ICAT Kyrgyzstan Project

Report on the Methodology for Developing Greenhouse Gas Emission and Removal Forecasts for the Transport Sector

Deliverable 6

Ministry of Natural Resources,
Ecology and Technical Supervision
of the Kyrgyz Republic

ICAT Initiative for
Climate Action
Transparency

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Ministry of Natural Resources,
Ecology and Technical Supervision
of the Kyrgyz Republic

Initiative for Climate Action Transparency – ICAT

Diagnosis/Scoping report containing the scope in activity 1

Deliverable #6

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DISCLAIMER

PREPARED UNDER

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Report on the Methodology for Developing Greenhouse Gas Emission and Removal Forecasts for the Transport Sector

1. Introduction

Forecasting greenhouse gas (GHG) emissions in the transport sector of the Kyrgyz Republic is an important element of national climate policy and sustainable development planning. Transport is one of the key sources of CO_2 emissions in the country, and its contribution to the national emissions continues to grow against the backdrop of an increase in the vehicle fleet and fossil fuel consumption.

The development of reliable and valid emission forecasts is necessary for:

- preparation of national reports within the framework of the United Nations Framework Convention on Climate Change (UNFCCC);
- assessment of the implementation of updated nationally determined contributions (NDCs);
- the formation of climate and transport strategies, including policies on energy efficiency, taxation and the transition to sustainable modes of transport.

This methodology aims to create a transparent and reproducible tool for estimating future GHG emissions in the road transport sector. It allows for the impact of both technical and behavioural factors (e.g. changes in the vehicle fleet structure, fuel demand, pricing policy, etc.) to be taken into account.

Development tasks include:

- formation of scenarios for the short and medium term;
- use of available national and international data sources;
- application of approaches consistent with the recommendations of the Intergovernmental Panel on Climate Change (IPCC).

The intended audience of this report includes government agencies (the Ministry of Natural Resources, Ecology and Technical Supervision of the Kyrgyz Republic, the Ministry of Transport and Communications of the Kyrgyz Republic, the Ministry of Economy and Commerce of the Kyrgyz Republic and the Ministry of Finance of the Kyrgyz Republic), international development partners, as well as national analysts involved in climate planning and reporting.

1. Evaluation summary

- Brief description of the purpose of developing the methodology
- Indication of who prepared the report and when
- Purpose of the forecast: for inventory, planning, reporting (NDC, etc.)
- Key findings, limitations and recommendations

2. Evaluation summary

This report is devoted to the development of a methodology for forecasting greenhouse gas (GHG) emissions and removals in the transport sector of the Kyrgyz Republic. The purpose of the assessment is to create a consistent, transparent and reproducible approach to constructing CO_2 emission scenarios in transport in the short and medium term (2025–2035).

The report was prepared with the technical support of international partners and national experts involved by the Ministry of Natural Resources, Ecology and Technical Supervision of the Kyrgyz Republic. Completion of preparation – June 2025.

The methodology being developed is intended for use in national reports within the framework of Kyrgyzstan's international commitments, including updated nationally determined contributions (NDCs), national reports under the UNFCCC, as well as in the Carbon Neutrality Achievement Plan.

The main findings of the assessment are:

- bottom - up approach, relies on a forecast of fuel demand, an assessment of the change in the vehicle fleet and involves the use of IPCC emission factors.
- The methodology is based on a top-down approach, starting with the forecast of fuel demand using IPCC emission factors.
- Scenario approaches are possible, taking into account the development of alternative transport, policies to improve fuel efficiency and tax incentives.
- There are limitations associated with the incompleteness of statistical data, especially on mileage and vehicle fleet structure.

Further improvements to the data collection system, harmonization of assumptions across agencies, and regular updating of forecasts in line with current transport sector policies and measures are recommended.

3. Description of the transport sector

Physical and geographical features (mountainous terrain, lack of navigable rivers and seas) and economic factors (limited development and high cost of air transportation) predetermine the dominance of automobile transport in the system of domestic transportation of the Kyrgyz Republic.

In foreign trade transportation, the structure remains unchanged: the bulk of freight flows in the northern direction (EAEU countries, Europe) are still carried out primarily by road transport, with an insignificant share of rail transport; in the south-eastern direction (towards China), mainly motor vehicle routes are used. Air transport retains a limited role, mainly in the area of passenger transportation. The volume of transportation carried out by water transport on Lake Issyk-Kul has been reduced to zero and does not represent an active transport category.

The length of the national railway network is 423.9 km. Most of it passes through the Chui region and connects with Kazakhstan. Some short branches pass through the territory of the Osh, Jalal-Abad and Batken regions.

The pipeline transport consists of the Bukhara-Tashkent-Bishkek-Almaty and Mailuu-Suu-Jalal-Abad-Kara-Suu-Osh main gas pipelines and the local gas distribution network.

The dynamics of freight and passenger turnover are shown in Fig. 3.1.1 and 3.1.4. This does not take into account personal vehicles, statistics for which are not available.

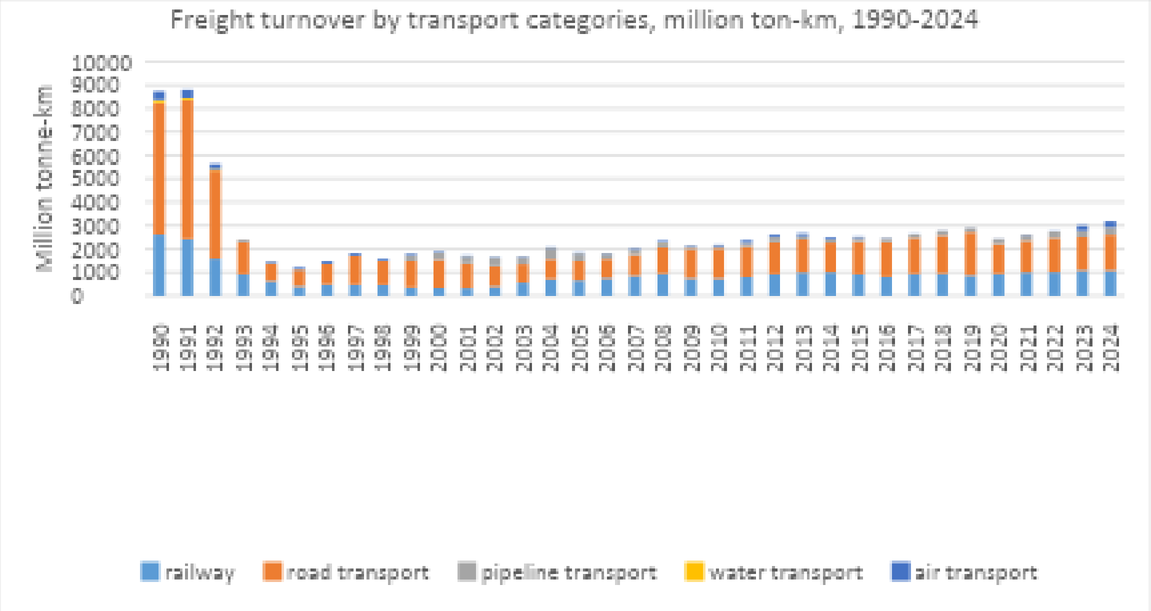

Figure 3. 1. 1. Dynamics of freight turnover by type of transport in the Kyrgyz Republic for 1990-2024 (million ton-kilometers).[1]

Figure 3.1.2 shows the distribution of freight traffic in Kyrgyzstan by type of transport in 1990 and 2024:

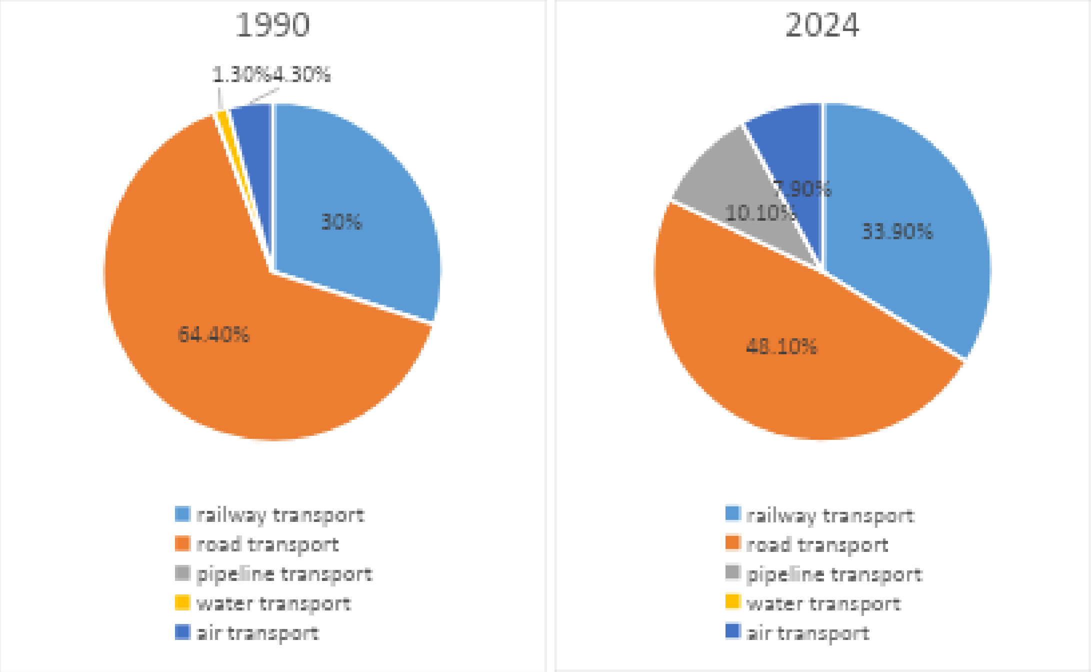

Figure 3.1.2 Structure of freight transportation in 1990 and 2024.

Freight transportation by type of transport is presented in Figure 3.1.3, million tons:

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[1] NSC. http :// www . stat . kg / ru / statistics / transport - i - svyaz /

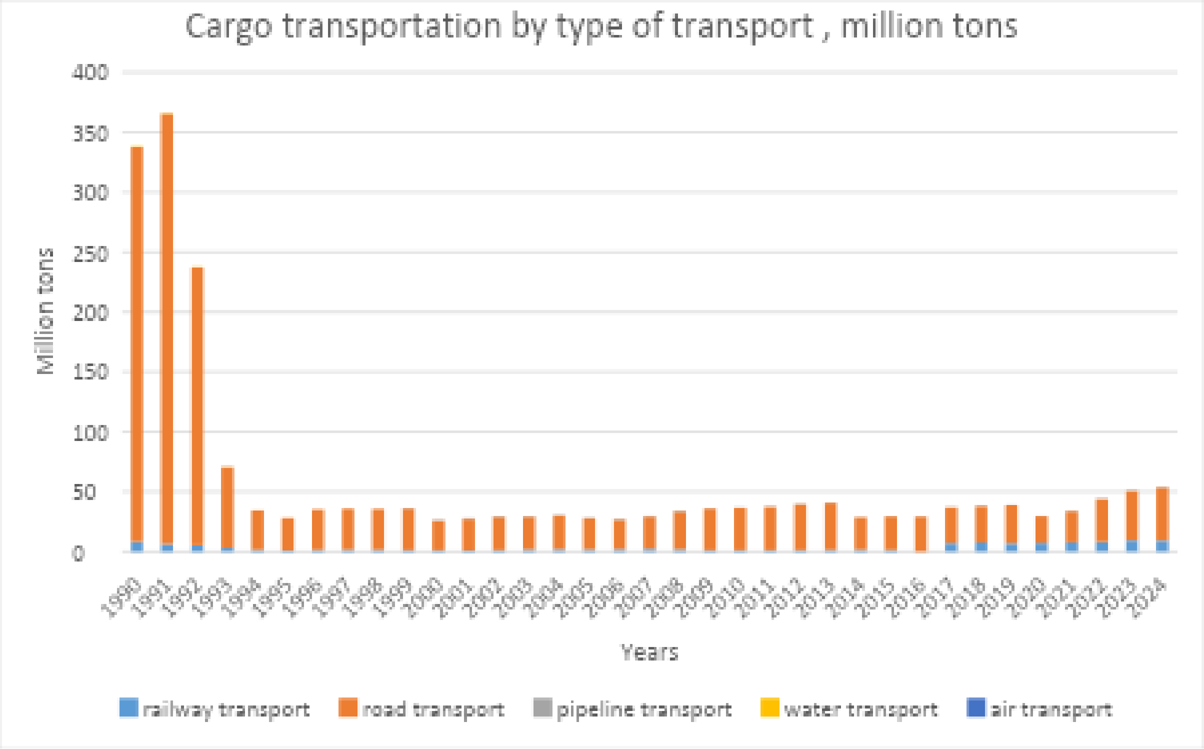

Figure 3.1.3 Transportation of goods by types of transport.

The mobility of the country's population is also provided mainly by land transport. Figure 3.1.4 shows the dynamics of passenger turnover in the period 1990-2017. Passenger transportation by type of transport, 2020 is a pandemic year:

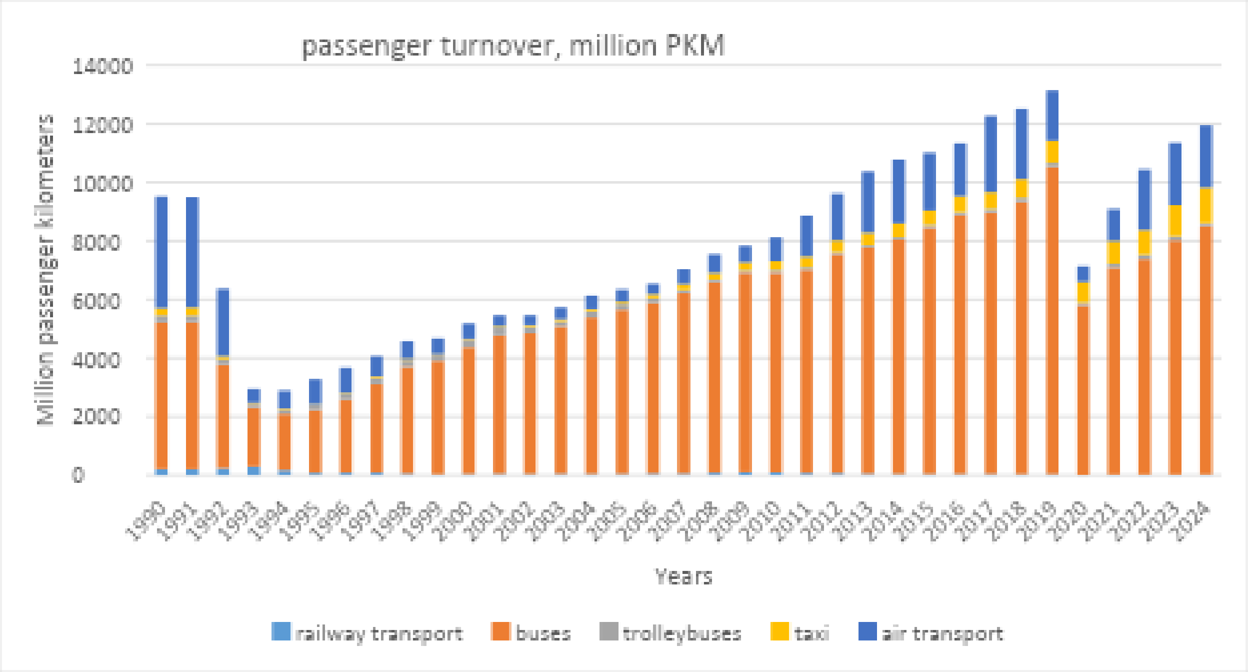

Figure 3.1.4. Dynamics of passenger turnover in the period 1990-2017 (million passenger-kilometers).[2]

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[2] NSC. http :// www . stat . kg / ru / statistics / transport - i - svyaz /

The structure of passenger transportation by type of transport in 1990 and 2024 is presented in Figure 3.1.5:

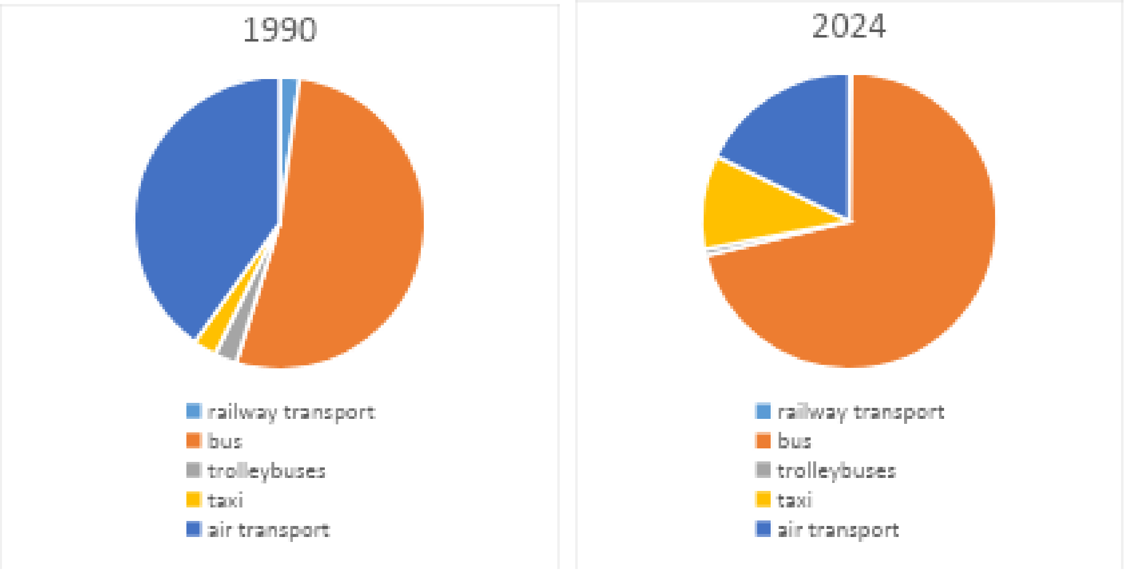

Figure 3.1.5 Structure of passenger transportation by type of transport in 1990 and 2024:

The dynamics of passenger transportation in the period 1990-2024 is presented in Figure 3.1.6:

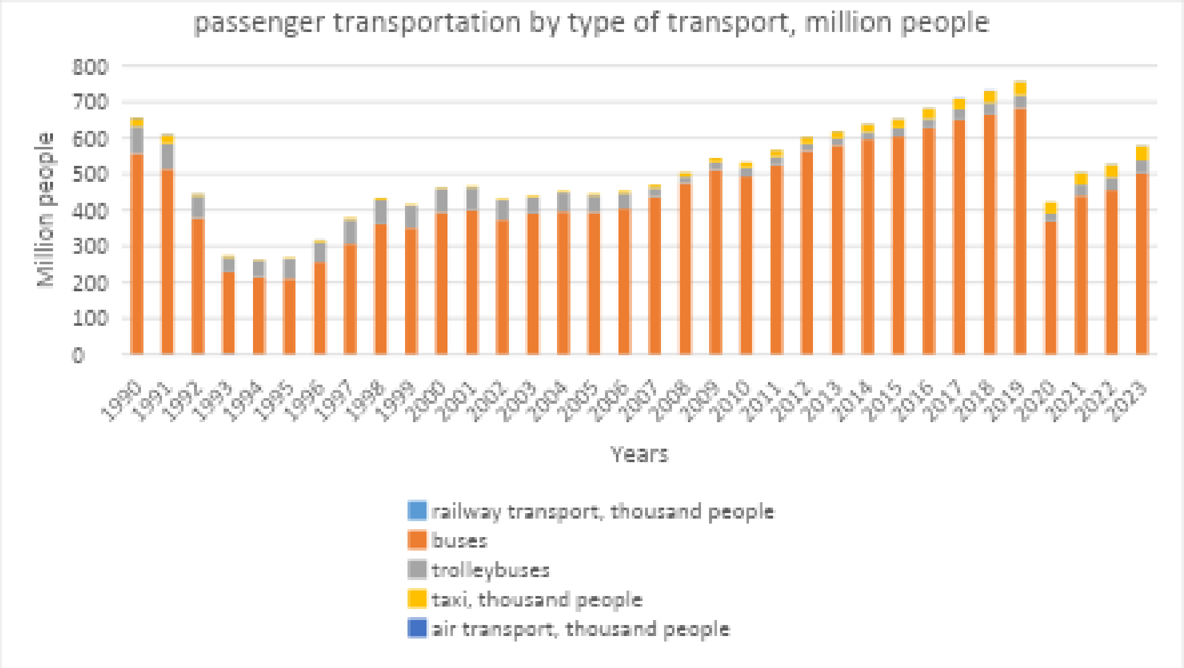

Figure 3.1.6. Dynamics of passenger transportation in the period 1990-2024 (million people).

The transport sector plays an important role in the formation of greenhouse gas emissions in the Kyrgyz Republic. As of recent years, transport accounts for about 20-25% of the country's total CO_2 emissions, and this share has a steady upward trend. The bulk of emissions comes from road transport, primarily passenger cars, as well as freight and public transport, which operate primarily on gasoline and diesel fuel.

3.1. Vehicle fleet structure and types of transport

Kyrgyzstan's vehicle fleet is largely made up of used vehicles imported from Japan, Europe and Russia. As of 2023:

- more than 80% of the vehicle fleet are passenger cars;
- about 15% are trucks;
- the rest are buses, motorcycles and special vehicles;
- a significant portion of passenger cars are right-hand drive and over 10 years old;
- The main fuel is gasoline (AI-92 and AI-95), to a lesser extent diesel fuel, and only a small share is liquefied gas (LPG) and natural gas (CNG).

The level of transport electrification remains low: as of early 2025, there were about **7,000** registered electric vehicles in the country, concentrated mainly in the cities of Bishkek and Osh. However, there is a positive trend due to customs privileges and tax incentives for the import of electric vehicles.

3.2 Key trends and challenges

1. **Rising motorisation** – the rapid increase in the number of cars per capita, especially in cities, is straining road infrastructure and increasing emissions.
2. **Urbanization** - the movement of population to cities increases the transport load, especially in Bishkek, where there are traffic jams and deteriorating air quality.
3. **Energy efficiency** – the average age of the vehicle fleet exceeds 15 years, which reduces overall fuel efficiency and increases emissions.
4. **Electrification** - with the support of international partners and a policy of subsidizing electric vehicles, this segment has the potential to grow, especially with the availability of cheap electricity from hydroelectric power plants.
5. **The lack of centralized public transport** —the development of fixed-route taxis and private transportation—does not allow for the optimization of emissions and the load on the transport network.

Kyrgyzstan’s transport sector is thus at a crossroads between growing mobility needs and the need for decarbonization in the context of the country’s climate commitments. This makes it particularly important to develop credible emissions scenarios for informed policy decisions.

4. Methodological approach

The methodology presented in this report is intended to build projections of greenhouse gas (GHG) emissions in the transport sector of the Kyrgyz Republic in the medium and long term. The development of projections of greenhouse gas emissions in the transport sector of the Kyrgyz Republic is based on internationally recognized approaches, in particular, **the IPCC Guidelines of 2006**, as well as **ICAT instrumental recommendations**, including **the Transport Pricing Assessment Guide** [3], in terms of analyzing behavioral factors and responses to policy changes, and additional recommendations of the UNECE. The selected methodological approach is consistent with the objectives of national reporting, including within the framework of NDCs and the Global Emissions Registry (GHG Inventory).

Accepted standards and sources

- IPCC 2006 Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy
- EEC UN: "Guidelines for Developing National Strategies to Use Energy-Efficient and Environmentally Friendly Transport"
- Examples of national practices in other countries of the region (Uzbekistan, Kazakhstan)
- National documents: NDC reports, National GHG emission inventories

The activity-based approach is used as the main approach. It allows for a quantitative assessment of emissions based on the volume of fuel consumed by different types of vehicles and the corresponding emission factors.

The forecast model is based on the calculation formula:
(Emissions) = (Fuel Consumption × Emission Factor

Where:

(Fuel Consumption) — the amount of transport work, the volume of fuel consumed (TJ or liters) consumed by a certain type of transport per year.

(Emission Factor) — the CO_2 emission factor depending on the type of fuel (petrol, diesel, gas, etc.), expressed in tons of CO_2/TJ.

Levels of Detail (Tier 1 and Tier 2)

- In cases where data is limited, Tier 1 with aggregated fuel consumption by type is used. That is, based on aggregated data on fuel consumption by type, using standard IPCC emission factors (or nationally adapted values);
- Where structured data on mileage, vehicle categories, and fuel consumption are available, Tier 2 is applied with activity calculated by vehicle type—in cases where data on vehicle types, mileage, and average fuel efficiency are available (e.g. based on research or tax/customs service data).
- The transition to Tier 3 (models based on traffic data, vehicle registration and specific technical characteristics) is possible in the future with the development of the database and automated monitoring systems.

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[3] TRANSPORT PRICING METHODOLOGYAssessing the greenhouse gas impacts of transport pricing policies . https://www.researchgate.net/publication/375743865_Transport_Pricing_Methodology_Assessing_the_greenhouse_gas_impacts_of_transport_pricing_policies

Tier 1 – aggregated fuel consumption data

Formula:

$\text{Emissionsi}=\sum FC_f \times NCV_f \times EF_f$

Where:

- FC_f: fuel consumption by type *f* (TJ or tonnes),
- NCV_f: net calorific value (TJ/tonne),
- EF_f: IPCC default or nationally adapted emission factor (kg CO_2/TJ).

Tier 2 – by vehicle categories

Formula:

$\text{Emissionsi}=\sum (VKT_v \times FE_v \times Eff_{,v})$

Where:

- v: vehicle category (cars, buses, trucks, etc.),
- VKT_v: vehicle-kilometers traveled by type *v*,
- FE_v: average fuel efficiency per vehicle type (l/km),
- $EF_{f,v}$: emission factor for fuel *f* and category *v*.

Tier 2 uses structured data on mileage, vehicle categories, and fuel consumption (e.g., tax/customs records, surveys).

Tier 3 – traffic models and specific characteristics

Formula:

$\text{Emissionsi}=\sum\sum (N_{v,m} \times D_{v,m} \times FE_{v,m} \times EF_{f,v,m})$

Where:

- v: vehicle category,
- m: driving mode (urban cycle, highway, idling, acceleration),
- $N_{v,m}$: number of vehicles of type *v* in mode *m*,
- $D_{v,m}$: distance or time driven in mode *m*,
- $FE_{v,m}$: fuel efficiency in that mode,
- $EF_{f,v,m}$: emission factor in that mode.

Tier 3 is based on advanced traffic models, registration databases, GPS/telematics, and automated monitoring systems. It allows differentiation by driving conditions and technologies (aligned with IPCC, CDM methodologies such as AMS-III.C, ACM0016).

Glossary of variables:

- FC – fuel consumption
- NCV – net calorific value
- EF – emission factor
- VKT – vehicle-kilometers traveled
- FE – fuel efficiency
- N – number of vehicles
- D – distance/time in a driving mode

Core emission formulae (fuel already in TJ)

For each fuel type f:

CO_2 from fuel f:
$CO_2(f) = Fuel\_TJ(f) \times EF\_CO_2(f) \times OF$

CH_4 from fuel f:
$CH_4(f) = Fuel\_TJ(f) \times EF\_CH_4(f)$

N_2O from fuel f:
$N_2O(f) = Fuel\_TJ(f) \times EF\_N_2O(f)$

Aggregate across fuels:
$Emissions\_gas = \Sigma_{(f)}\ Emissions\_gas(f)$

Variable definitions and units

- *Fuel_TJ(f)* — fuel consumed of type f, TJ
- $EF\_CO_2(f)$ — CO_2 emission factor for fuel fff, t CO_2/TJ (or kg/TJ)
- $EF\_CH_4(f)$ — CH_4 emission factor, kg CH_4/TJ
- $EF\_N_2O(f)$ — N_2O emission factor, kg N_2O/TJ
- *OF* — oxidation factor (dimensionless), typically 0.99–1.00 for road transport (IPCC)

Separate fuel-to-TJ conversion formulae

From litres to TJ

$Fuel\_TJ(f) = Vol\_L(f) \times \rho(f) \times (1\ tonne / 1000\ kg) \times NCV(f)$

Where:

- $Vol\_L(f)$ — fuel volume, litres
- $\rho(f)$ — density, kg/l
- $NCV(f)$ — net calorific value, TJ/tonne

(Alternative via m^3: $Vol\_m^3 = Vol\_L/1000$, density in kg/m^3.)

From tonnes to TJ

$Fuel\_TJ(f) = Mass\_tonne(f) \times NCV(f)$

Where:

- $Mass\_tonne(f)$ — tonnes
- $NCV(f)$ — TJ/tonne

Convert CH_4 and N_2O to CO_2-eq.

$GHG\_CO_2e = CO_2 + CH_4 \times GWP_{100}(CH_4) + N_2O \times GWP_{100}(N_2O)$
(GWP values per selected IPCC assessment)

Alignment with sources

- IPCC Guidelines (Vol. 2, Ch. 3) — EFs in t/TJ (CO_2) and kg/TJ (CH_4, N_2O); OF for transport.
- UNFCCC guidelines (NC/ETF/BTR) — reporting requirements/CTFs.
- Compendium on GHG Baselines and Monitoring — baseline/mitigation scenario approaches, links to VKT/mileage.
- CDM methodologies (AMS-III.C, ACM0016) — transport project/program accounting (activity-based, VKT, specific factors).

Tier 1 Fuel-based (top-down, aggregated)

When to use: only national fuel sales/consumption by fuel type are available.

Core formula (by fuel f):

Notes:

- Tier 1 uses default IPCC emission factors (EF) and default oxidation factor (OF) (often 0.99–1.00 for road).
- Units must be consistent. Typical: Fuel_cons in TJ or in tonnes/m^3 converted via NCV (net calorific value).
- If you only have litres/tonnes sold, convert to energy with NCV.
-

Tier 2 Activity by vehicle category (bottom-up lite)

When to use: you have vehicle stock, VKT, and average fuel economy by category (but not detailed speed/tech splits).

Approach A (fuel-backed from activity):

$F_{i,j,y}$ –(TJ), Total fuel energy i (gasoline, diesel and electricity) used in type j of passenger transport (road and rail) in year y

$FC_{i,j,y}$ in volume units (L) = $d_{i,j,y}$ (in VKT) × $sfc_{i,j,y}$ (in L per VKT)

$F_{i,j,y}$ in energy units (TJ) = $FC_{i,j,y}$ in volume units (L) × r_i × $NCV_i \div 10^9$

Where:

$d_{i,j,y}$ = Vehicle kilometers traveled (with fuel type i , mode j, per year)

$sfc_{i,j,y}$ = Average consumption per VKT in a municipal, regional or national vehicle fleet

r_i = Density of fuel type i

NCV_i = NCV_i of fuel type i

Tier 3 Detailed fleet & traffic model (bottom-up full)

When to use: you have (or can model) speed, road type, temperature, technology/Euro class, cold-start shares, and evaporative emissions (for VOCs if needed). This mirrors EMEP/EEA/COPERT-style models.

Hot exhaust (by vehicle tech t, road type r, speed bin s, fuel f):

- Hot(v,t,r,s,f) = VKT(v,t,r,s) × EF_hot_per_km(v,t,f | speed s, temp)

Cold-start excess (if applicable):

- Cold(v,t,f) = Start_trips(v,t) × EF_cold_excess(v,t,f | temp)
  (or as a km-based uplift using cold distance share)

Evaporative (VOC; optional for GHG scope unless CH_4 included):

- Evap(v,t) = function of temp, fuel volatility, canister tech, diurnal + running losses

N_2O and CH_4:

- Either embedded in EF_hot_per_km or added via specific per-km factors by tech/speed.

Sum:

- Emis = Σ_v Σ_t Σ_r Σ_s [Hot] + Σ_v Σ_t [Cold] (+ Evap for CH_4 if in scope)
- Convert CH_4/N_2O to CO_2e, add to CO_2.

Notes:

- t = technology/standard (e.g., Euro 0–6/VI, 3-way cat, DPF, etc.)
- r = urban / rural / motorway (shares differ strongly)
- **s** = average operating speed bin (speed-dependent EF)
- Tier 3 allows policy-sensitive modelling (e.g., speed limits, congestion, fleet renewal, ITS, cold-start mitigation).

The use of internationally recognized methodologies ensures the comparability of forecasts, transparency and validity of results, which is especially important when developing policies within the framework of global climate commitments.

Application of the methodology in the context of reporting and climate planning

In addition to approaches related to pricing policies (e.g. fuel taxation, fuel tariffs), it is important to consider other international guidelines and methodologies when conducting impact assessments.

Key sources:

1. UNFCCC Guidelines:
   - *Guidelines for the preparation of national communications*;
   - *Modalities, procedures and guidelines for the enhanced transparency framework (ETF).*
     These documents set requirements for transparency, completeness, and comparability of data in reporting, including the assessment of mitigation impacts.

2. CDM Methodologies:
    - *AMS-III.C: Emission reductions by electric and hybrid vehicles*;
    - *ACM0016: Mass Rapid Transit Projects*;
    - and other relevant project- and programme-level methodologies applicable to the transport sector.
      These methodologies provide detailed approaches for calculating GHG emissions and reductions at the project and programme levels.
3. Compendium on Greenhouse Gas Baselines and Monitoring (UNFCCC/UNEP/UNDP): This compendium is designed to support countries where emissions are dominated by the energy sector. It provides methods for developing baseline scenarios and assessing emission reductions from national-level mitigation measures, including those in transport.

The ICAT transport pricing methodology can be used at different stages of policy development, implementation and evaluation. It is particularly useful for countries seeking to comply with the Paris Agreement transparency framework and Nationally Determined Contributions (NDCs).

In particular, the methodology allows:

- Estimate baseline (business-as-usual) GHG emissions before implementing pricing policies;
- Model the expected impact of policies on consumer behaviour, fuel demand and emissions;
- Monitor and track progress against key metrics (e.g. reduction in fossil fuel consumption, growth in EV share);
- Compare parameters and indicators between emissions calculations for domestic policy purposes and international reporting.

The methodology can be applied:

- Before policy implementation (ex-ante evaluation) – to predict future effects and justify policy;
- During implementation – to assess current results and achieve key indicators;
- After implementation (ex-post evaluation) – to understand the actual impact of the policy and make course adjustments.

For maximum benefit, it is recommended:

- Use the same metrics and parameters in impact models and NDC reports;
- Align the time frames and geographical boundaries of the assessment between different reporting documents;
- Be based on the principles of reliability, completeness, consistency, transparency and accuracy.

The methodology also includes key recommendations that help ensure high quality and comparability of the assessment. However, users can also take a more flexible approach, adapting the steps to their national circumstances.

While ICAT is primarily intended for pricing-related measures—such as fuel taxes, road user charges, or congestion pricing—its application can be broadened and complemented by other recognized international methodologies, depending on the scope of the policy or measure being assessed.

For example:

- **UNFCCC guidelines** – including the "Guidelines for the preparation of national communications" and the "Modalities, procedures, and guidelines for the enhanced transparency framework," which provide overarching requirements for reporting mitigation impacts.
- **COMPENDIUM ON GREENHOUSE GAS BASELINES AND MONITORING NATIONAL-LEVEL MITIGATION ACTIONS**- This the Compendium on Greenhouse Gas Baselines and Monitoring aims at supporting countries in assessing emission reductions from national-level mitigation actions in economies that are dominated by energy-related emissions3 and provides an overview of the main approaches for developing baseline and mitigation scenarios at the national level.
- **CDM methodologies** – such as AMS-III.C ("Emission reductions by electric and hybrid vehicles") or ACM0016 ("Mass rapid transit projects"), which offer project- or program-level approaches for calculating GHG reductions in transport.
- **IPCC Guidelines for National GHG Inventories** – particularly Volume 2, Chapter 3, which provides tiered approaches (Tier 1–3) for estimating emissions from fuel combustion in transport, including definitions of variables such as vehicle-kilometers traveled (VKT), mileage, and fuel efficiency.

Combining ICAT methodology with these additional resources allows for a more robust, transparent, and verifiable assessment of the GHG impacts of transport policies, ensuring methodological consistency and international comparability of results.

Assessing the impact of policies on greenhouse gas emissions

The impact of pricing policy on GHG emissions is manifested in changes in consumer behaviour, which in turn leads to a reduction in overall fuel consumption and emissions. The ICAT methodology offers a systematic approach to identifying and assessing such effects.

Main mechanisms of action:

- Reduction in the number of trips, especially with rising fuel prices;
- Switching to other modes of transport, including public transport, walking or cycling;

- Switching to more fuel-efficient or alternative vehicles, such as hybrids or electric vehicles.

Intermediate effects

Policy first causes changes at the behavioral and technological levels:

- Drivers are cutting back on trips or switching to more efficient transport;
- companies are changing logistics;
- Consumers are switching to public transport, cycling, walking, or buying more fuel-efficient cars.

These intermediate changes lead to the final impact - reduced emissions of CO_2, CH_4 and N_2O.

Defining the evaluation boundaries

- What gases are assessed (usually CO_2, CH_4, N_2O);
- What activities are included (road transport, off-road transport);
- Assessment time frame (2025–2035);
- Spatial boundaries (national level).

Evaluation period

It is recommended to choose a period that allows for tracking both the short-term and long-term effects of the policy. Typically, this covers several years before and after the implementation of the measure.

Sustainable development

If data are available, the impact of policies on sustainable development can also be assessed, for example:

- economic accessibility of transport;
- impact on vulnerable groups;
- improving air quality.

Forecast scenarios

The methodology includes the development of several scenarios for the development of the sector:

- Baseline scenario (BAU) – inertial development without new policies.
- Scenario with measures (WAM) - introduction of new initiatives such as fuel taxes, energy efficiency standards, EV support.
- The current measures scenario (WEM) is a continuation of the current policy without any new changes.

Scenarios are built taking into account:

- Forecast of the vehicle fleet size;
- Changes in the structure of fuel consumption;
- Level of electrification;

Price assumptions and behavioral responses (elasticity of demand).

Baseline Scenario and Emissions Assessment

In order to determine the impact, for example, of transport pricing policy on greenhouse gas emissions, it is necessary to first construct a so-called **baseline scenario**. This is the "default" scenario – it shows how events will develop **without the introduction of new policies**, for example, without increasing fuel taxes.

What is the base case scenario?

The baseline scenario reflects the likely development of the transport sector if the pricing policy is not adopted. It includes:

- growth in the number of vehicles in the fleet;
- mileage change;
- fuel consumption and types of vehicles used;
- emission factors and economic assumptions.

This scenario is used as a baseline against which alternative scenarios (e.g. with the introduction of new policies) are compared to assess impact.

Estimating base year emissions

The assessment begins with a base year, which is the starting point from which all projections are made. This is typically the same year as the latest available good-quality statistics (2023). The projection is intended for use in NDC reporting, and it is recommended that the base year of the assessment be consistent with the base year used in the NDC.

This year, CO_2 emissions are calculated based on:

- volume of fuel consumed;
- the number and structure of the vehicle fleet;
- specific fuel consumption;
- emission factors (usually from IPCC).

Note: For simplicity, CH_4 and N_2O emissions can be excluded and focus on CO_2 as the main gas associated with fuel combustion.

Baseline Emissions Projection

Once the base year emissions have been estimated, a projection of baseline emissions is developed for the entire assessment period (e.g. 2025, 2030, 2035 and 2050). This is done using:

- trends in vehicle fleet growth;
- forecasts of economic activity;
- fuel efficiency data;
- without taking into account new policies.

Thus, the baseline scenario and the corresponding emissions allow:

- quantitatively compare the impact of future policies;
- assess the contribution of policies to achieving emission reduction targets;
- use the obtained values in official climate reporting (NDC, BTR, etc.).

Developing a baseline emissions forecast

To assess the impact of a transport ~~pricing~~ policy, it is necessary to construct **a baseline emissions forecast** – that is, to predict what future greenhouse gas (GHG) emissions would be in the absence of the policy being assessed. This allows one to determine the difference between the “natural” development of the sector and the effect of the new measure.

Overview of the steps to forecast baseline emissions:

Step 1: Identify Influencing Policies

It is necessary to identify which other existing or planned policies may affect emissions in the transport sector. If such measures already have an impact (e.g. energy efficiency standards, electric vehicle support program), they should be included in the baseline. However, if a package of measures (including pricing policies) is assessed, these measures are considered together and their impact is not included in the baseline.

Step 2: Selecting Projection Elements and Parameters

It is important to determine what key parameters will be used to build the forecast, including:

- vehicle fleet growth rate;
- change in the structure of vehicles (diesel, petrol, EV);
- mileage and fuel consumption;
- socio-economic factors (population, GDP).

Population and economic growth have a major impact on the transport sector. They are considered as key factors and in most cases directly influence the activity parameters required for the calculation. Therefore, forecasts usually take into account expected trends in population and GDP. Users should define baseline scenario forecasts based on expected changes in population and GDP.

Secondary influences (e.g. car ownership rates, technological development, cost, availability of transport alternatives) can be valuable additional factors for impact assessment, provided they can be controlled.

For approaches A and B, fuel consumption depends on population and economic growth, while emission factors are independent. For approach C, population growth is likely to affect the number of trips made and possibly the distance traveled (e.g. through urban sprawl). Economic growth also affects the number of trips, distance traveled, and fleet composition; thus, there is a strong effect of population and/or GDP. Users should make forecasts based on per capita or GDP parameter ratios to ensure meaningful forecasts.

Step 3: Selecting a projection method

Depending on the availability of data, different approaches to extrapolation can be used:

- **Trend approach** - based on actual statistics for previous years (for example, average annual increase in mileage).
- **Normative approach** – if there are goals or plans (e.g. increasing EV to 30% by 2030).
- **Demand modeling** - using behavioral coefficients (e.g. price elasticity).

Methods for forecasting baseline emissions

When constructing a baseline transport greenhouse gas emissions forecast, it is critical to select an adequate parameter projection method. This choice depends on data availability, the purpose of the estimate, and the complexity of the model.

3.1 Using Time Series (Approach A or B)

If statistical data for several years (time series) is available, it is preferable to use trend analysis, i.e. extrapolate the identified trends (e.g. growth in mileage, vehicle fleet, fuel consumption) to future years. This approach allows for actual changes in the sector to be taken into account.

Example: If gasoline consumption has grown by 2% per year over the past 10 years, this trend can be extended over the forecast period.

It is important to:

- Adjust trends to account for the impact of other policies, such as support for electric vehicles or stricter standards.
- Check whether the trends do not violate logic (for example, too rapid growth of the vehicle fleet may be limited by the population's income).

3.2. Transport system modeling (Approach C)

The most accurate, but also complex method is integrated transport system modeling. It requires:

- Modeling travel demand (VKT - vehicle mileage);
- Calculation of distribution between modes of transport (modal shift);
- Taking into account technological transitions and consumer behavior.

This approach captures the relationships between travel volume, fuel consumption, policies and economics, but requires extensive data and modelling tools.

3.3 Using a single data point (in the absence of a time series).

If historical data is not available, single values (e.g. one fuel consumption or mileage value for the last year) can be used. The reliability of such estimates is lower, but they are acceptable in conditions of limited data.

To increase reliability in such cases, it is recommended:

- Use averages over multiple years if available;
- Normalize data per capita or per GDP;
- Borrow trends from comparable countries with similar transport situations.

Example: If a country has only one estimate of annual vehicle mileage, it can be normalized by population and extrapolated using the population forecast.

3.4. Demographic and economic drivers

Forecasts are often based on macro indicators such as:

- **Population** growth - affects vehicle fleet, trips, mileage;
- **GDP** growth affects the availability of cars and the level of consumption.

These factors can be used as drivers to estimate the growth of transport activity. For example, it can be assumed that the vehicle fleet grows proportionally to the population, and the average annual mileage - depending on the GDP per capita.

3.5. Selecting an approach depending on data availability:

Data availability	Recommended approach
Time series	**Approach A or B (trend)**
No time series	Approach C (intensity, norms)

Models available	Integrated modeling

Approach "B" was chosen: there are time series, there are data on types of fuel.

Approach A is the simplest (indicative)

Very limited data is used, often only one point (e.g. fuel volume for 1 year).

A simple extrapolation is made: for example, we take the specific fuel consumption per capita and multiply it by the population forecast. Minimum data, minimum calculations, maximum simplifications.

Example:

"We had a gasoline consumption of 100 liters per person in 2020. In 2030, there will be 7 million people → we predict 700 million liters of fuel."

Approach B - Medium Level (Trend)

Based on time series data (e.g. fleet, mileage, fuel consumption).

A trend (linear, logarithmic, etc.) is identified and extrapolated into the future.

It is possible to take into account changes in the structure of transport, fuel, and politics.

Example:

"We see that diesel consumption has grown by 3% per year from 2010 to 2020 → we apply this trend to 2035, taking into account population growth and economic changes."

Approach C is the most accurate and complex (modeling)

Detailed models are used, including:

- Drivers' behavior,
- Changes in technology,
- Fuel prices,
- Policy measures (taxes, subsidies, etc.)
- Requires a lot of data and effort, but gives the most realistic forecasts.

Often used in Tier 2/Tier 3 assessments and scenarios (BAU, WAM, etc.).

Example:

"We take into account that with a 10% increase in fuel prices, demand will fall by 2.4%, and the share of electric vehicles will increase to 15% - and we take all this into account in the emissions forecast."

Comparison by simplicity:

Approach	Data	Complexity	Accuracy	Example
A	1-2 values	Low	Very rude	Per capita
B	Time series	Average	Moderate	Linear trend
C	Detailed data	Tall	Tall	Model with measures

3.5. Accounting for emissions

In all approaches, CO_2 emissions are calculated based on fuel consumed, using emission factors based on carbon content (according to IPCC). For example:

- Gasoline: 18.9 t C/TJ → conversion to CO_2: multiply by 44/12 (molecular mass of CO_2/C).
- Mileage and consumption → activity → emissions.

The most sophisticated approach is transport sector modelling, which integrates these effects and reflects the interrelations between the various elements of the system. A combination of approaches is recommended, especially when reliable data and policy settings are available.

Step 4. Calculating projected emissions

At this stage, greenhouse gas (GHG) emissions are calculated for each year of the assessment period, using previously predicted values of key parameters (e.g. fuel consumption, etc.).

A simplified method for designing scenarios

Given the close relationship between population and/or GDP and some key parameters for calculating emissions, per capita values or intensities can provide a good basis for projections.

The simplest way to forecast parameter values in the future is to choose a key driver for the parameter (e.g. population or GDP) and assume constant growth over time, as shown in Figure 4.1.1 which uses approach A and forecasts fuel consumption based on expected population growth.

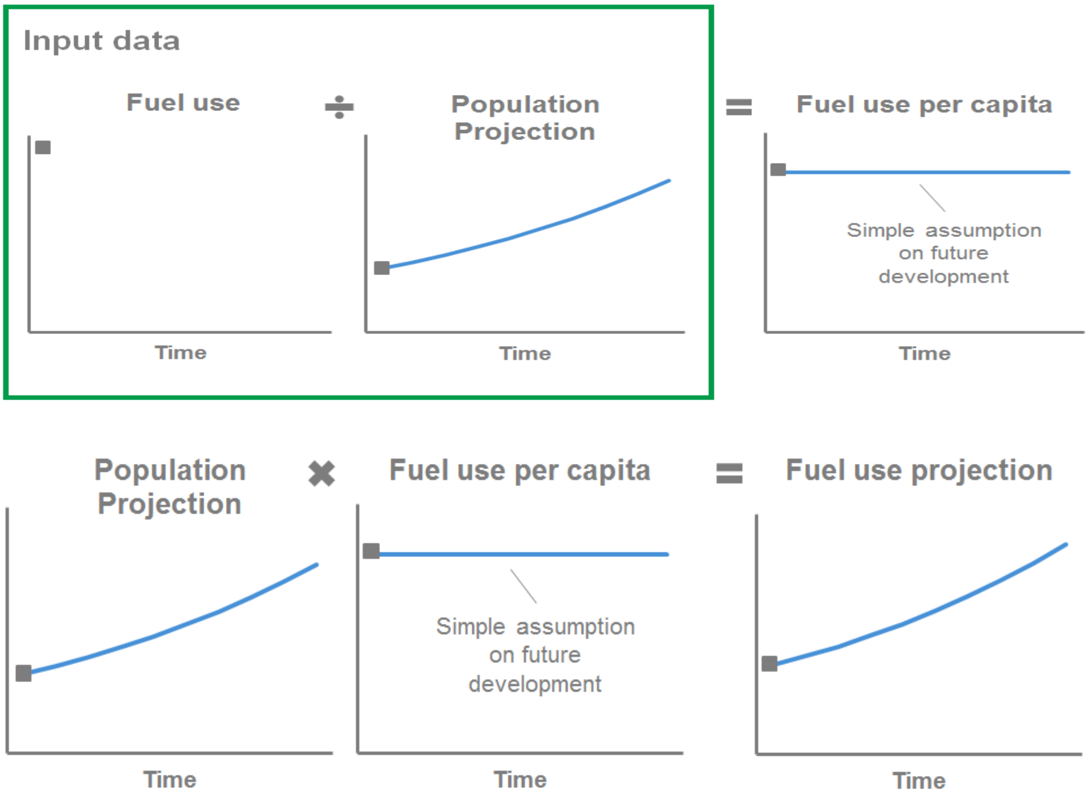

Figure 4.1.1 A simplified approach to forecasting parameters using population forecasts

Simplified Method (Approach A)

If only one year of data is available:

- Fuel consumption per capita is calculated.
- The population forecast is then used to extrapolate total fuel consumption for future years.
- It is assumed that the per capita intensity remains constant.

Example:
If gasoline consumption in 2020 was 100 liters per person, and the population is projected to be 7 million in 2030, then total consumption = 700 million liters.

Advanced Scenario Design Techniques

The assumption of constant absolute values is in most cases an oversimplification of expected real events.

Using per capita or intensity values addresses this problem to some extent, but still does not reflect real trends, especially since a parameter is usually influenced by more than one factor.

Macro-indicator approach (Approach B)

Includes the impact of GDP growth and the standard of living of the population:

- Income elasticity is used - how much consumption changes as income increases.
- The demand for travel or fuel is projected to change as a function of growth in GDP per capita.

Example:
Elasticity = 0.5 ; if GDP per capita increases by 10%, demand for travel will increase by 5%.

Trend Analysis[4]

A trend is a statistical technique that is often used to understand past events. By assuming that certain parameters are likely to develop in the same way as in the past, a trend is often extrapolated into the future. However, a trend does not necessarily represent the most likely scenario for all relevant variables when determining a baseline scenario. Trend analysis requires time series data for the relevant parameters. There are two types of trends:

- Linear trends are the extrapolation of historical events (trends) into the future in the form of a linear increase or decrease in parameters. This method is often used to extrapolate the historical development of vehicle efficiency (also called the development of autonomous technologies). Constant growth rates lead to linear trends.
- Nonlinear trends are usually captured by more complex models, but can also be detected in simplified calculations.

Figure 4.1.2 shows the design of parameters using linear and nonlinear trends.

How well a trend reflects likely future events depends on a number of factors. [5]For details, see the source at the link.

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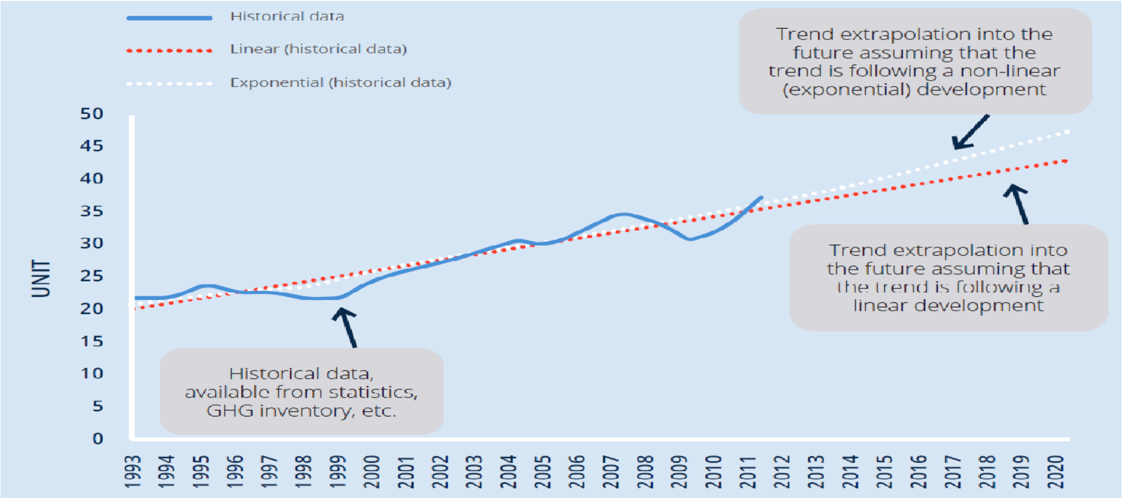
[4] TRANSPORT PRICING METHODOLOGYAssessing the greenhouse gas impacts of transport pricing policies . ICAT/ https://www.researchgate.net/publication/375743865_Transport_Pricing_Methodology_Assessing_the_greenhouse_gas_impacts_of_transport_pricing_policies

[5]see also



Trend extrapolation into the future assuming that the trend is following a non-linear (exponential) development

Trend extrapolation into the future assuming that the trend is following a linear development

Historical data, available from statistics, GHG inventory, etc.

Figure 4.1.2 Forecasting using trends

Trend with adjustments

To add another level of analysis to the trend, the influence of policies and other factors can be included. To do this, the trend is first determined and then adjusted based on the analysis of the influencing factors, as described in Section 7.4.1 [6]using a simple method.

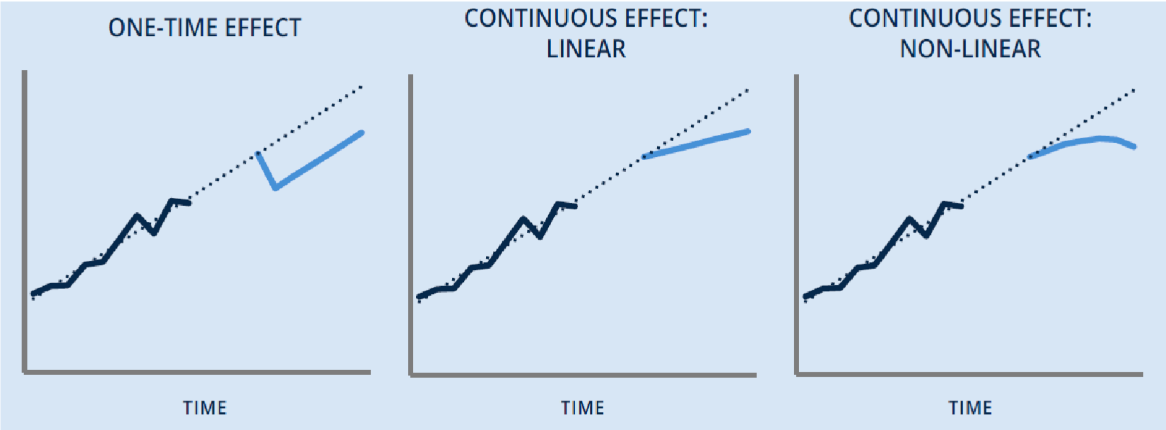


Figure 4.1.3 Forecasting using trends with adjustment

Modeling (Approach C)

The most advanced approach:

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[6] TRANSPORT PRICING METHODOLOGYAssessing the greenhouse gas impacts of transport pricing policies . https://www.researchgate.net/publication/375743865_Transport_Pricing_Methodology_Assessing_the_greenhouse_gas_impacts_of_transport_pricing_policies

- Interrelated parameters are integrated: growth of the vehicle fleet, change in fuel structure, transition to electric vehicles, etc.
- Requires a comprehensive model and scenario assumptions.

Recommendations for calculations:

- Use data on specific emissions of CO_2, CH_4 and N_2O depending on the type of fuel and type of vehicle (according to IPCC).
- Consider the impact of policies that have already been implemented or are under implementation (e.g. fuel tax, EV subsidies).
- For each year (e.g. 2025, 2030, 2035, 2050) apply the selected projection method and calculate the projected GHG emissions.

Addition:

- Alternative scenarios (BAU, WAM, WEM) can be constructed by varying the parameters:
  - Population forecast;
  - Income growth;
  - Rate of adoption of energy efficient vehicles;
  - The degree of modal shift (e.g. from car to public transport).

Alignment with climate reporting

- If the forecasts are to be used in NDC or BTR reporting, it is necessary to:
  - use the same input data as other national forecasts;
  - agree on a time frame (e.g. 2020–2050);
  - use compatible metrics and scenarios.

This step allows for the formation of a quantitative basis for the analysis of the impact of policies and the construction of scenario forecasts of GHG emissions in the transport sector.

Impact Assessment of Policies and Measures

Impact of non-pricing policies

In addition to pricing policies, the model will incorporate a set of non-pricing measures that address structural, technological, and behavioral aspects of the transport sector. These measures will be assessed primarily through **activity-based and technology-shift calculations**, following IPCC Guidelines and ICAT non-pricing policy assessment recommendations.

1. **Shift away from private vehicles**
   - **Improving traffic management and developing bicycle infrastructure:** Impact will be modeled by estimating vehicle kilometers traveled (VKT)

    reduction in urban areas due to improved signal control, adaptive traffic systems, and expanded bicycle networks. This will be linked to modal shift parameters from private cars to bicycles, public transport or walking, based on urban transport survey data.
  - **Improving public transport management:**
    Changes in operational efficiency (higher passenger load factors, reduced waiting times) will be translated into lower per-passenger-km fuel use for buses and minibuses. This will be modeled by adjusting the activity data (VKT) and fuel economy factors for public transport.

2. **Technological and economic measures, improve**
   - **Development of electric transport:**
     Gradual penetration rates of electric buses, cars, and two-wheelers will be introduced into the fleet projection module. Emission reduction is calculated as the difference between baseline ICE (internal combustion engine) fuel emissions and the marginal grid emission factor for electric vehicles.
   - **Replacement of diesel/ICE buses with gas buses (Bishkek, Osh, suburban routes):**
     Reduction potential is estimated by replacing emission factors for diesel buses with those for compressed natural gas (CNG) buses, combined with the expected service life and annual mileage.
   - **Improving vehicle operation and management systems:**
     Includes optimized routing, eco-driving programs, and preventive maintenance. The effect is modeled as a percentage improvement in fuel economy for targeted fleet segments, based on literature values and pilot project data.

Approach in the model:

- Each measure will be assigned a specific baseline activity value (e.g., VKT, fleet size, passenger-km) and an improvement factor (e.g., % efficiency gain, % modal shift).
- The calculation will follow the formula:

  Emission reduction= (Baseline activity×Emission factor) − (Post-measure activity×New emission factor).

- Where data gaps exist, proxy values will be used from comparable countries with similar transport patterns, adjusted for Kyrgyz conditions.

- Cumulative results will be integrated into the scenario analysis alongside pricing policies, ensuring no double counting of overlapping effects.

Accounting for absorption and indirect emissions

Although transport is not directly involved in GHG absorption, the methodology can be complemented by the analysis of:

- indirect emissions from electricity production and distribution (for electric vehicles),
- potential gains from changing modality (for example, from car to rail or public transport).

Transparency, comparability and reproducibility

The methodology takes into account the principles set out in ICAT:

- Transparency of calculations;
- Scenario thinking;
- Multivariate analysis;
- Ability to update the model as new data becomes available.

5. Timeframes and scenarios

Forecasting period

The forecast of greenhouse gas emissions in the transport sector of the Kyrgyz Republic covers **the medium and long term**. The following time milestones are used in the assessment:

- **Base year**: 2023 (the latest year with relatively complete and comparable data);
- **Forecast years**: 2025, 2030, 2035 and 2050.

The choice of the years indicated reflects the need to link the projections with national strategic goals (e.g. implementation of the National Development Strategy, NDC) and the global climate framework, including the Paris Agreement (long-term goals up to 2050).

Types of scenarios

The methodology involves developing **several scenarios**, each reflecting different assumptions, policies and dynamics of key factors:

1. **Scenario without additional measures** (Baseline scenario / BAU – Business As Usual)
   Assumes that current trends in politics, economics, technology and consumer behavior will continue. Reflects the trajectory of the sector's development without new climate or fuel initiatives.
2. **With Additional Measures (WAM) scenario**
   Includes implemented and planned policy and regulatory measures aimed at reducing emissions: increasing fuel taxes, stimulating energy efficiency, updating the vehicle fleet, developing public transport and electric vehicles.

3. **Alternative or With Existing Measures (WEM)**
   A variant between BAU and WAM: takes into account measures already implemented, but does not take into account ambitious new initiatives. Allows to reflect the current trajectory against the background of existing policies.

Approach to scenario building

The work uses a combined approach to scenario formation, which includes the following elements:

- **Trend (extrapolation)**
  Based on existing trends in vehicle fleet growth, motorization level, fuel price dynamics and other macroeconomic indicators.
- **Normative (goal-oriented)**
  Used in modeling WAM scenarios. In this case, targets (e.g., reducing emissions by 20% by 2030) define the parameters for the development of the sector, including planned decarbonization measures.
- **Behavioural (based on changes in consumer behaviour)**
  Used in modelling reactions to price changes (price elasticity of demand), infrastructure development, and changes in preferences (for example, switching from personal to public transport).

Flexibility of scenario analysis

The methodology allows for scenarios to be adapted depending on:

- New political decisions;
- Changes in international conditions (for example, oil prices);
- Availability and updating of data;
- Stakeholder involvement (e.g. recommendations from development partners or industry associations).

Developing scenarios provides a basis for assessing different emission pathways, enabling comparative analysis and informed climate and transport decisions.

6. Data and assumptions

To develop a forecast of greenhouse gas (GHG) emissions in the transport sector of the Kyrgyz Republic, both national and international data sources were used. The methodological approach takes into account the availability of time series, the nature of available data, and the level of detail of the model.

Main data sources:

- National Statistical Committee of the Kyrgyz Republic (data on the number of vehicles, fuel consumption)
- Customs Service and the Ministry of Energy (data on fuel and car imports)

- National GHG Emissions Inventory
- International sources (IPCC 2006 Guidelines, UNECE, UNFCCC BUR/NC Reports)

Input parameters and indicators:

- Number of vehicles in the fleet by vehicle category (passenger cars, trucks, buses, etc.)
- Average annual mileage for each type of transport
- Specific fuel consumption by engine categories and types
- Fuel types: gasoline (AI-92/AI-95), diesel, natural gas, electricity
- Share of electric transport, including baseline and target scenarios for electrification
- Emission factors according to IPCC methodology:
  – gasoline – 69.3 t CO_2/TJ– diesel – 74.1 t CO_2/TJ– CNG – 56.1 t CO_2/TJ

Key assumptions:

- Vehicle fleet growth is based on trend analysis (linear and, less frequently, exponential extrapolation)
- Population growth and GDP influence the level of motorization (simplified method based on specific consumption)
- Scenario assumptions for increasing energy efficiency, electrification and technological upgrading
- Reduction of specific fuel consumption per km traveled with the introduction of new standards and fleet modernization
- Absence of abrupt political and economic changes affecting the fuel structure

Selection and adaptation method:

Depending on the availability of time series and parameters, the following approaches were used:

- With time series available - advanced trend extrapolation
- If there is limited data, calculation is based on specific indicators per capita or GDP
- When constructing alternative scenarios, adjusting the baseline trend taking into account policies and measures

7. Calculation structure of the model

Basic formula:
Emissions = Activity × Emission Factor

- Activity: defined as the product of the fleet size, average annual mileage and specific fuel (or energy) consumption by vehicle category and fuel type.
- Emission factors: taken from the 2006 IPCC Guidelines. Separate factors for CO_2, CH_4 and N_2O are included for each fuel and engine type.

Division by types of PG:

- **CO_2**: calculated directly from the fuel burned
- **CH_4 and N_2O**: depend on engine technology and environmental standards (e.g. Euro 2/3/4 etc.)

Taking into account the characteristics of transport types and fuel:

- **Electric vehicles**: direct emissions = 0; indirect emissions from the energy sector may be included
- **Hybrids**: calculated proportionally to the time of operation on the internal combustion engine
- **Biofuels**: CO_2 emissions are considered neutral by IPCC; CH_4 and N_2O are taken into account

Structure of the internal model:

- Introductory tables: fleet, mileage, consumption, share by fuel types
- Calculation tables: activity by category
- Emission tables: coefficients for each type of NG
- Scenario tables: growth of the vehicle fleet, transition to electric vehicles, improvement of energy efficiency

8. Forecast results

Model output:

- CO_2, CH_4, N_2O emissions charts by year (2020, 2025, 2030, 2035, 2050)
- Tables of total emissions and by transport category

Comparison of scenarios:

- BAU (without additional measures)
- WAM (with measures: electrification, fuel standards, etc.)
- WEM (alternative measures and changes in demand)

The main drivers of emissions are:

- Growth of the vehicle fleet, especially passenger cars
- Fuel consumption and its structure
- Low penetration of electric transport

9. Uncertainties and Sensitivities

Sources of uncertainty:

- Quality of statistical data (fleet, mileage, fuel consumption)
- IPCC emission factors for the region
- Future developments in technology and policy (e.g. growth of electric vehicles)

Sensitivity analysis:

- +/- 20% of mileage (which model parameters are most sensitive)
- Changes in specific fuel consumption
- Share of alternative modes of transport (EV, CNG, etc.)

Potential for clarification:

- Improving data collection at the national level
- Implementation of regular studies of mileage, fuel consumption
- Tier 2/3 model extension for select categories

10. Conclusion and recommendations

Key findings:

- Projections show emissions rising under the BAU scenario
- Electrification and energy efficiency measures can reduce emissions

Recommendations:

- Ensure regular collection of transport data (structure, mileage, fuel)
- Institutionalize the emissions forecasting process
- Use forecast results for NDC and BTR planning

11. Appendices

Applications No

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