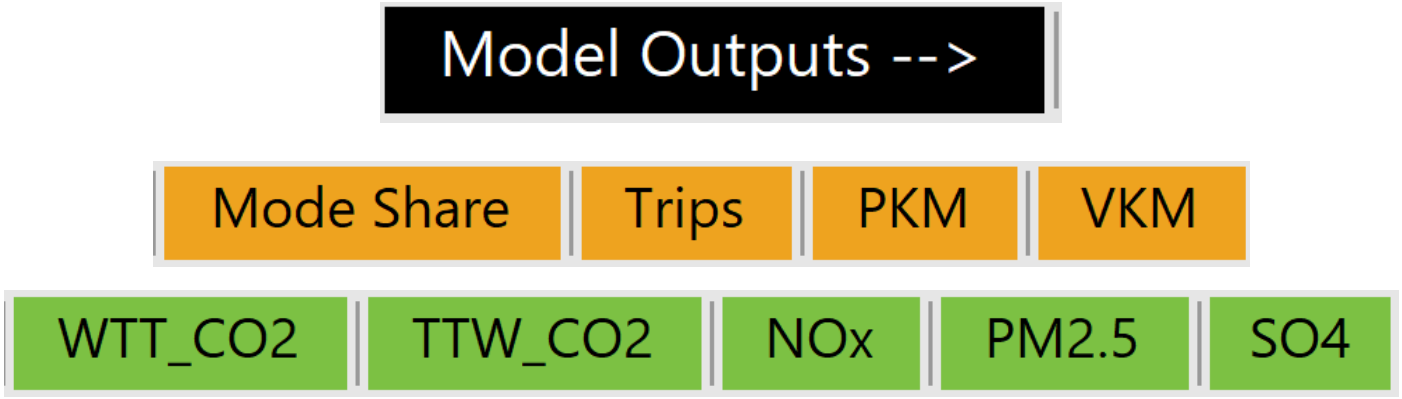
Carownership	Year		
	2015	2020	2025
total pop	2 927 848	3 072 044	3 217 722
car ownership per 1000 capita	212	192	176
increase	1.0	0.9	0.9

Intermediate calculations

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

- Trip Rates & Distances contains **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**, for some of them with the variation depending on the distance bin
- Mode Share Utilities contains values of the mode utility functions, calculated based on the mode choice parameters from Sub-models calibration (this sheet is hidden)

Model outputs



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

Model outputs

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

→ By distance bin, By gender

- CO2 by mode
- Local pollutants by mode

→ By fuel type, By gender

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THANK YOU FOR YOUR ATTENTION

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