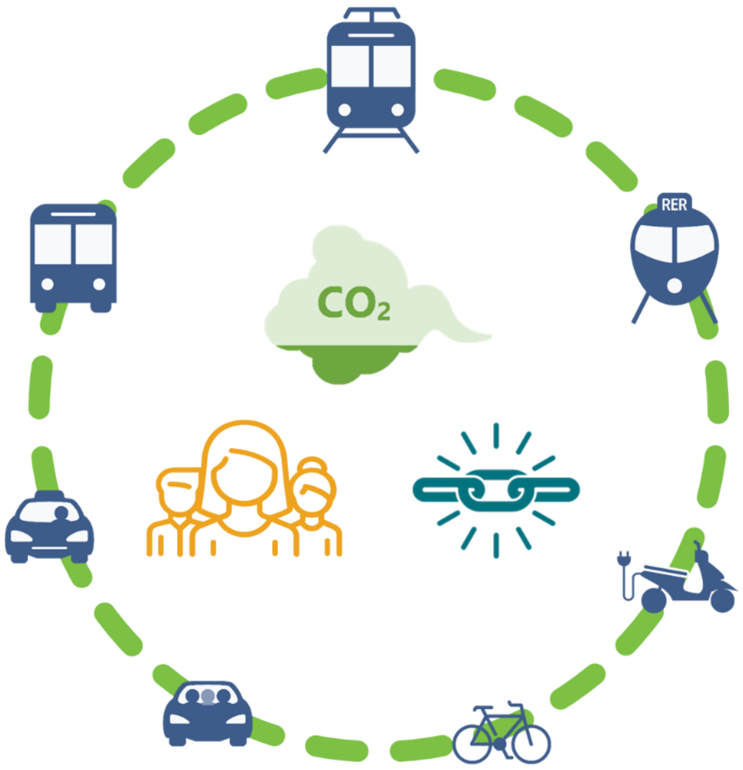


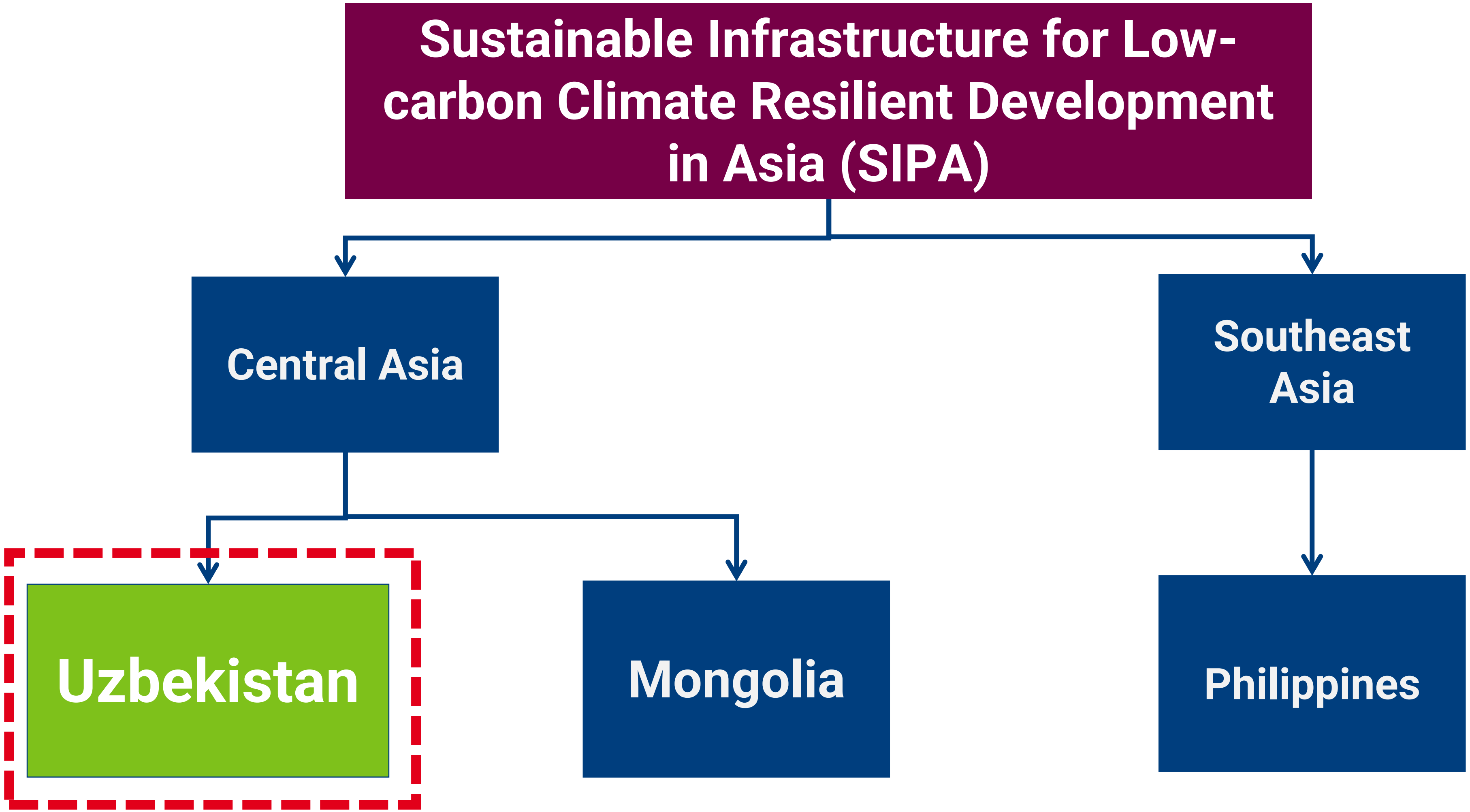
National Roadmap Study For Uzbekistan

Develop Decarbonising Pathways for Urban Passenger Transport: the ITF approach

11 January 2022

Guineng Chen, PhD

Programme scheme



ITF project team for Uzbekistan

Key Experts		Role for the programme		
Guineng Chen Team Lead	→	ITF overall Programme manager		
Yaroslav Khodolov Policy Analyst & Modeller	→	ITF Lead for Uzbekistan	&	ITF Analyst for Central Asia
Mallory Trouvé Policy Analyst & Modeller	→	ITF Lead for Mongolia	&	ITF Analyst for Central Asia

Non-key experts from ITF will also provide support on different aspects throughout the project (e.g. specific policy analysis, stakeholder engagement, administration, logistics).

Reforming the Public Transport Sector to Provide Sustainable Urban Mobility in Tashkent, Uzbekistan

Part 1: Understanding the urban transport context in Tashkent

Part 2: Developing a public transport improvement plan for Tashkent

Part 3: Quantitative assessment of PT-focused decarbonisation pathways for Tashkent

Part 4: Dissemination of best practices about PT reform and decarbonising urban mobility

Part 1: Understanding the urban transport context in Tashkent

Task 1: Engagement with relevant stakeholders

- List of relevant stakeholders

Task 2: Mapping transport policies and plans, and data collection

- Review of existing policies and mobility plans in Tashkent
- Identification of data sources and data collection

Task 3: Stakeholder consultation to assist with design and analysis of policy pathways/scenarios

- In-country workshop to identify future policy pathways

Part 2: Developing a public transport improvement plan for Tashkent

- Develop **a tailored public transport improvement plan** in consultation with the MoT and other key stakeholders in Uzbekistan, including policies and strategies for development and a series of concrete improvement actions:
  - ✓ Network design and capacity;
  - ✓ Service levels and quality, particularly reliability, public transport infrastructure provision, fare level and structure issues;
  - ✓ Institutional, regulatory, and organisational aspects of the public transport sector.

Part 3: Quantitative assessment of PT-focused decarbonisation pathways for Tashkent

Task 1: Model refinement

- Model with city-specific data and relevant functionalities

Task 2: Development of baseline projections of travel demand and CO_2 up to 2050

- Set up of a scenario with existing and committed policies and measures

Task 3: Development of public-transport-focused decarbonisation pathways

- Policy guidance on the most effective way to decarbonise the urban mobility sector in Tashkent, with a focus on PT development.

Task 4: Model hand-over and training webinar

- Presentation of the tool and results of the quantitative analysis

Part 4: Dissemination of best practices about public transport reform and decarbonising urban mobility

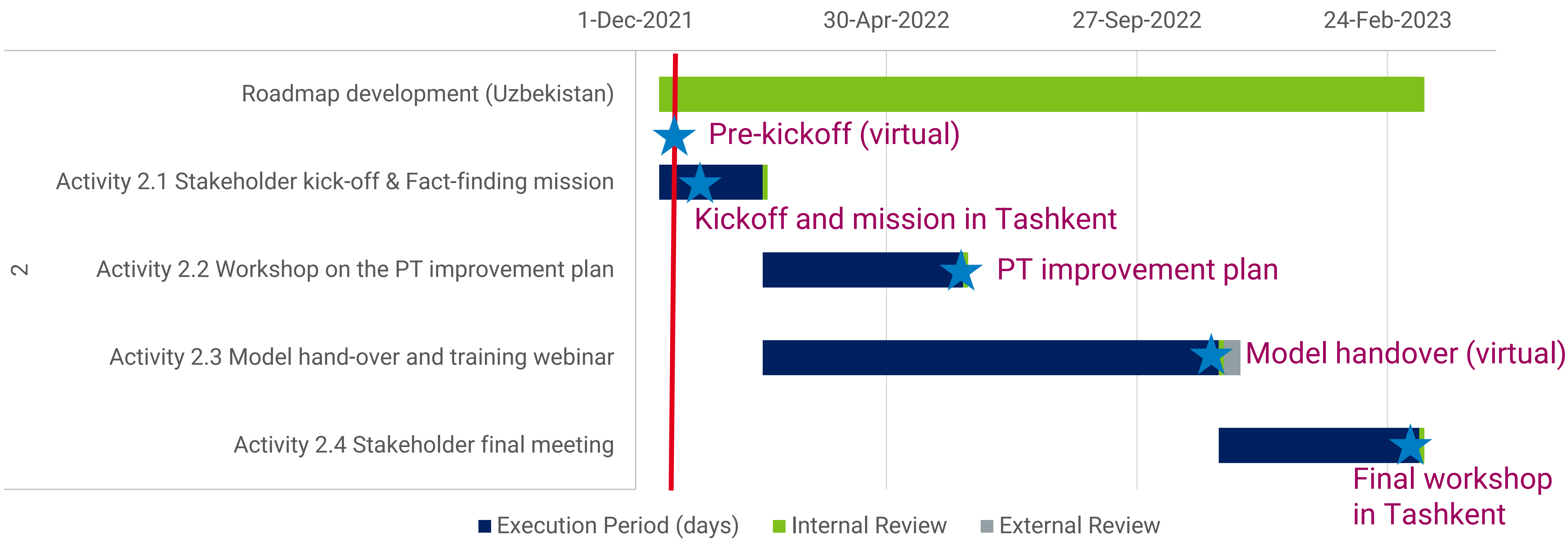
A **joint workshop** will be organised by the ITF and the MoT in Tashkent, inviting a wide range of participants.

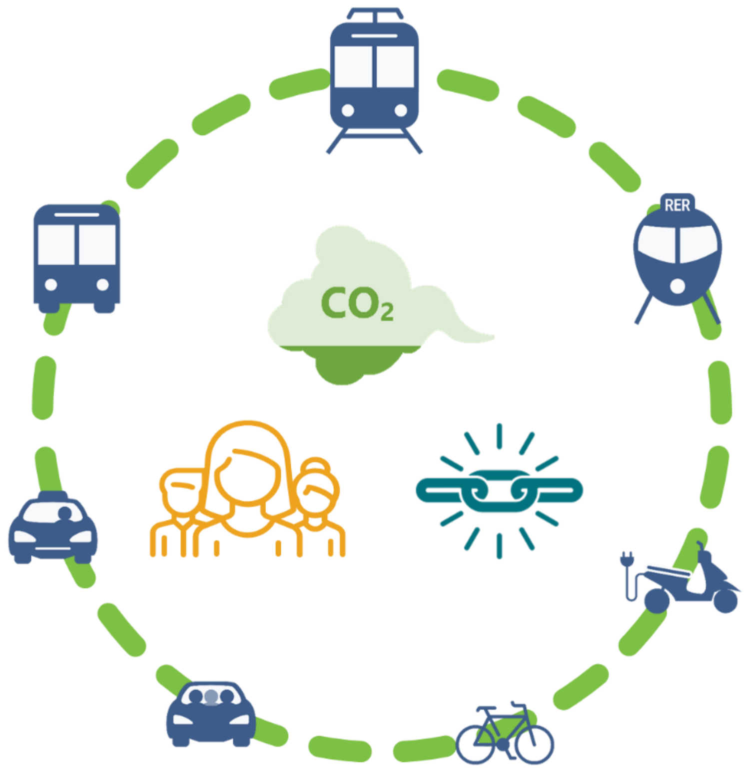
- dissemination of the public transport improvement plan, the scenario building tool, as well as the best practices identified during the work

Additional dissemination process could also include **other events** such as:

- Media releases, press conferences, webinars;
- Promotion of the project at other events (e.g. ITF Annual Summit, international conferences).

Project timeline





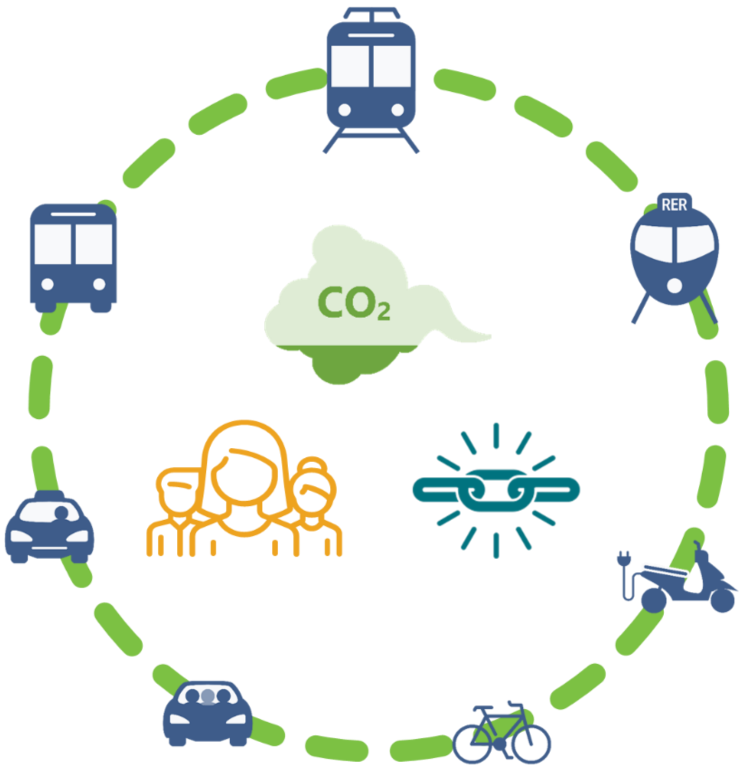
Thank you for your attention

Guineng CHEN, PhD
guineng.chen@itf-oecd.org

2 rue André Pascal
F-75775 Paris Cedex 16

International Transport Forum

OECD



Transport Modelling and Travel Demand Data Collection

Develop Decarbonising Pathways for Urban Passenger Transport: the ITF approach

11 January 2022

Yaroslav Kholodov, Transport Modeller/Analyst, ITF

Presentation structure

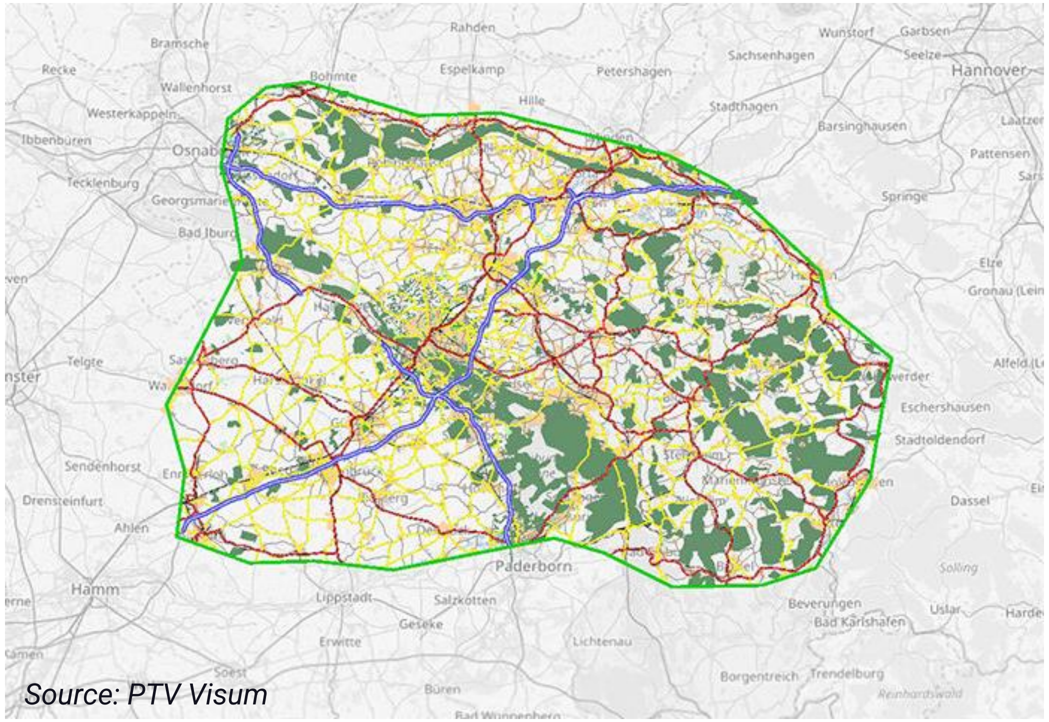
Transport modelling theory

Travel demand data collection

ITF urban passenger transport model

Transport modelling theory

Transport modelling: general framework



Concept: replicate transport and land-use systems

Goal: describe existing and future system performance

Instruments: mathematical algorithms, implementation software, visualization tools

Result: identify the need for policy programs and assessment of their impacts

Traveller's decision principles

Decision maker: an individual or a group of people

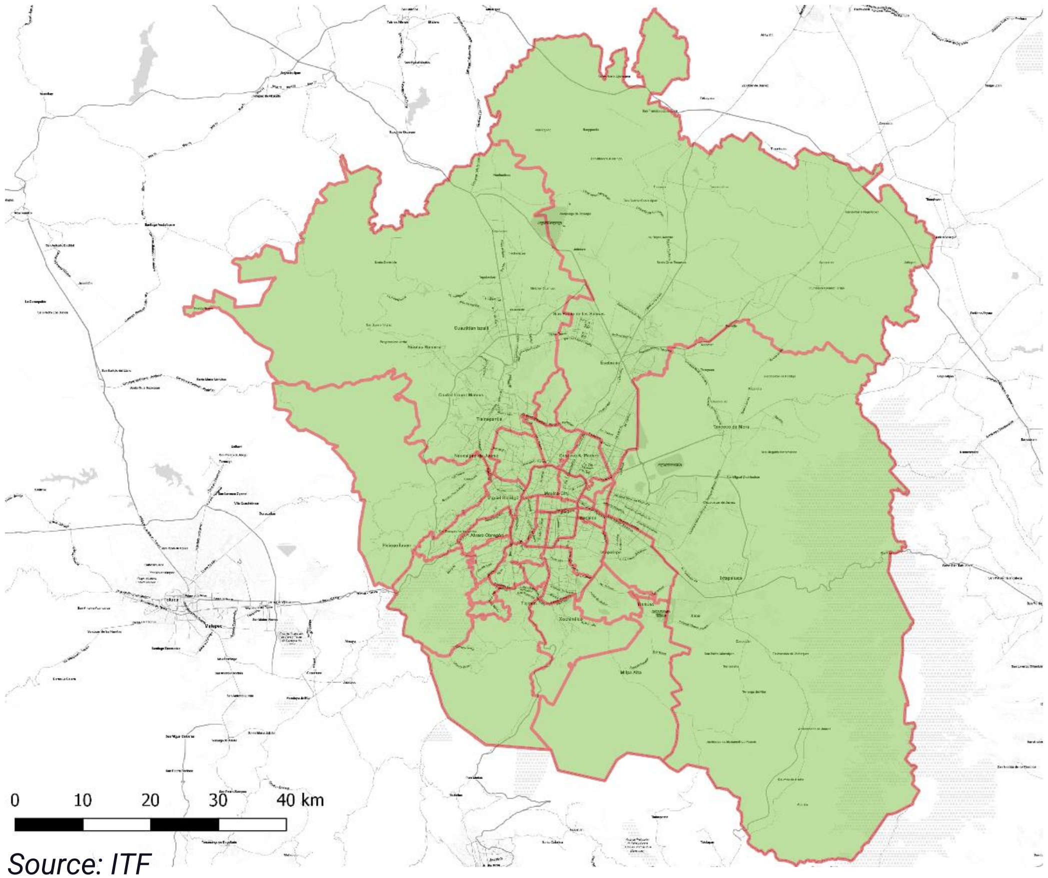
Alternatives: a set of feasible and known choice items

Utility: general measure of satisfaction (U)

Attributes: a set of characteristics enabling comparison across each alternative

Decision rule: maximize utility U_j by choosing an alternative j with attributes x_j

Modelling zonal structure



Source: ITF

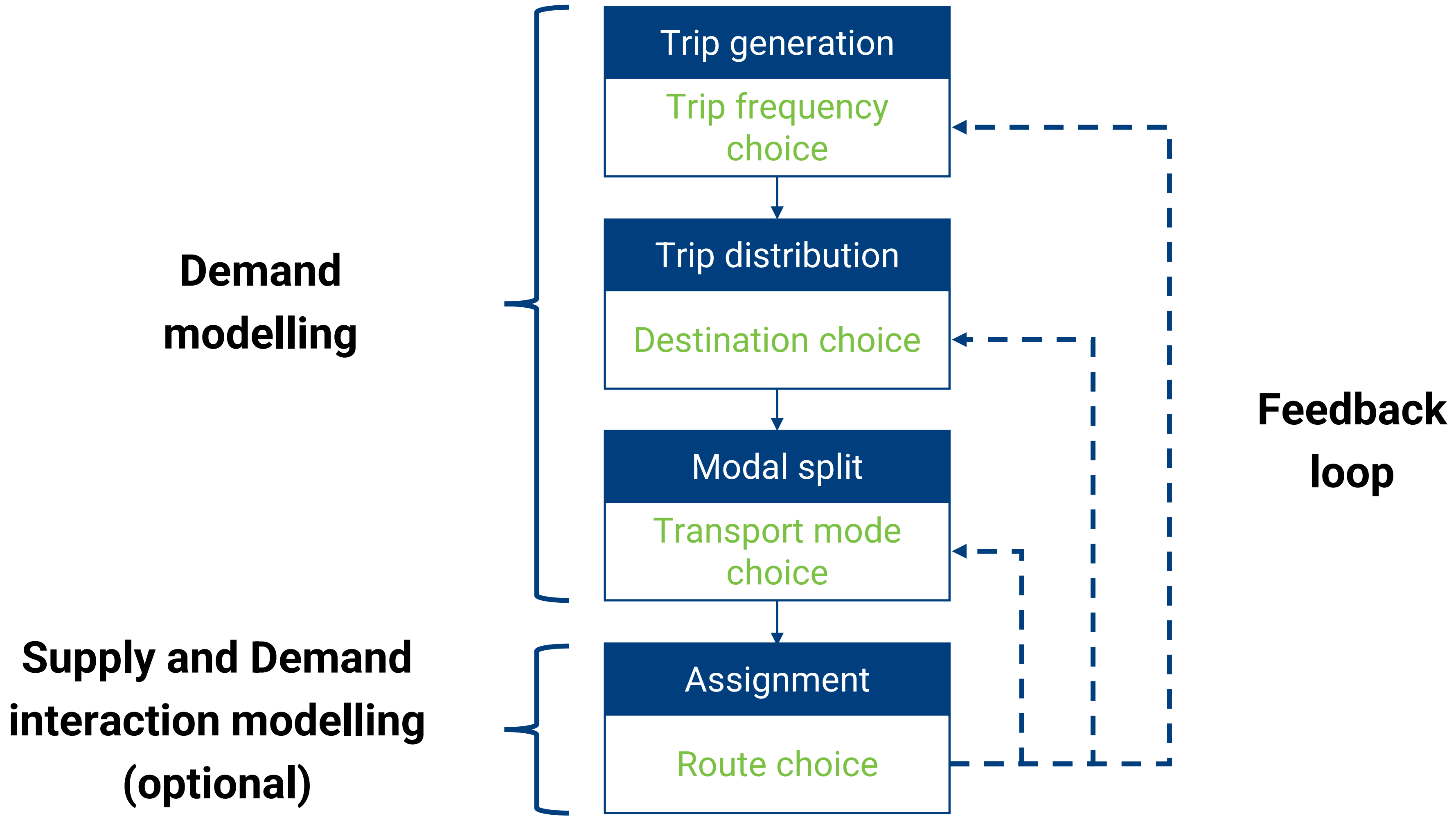
Modelling zone:

- Based on a certain zoning system
- Aggregated attributes
- Origin/destination for trips

Zoning systems:

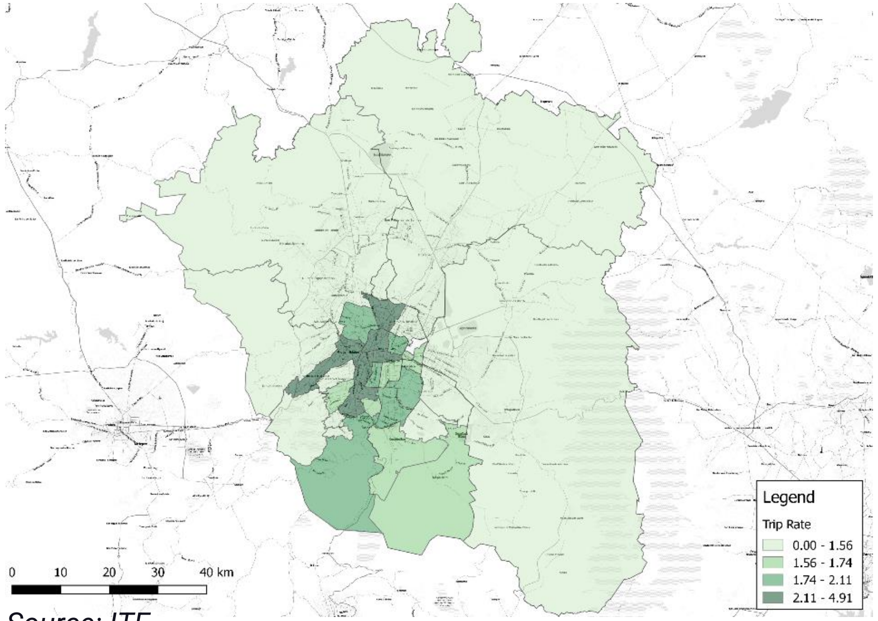
- Administrative area
- Census zones
- Transport analysis zones (TAZ)

4-step transport model: overview



4-step transport model: trip generation

O/D	Zone 1	Zone 2	Zone 3	Zone j	Total production
Zone 1					Trips 1-all
Zone 2					Trips 2-all
Zone 3					Trips 3-all
Zone i					Trips i-all
Total attraction	Trips all-1	Trips all-2	Trips all-3	Trips all-j	Total Trips



Source: ITF

Linear regression: $$Trips_i = a * income_i + b * population_i + c * car\ ownership_i$$

Growth factor model: $$Trips_i(t+1) = G_i * Trips_i(t)$$

4-step transport model: trip distribution

O/D	Zone 1	Zone 2	Zone 3	Zone j	Total production
Zone 1	Trips 1-1	Trips 1-2	Trips 1-3	Trips 1-j	
Zone 2	Trips 2-1	Trips 2-2	Trips 2-3	Trips 2-j	
Zone 3	Trips 3-1	Trips 3-2	Trips 3-3	Trips 3-j	
Zone i	Trips i-1	Trips i-2	Trips i-3	Trips i-j	
Total attraction					

Gravity model:

$$Trips_{ij} = f(Q_i, X_j, F_{ij})$$

$$Trips_{ij} = a_i * b_j * P_i * A_j * F_{ij}$$

4-step transport model: modal split

O/D	Zone 1	Zone 2	Zone 3	Zone j	Total production
Zone 1					
Zone 2					
Zone 3					
Zone i					
Total attraction					

Overall OD-matrix

Mode-specific OD-matrix

(car, PT, bike, walk, taxi, etc.)

O/D	Zone 1	Zone 2	Zone 3	Zone j	Total production
Zone 1					
Zone 2					
Zone 3					
Zone i				Trips i-j-z	
Total attraction					

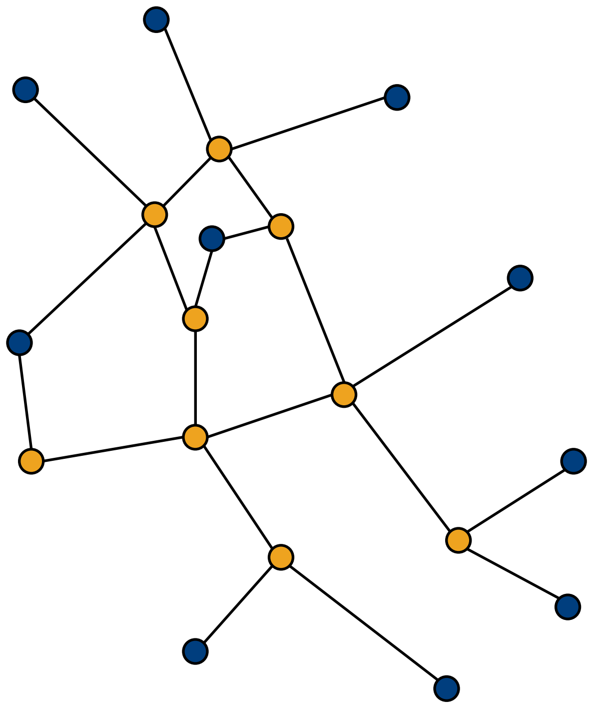
Discrete choice model:

$$P_{ijz} = \frac{e^{\beta V_{ijz}}}{\sum_w e^{\beta V_{ijw}}}$$

$$V_{ijz} = ASC + \theta_1^z * U_{ij1}^z + \theta_2^z * U_{ij2}^z$$

4-step transport model: assignment

Network structure

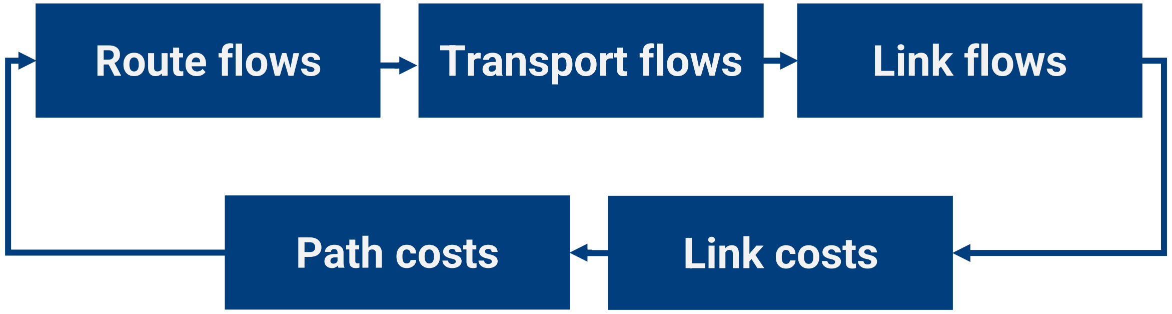


Node
X-coordinate
Y-coordinate

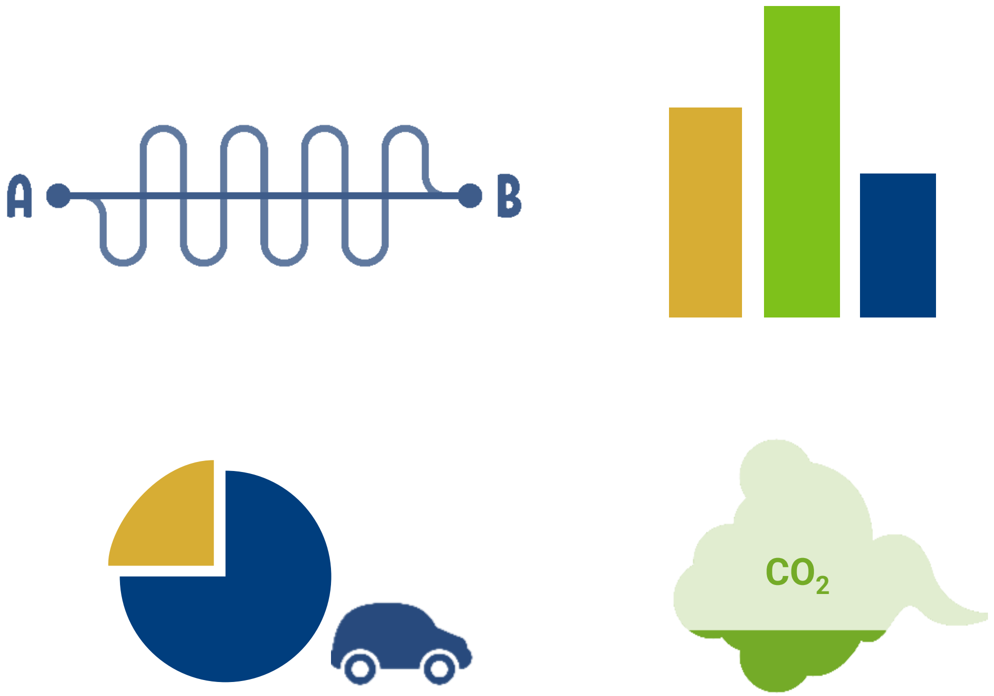
Centroid
zonal data
origin/destination

Link
node-from
node-to
length
maximum speed
number of lanes
capacity

Assignment loop

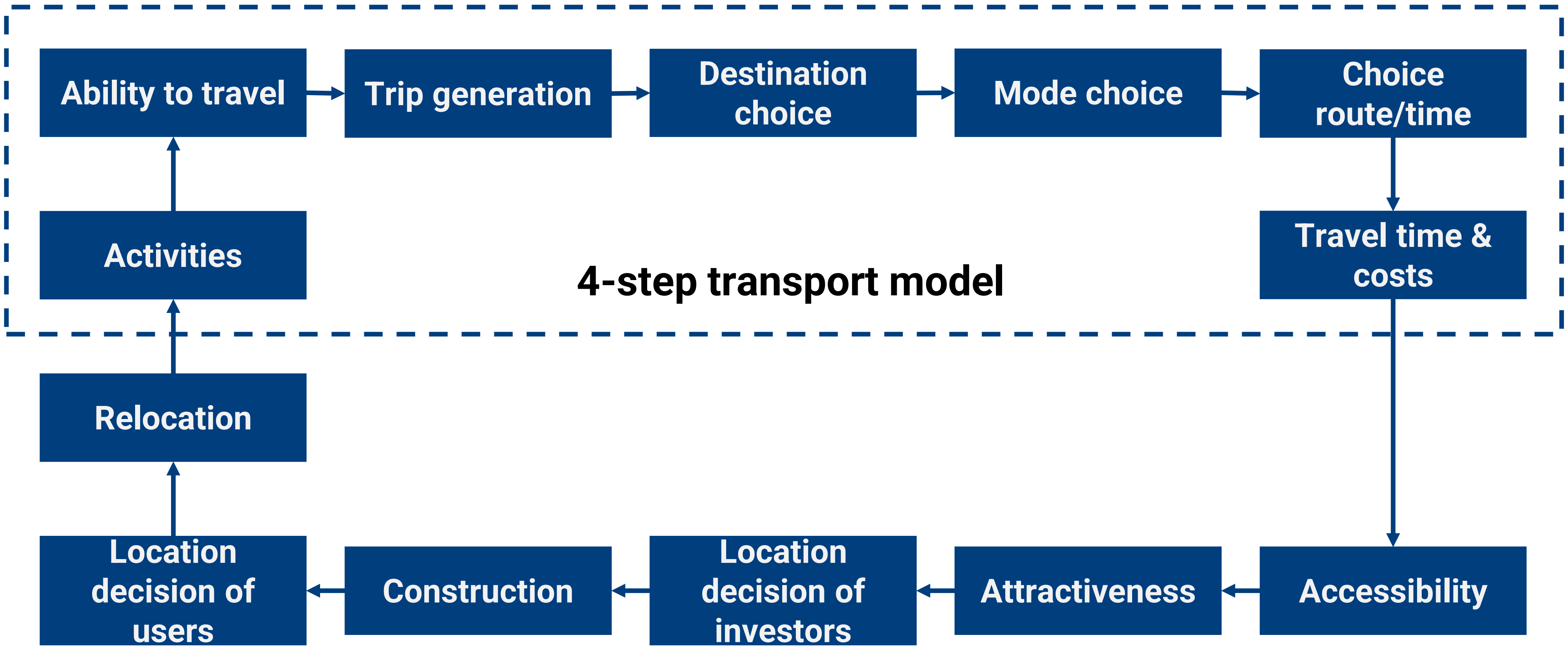


4-step transport model: output indicators



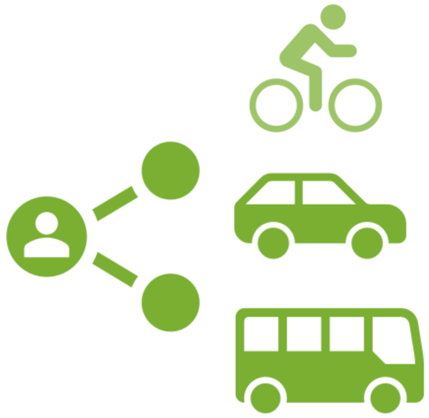
- Trip numbers
- Trip rate
- Trip length distribution
- Trip duration distribution
- Modal split
- Passenger-km / vehicle-km
- Traffic flows
- V/C ratio for intersections and roads
- CO_2 emissions and pollutants

Land-use and transport interaction



Travel demand data collection

Essential aspects of travel demand data



Travel demand data:

- Required for model development (e.g. calibration and validation)
- Have to be relevant, up-to-date and accurate
- Represent a snapshot of travel patterns on a particular day/days
- Usually obtained through transport surveys
- Only collected at a few locations and for a sample of travellers

Main data components

Household characteristics

- Dwelling type
- Dwelling ownership
- Household size
- Household composition
- Household income
- Vehicle ownerships

Individual characteristics

- Age
- Gender
- Residency status
- Education
- Employment status
- Occupation
- Personal income
- License holding

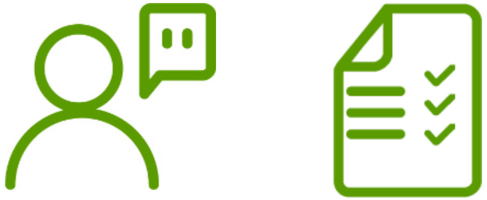
Travel characteristics

- Travel origin/destination
- Departure/arrival time
- Travel purpose
- Transport mode
- Vehicle: type, occupancy, route, parking
- PT: ticket and fare information

Main data source: survey

Passive surveys:

- No interference with transport users
- Limited to the direct area under study
- Cover actual behavior only



Active surveys:

- Disturb transport activities
- Broader travel information
- Cover actual and "latent" demand (with subjective bias)

Survey design: example questions

Revealed Preference

8. Think about your **journeys to and from work.**
(e.g. travel to and from your place of work, accompanying your spouse to and from their work).

a. How often did you make such a journey over the **last seven (7) days**? ☐ TIMES ☐ IF ZERO TIMES, TICK HERE AND GO TO QUESTION 9.

b. How much time in total over the last seven (7) days did you spend travelling **to and from work** by:

	HOURS	MINUTES
Walking		
Cycle		
Bus		
Train		
Car, as a driver		
Car, as a passenger		
Other (please specify): ___________		

c. How far did you travel in total over the last seven (7) days **to and from work** by:

	MILES
Walking	
Cycle	
Bus	
Train	
Car, as a driver	
Car, as a passenger	
Other (please specify): ___________	

Stated Preference

Scenario one - What Option would you choose?

Danfo	Car	Bus	Okada	Keke	Light Rail
					
Travel Time: 50 Min	Travel Time: 60 Min	Travel Time: 65 Min	Travel Time: 45 Min	Travel Time: 45 Min	Travel Time: 37.5 Min
Travel Cost: 50 Naira	Travel Cost: 70 Naira	Travel Cost: 55 Naira	Travel Cost: 20 Naira	Travel Cost: 25 Naira	Travel Cost: 40 Naira
Comfort: 5	Comfort: 6	Comfort: 5	Comfort: 1	Comfort: 2	Comfort: 6
Select: ○	Select: ○	Select: ○	Select: ○	Select: ○	Select: ○

I would not choose any of these options: ○

Complimentary data sources

Traffic data:

- Screenline/cordon counts
- Traffic signal counts
- Automatic Vehicle Location (AVL)
- License plate recognition

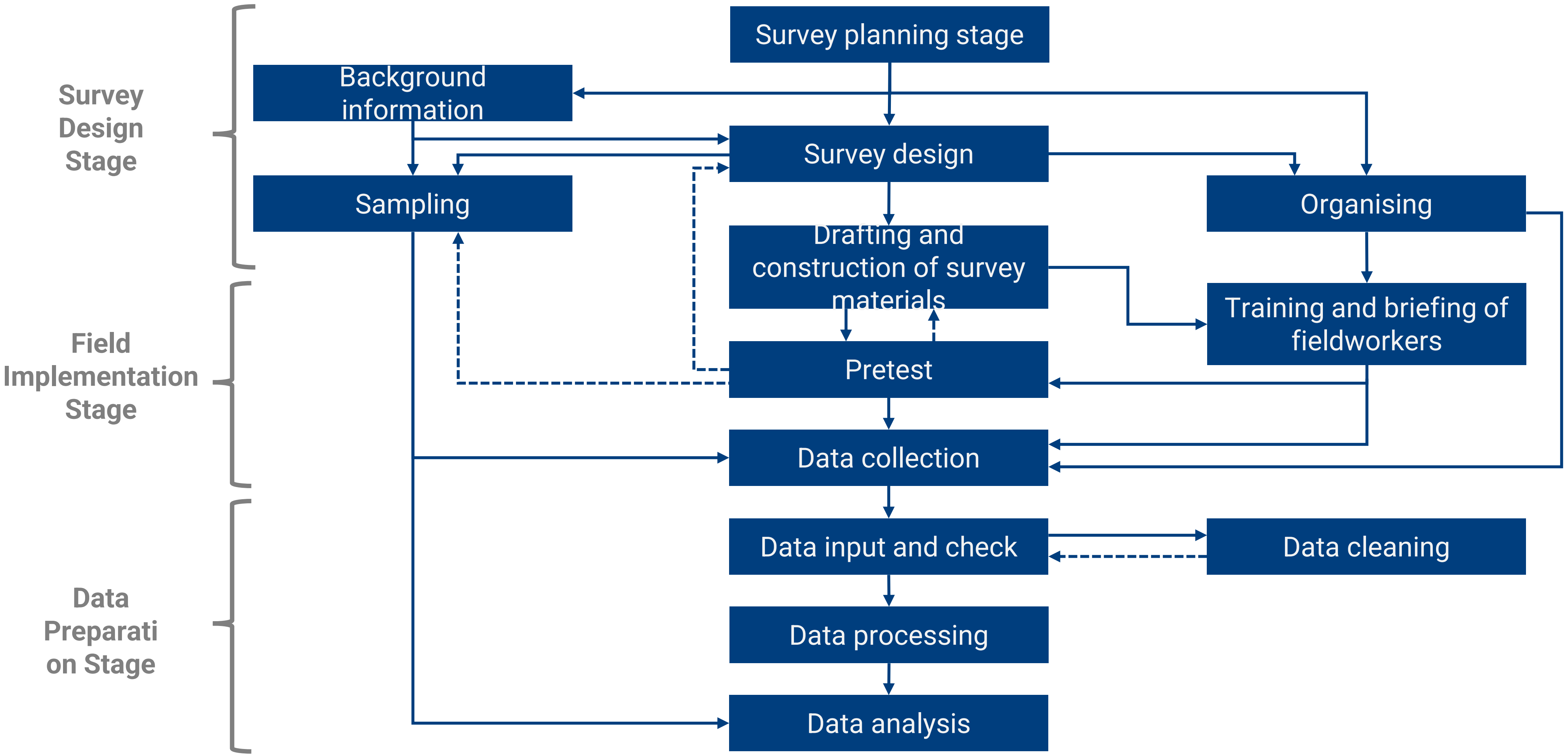
Mobile data:

- Bluetooth
- GPS
- GSM

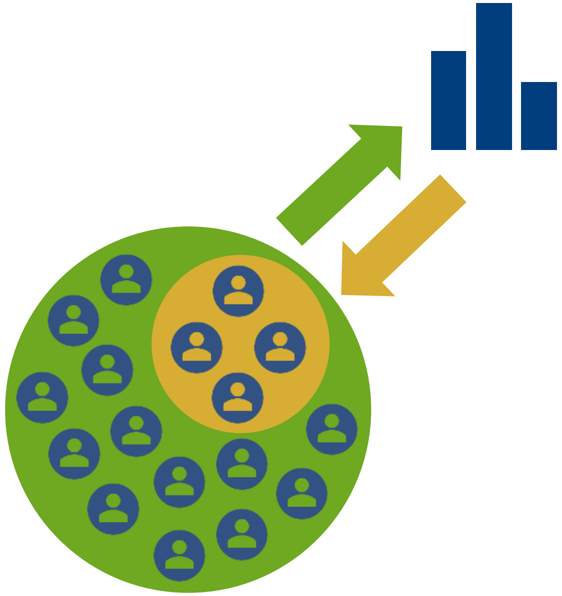
Public transport data:

- Smart card information
- Camera/detector count
- On-board or station surveys

Survey implementation process



Sampling



Sample design steps:

- Definition of target population
- Definition of a sampling unit
- Selection of a sampling frame
- Choice of a sample method
- Consideration of likely sampling errors and biases
- Determination of a sample size

Survey data processing steps

Data input and check

- Reformatting
- Cleaning
- Correction
- Validation
- Aggregation

Data expansion

- From sample to population
- Performed for modelling zones
- Based on the distribution of known attributes
- Household or personal level

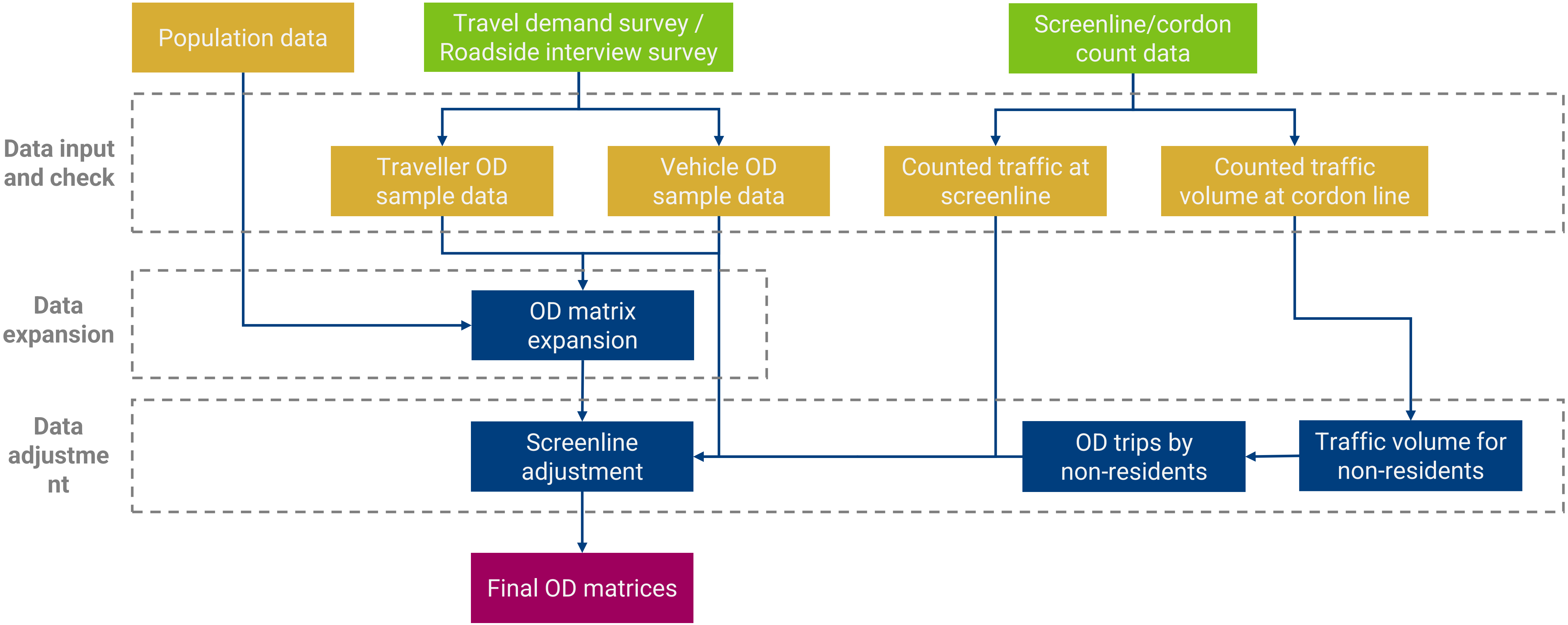
Data adjustment

- Based on screenline traffic counts
- Requires vehicle occupancy ratios
- Trips by non-residents should be separated

Model calibration

- Utilises the base OD-matrix
- Explanatory variables come from survey data
- Performed for each step of the transport model

Survey data processing: OD-matrix development



ITF urban passenger transport model

ITF global modelling framework

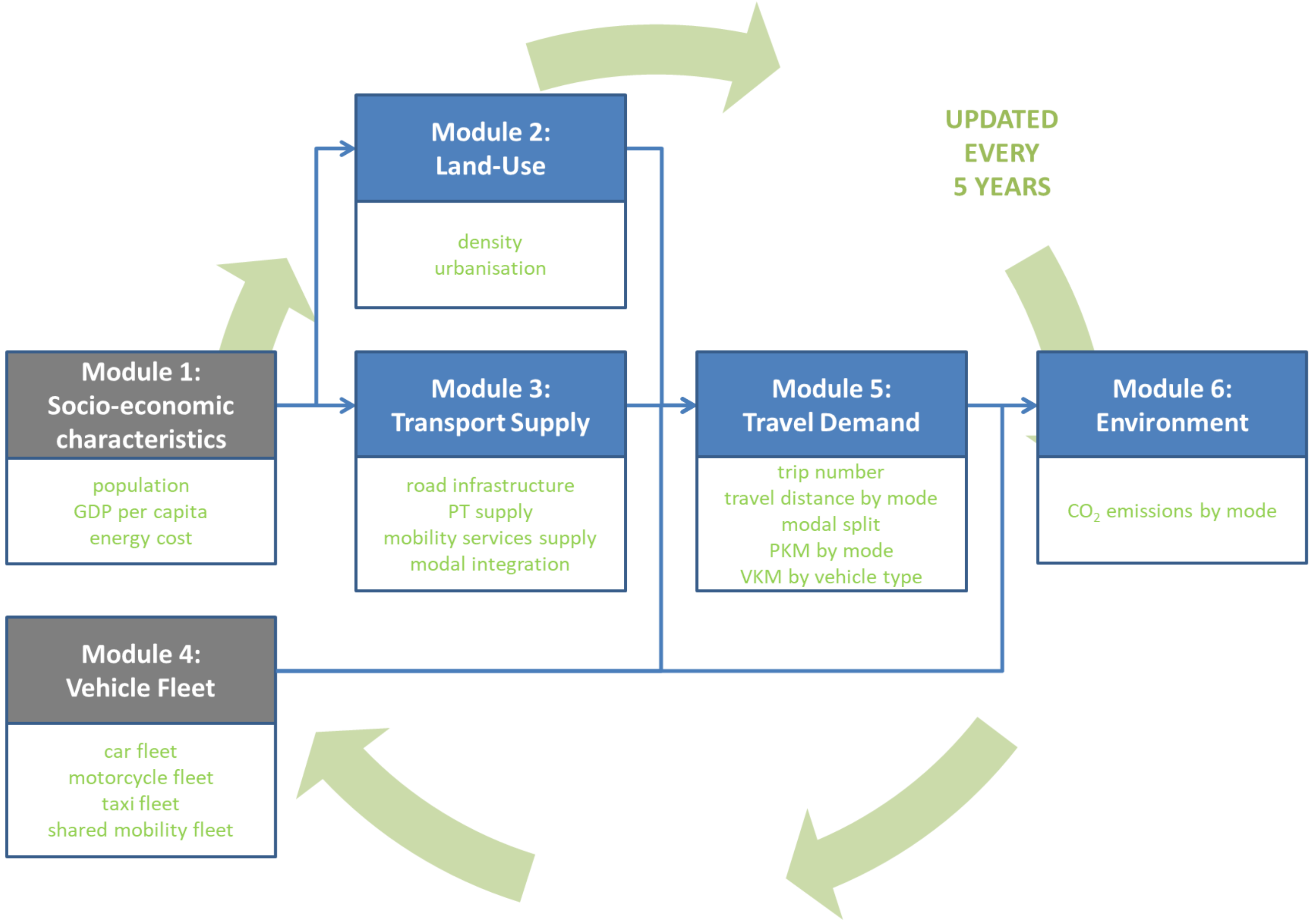
Urban passenger transport model

Non-urban passenger transport model

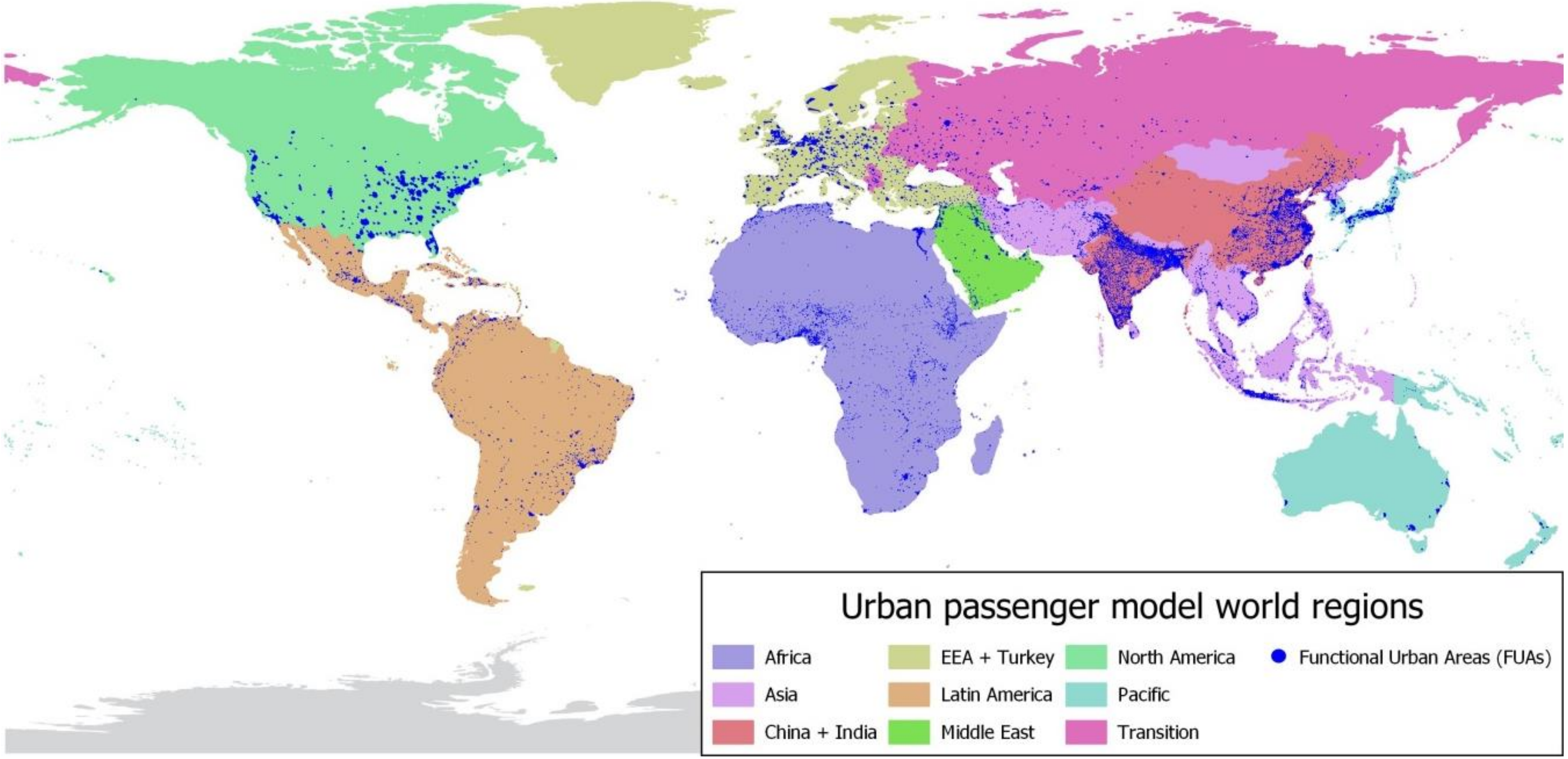
Urban freight transport model

Non-urban freight transport model

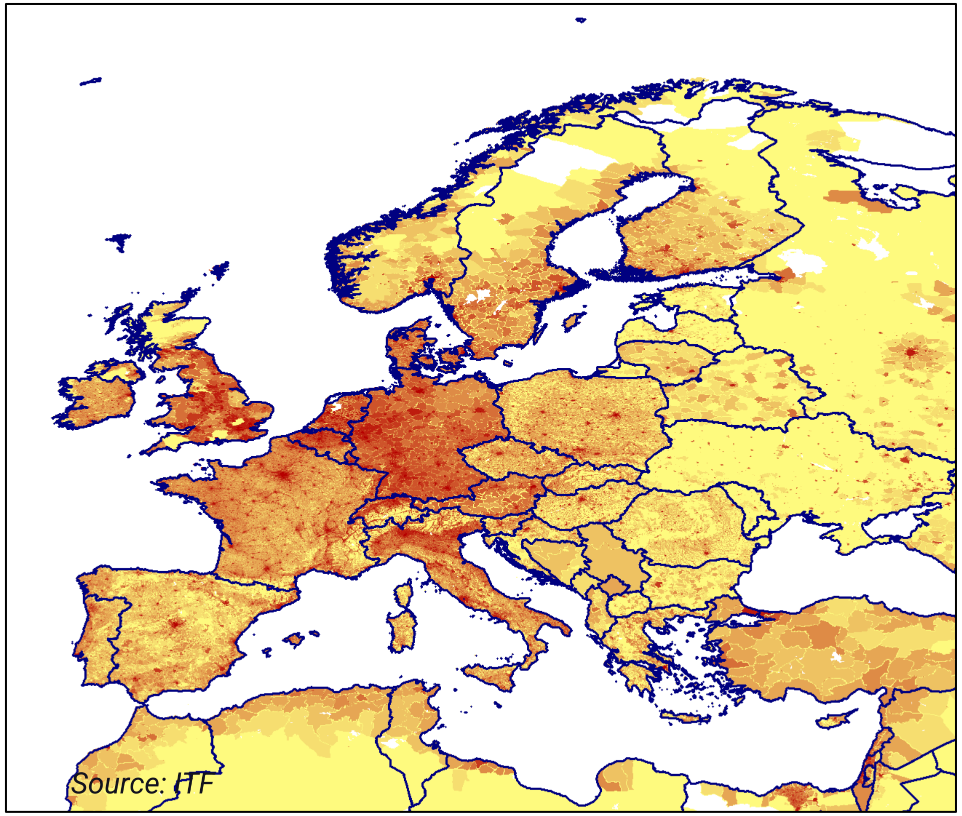
ITF urban passenger model

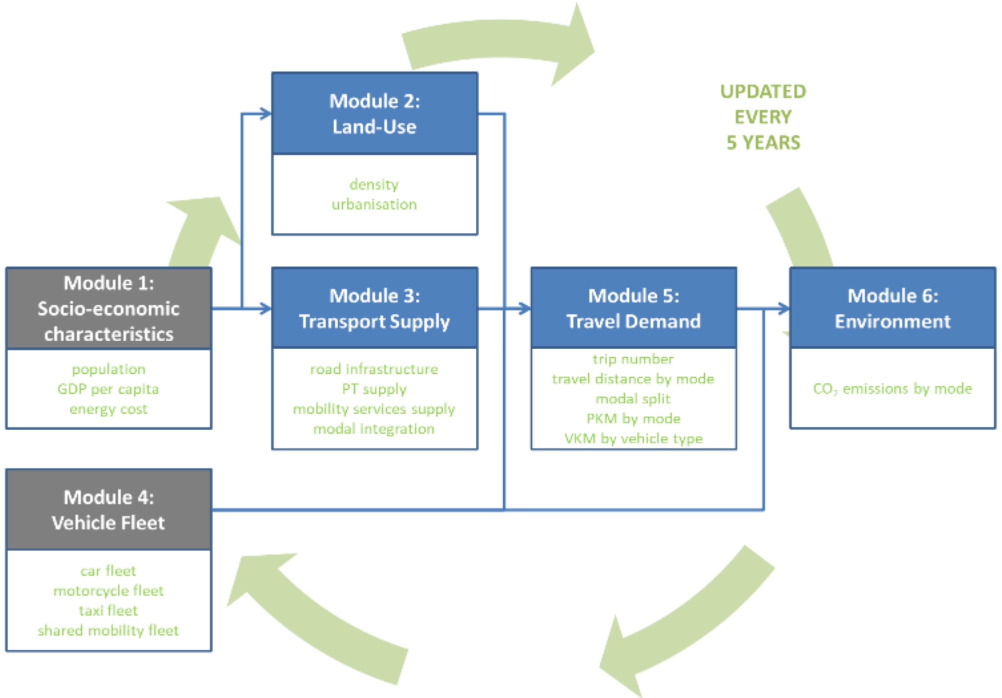


ITF urban passenger model: scale

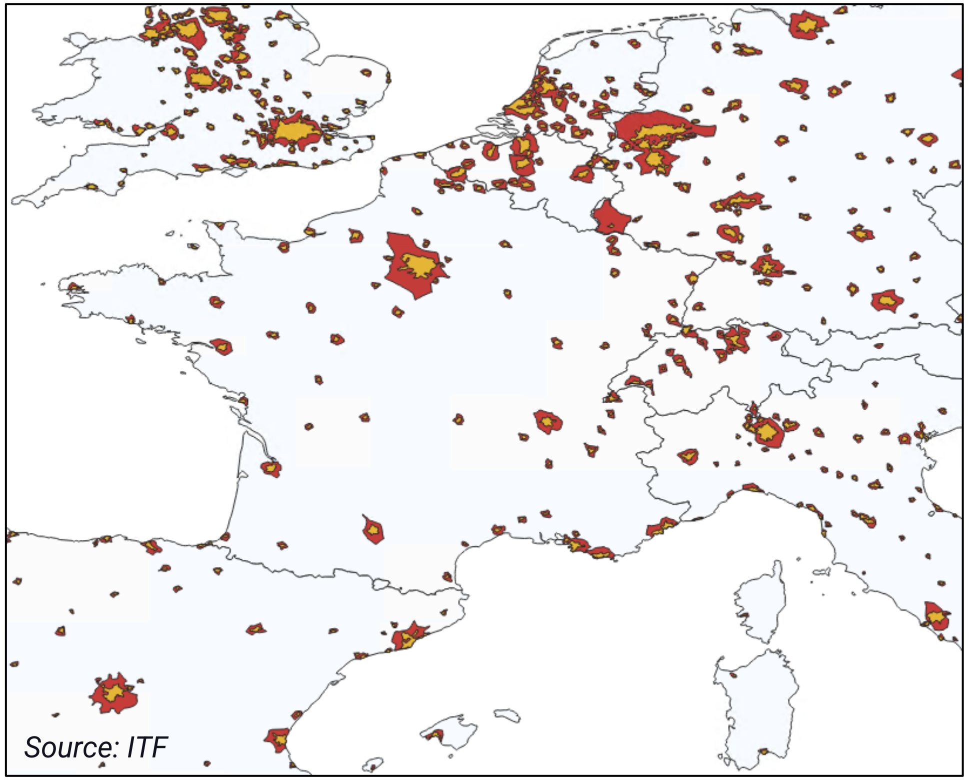


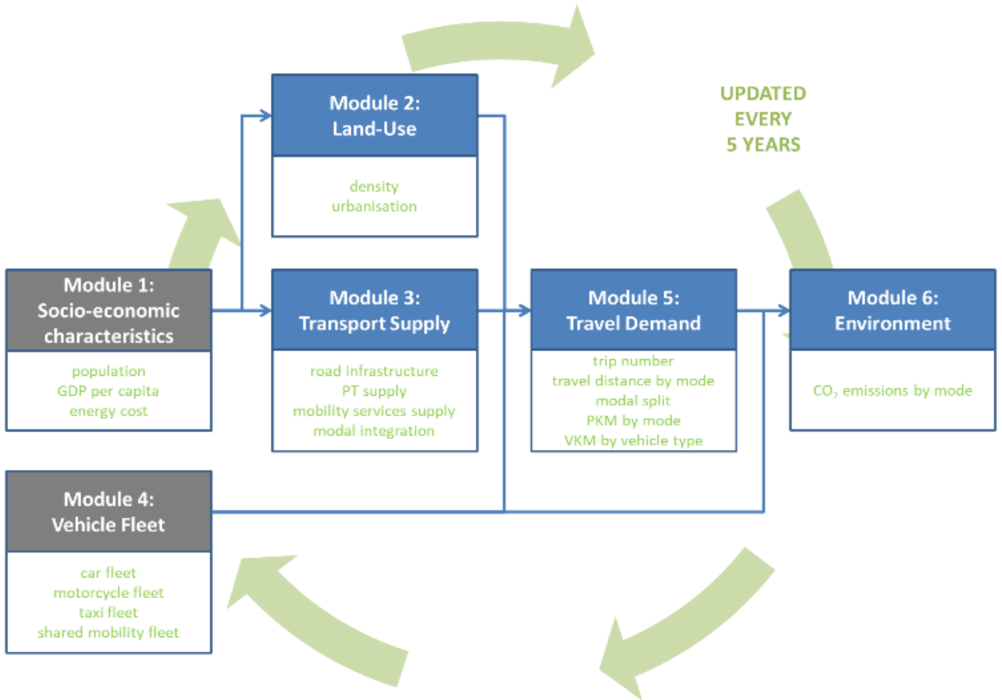
ITF urban passenger model: socio-economic characteristics



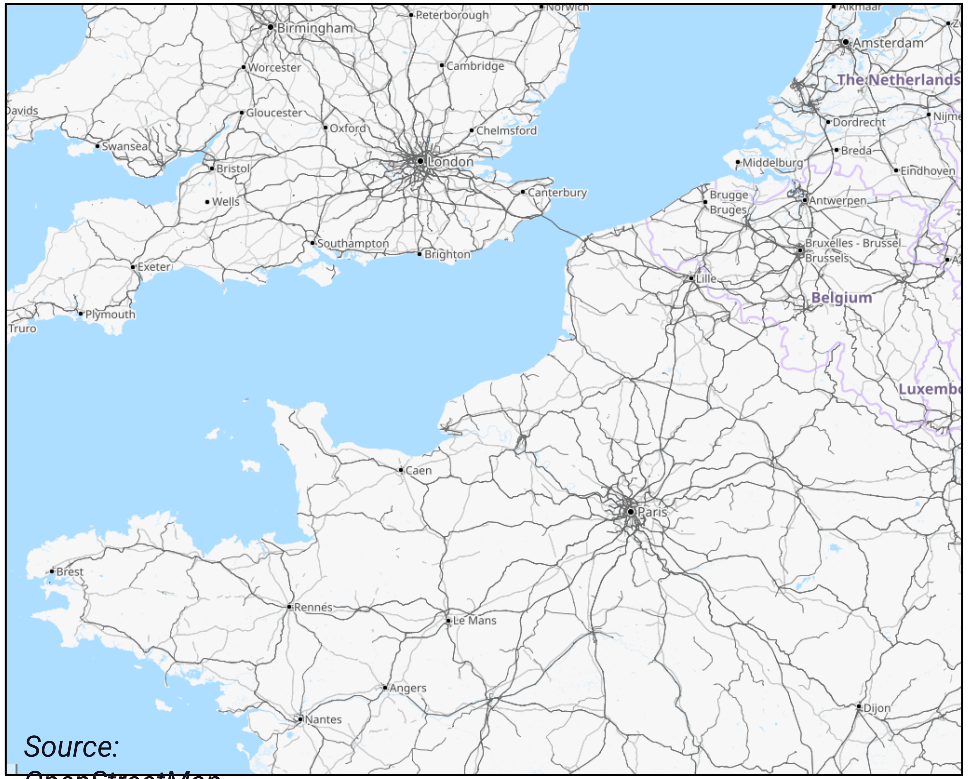


ITF urban passenger model: land-use

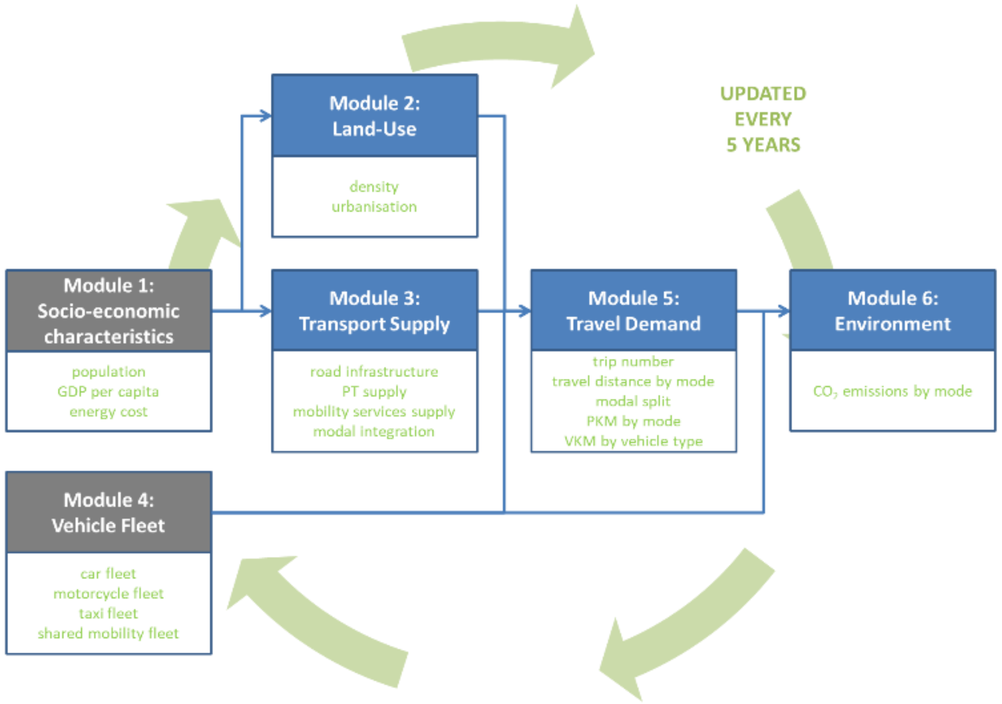




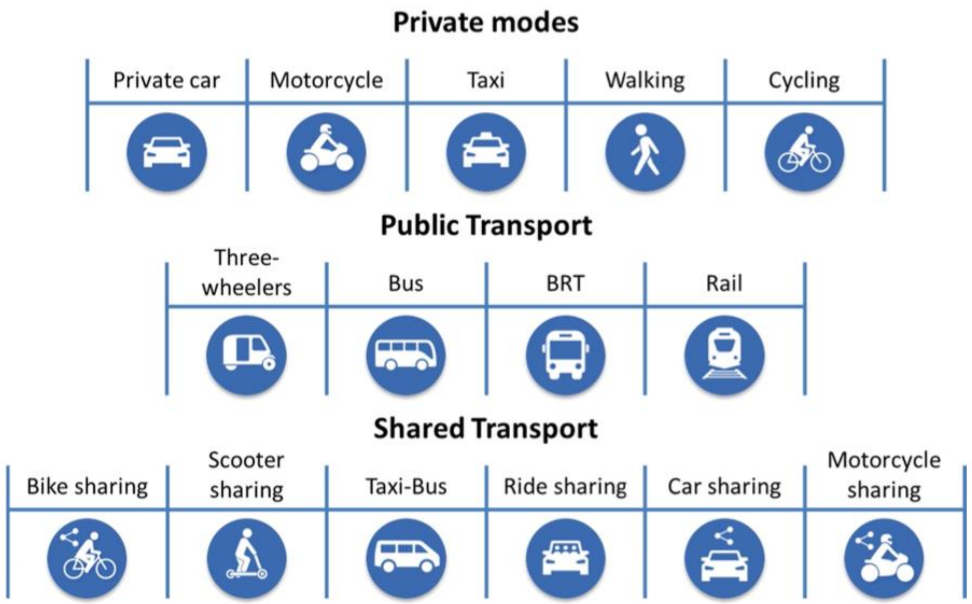
ITF urban passenger model: transport supply

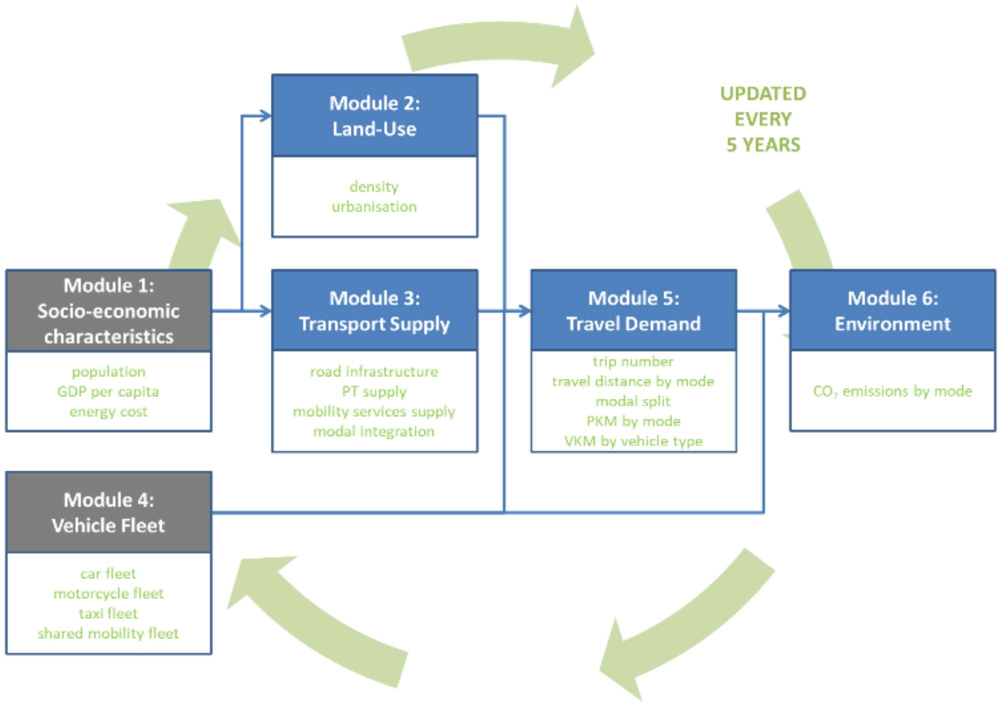


Source: OpenStreetMap

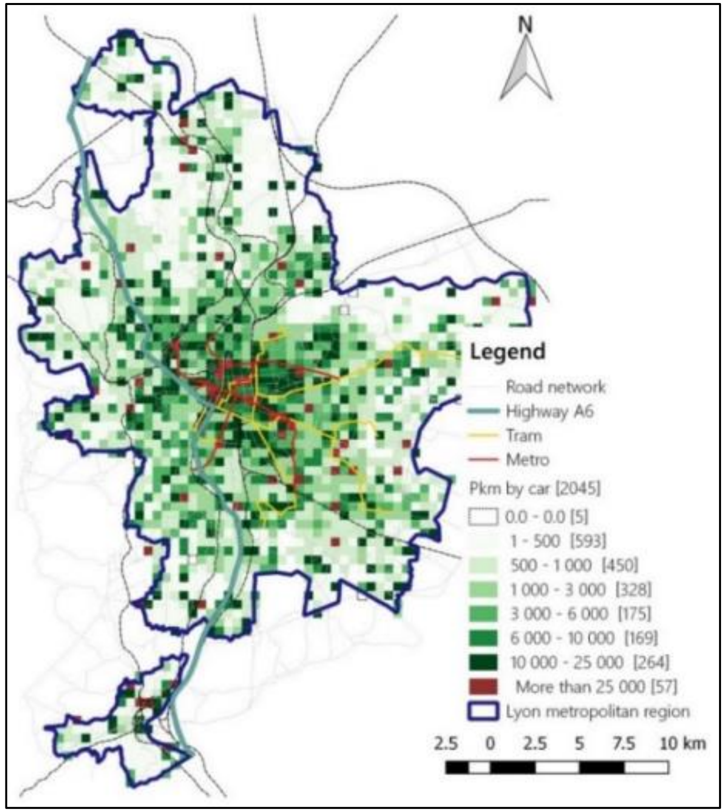


ITF urban passenger model: vehicle fleet

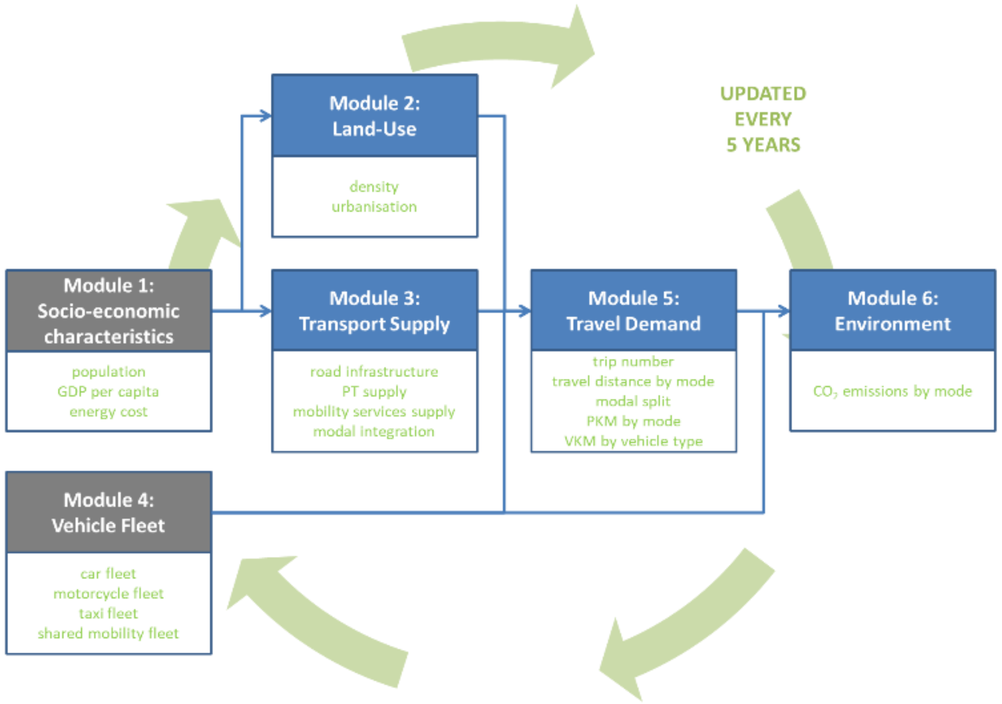




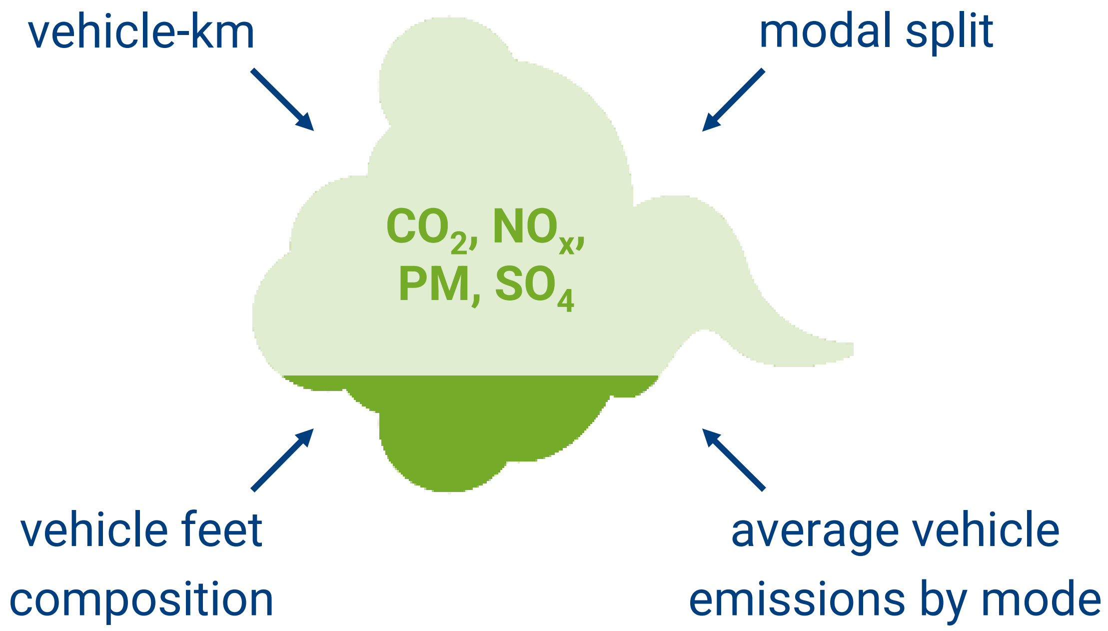
ITF urban passenger model: transport demand

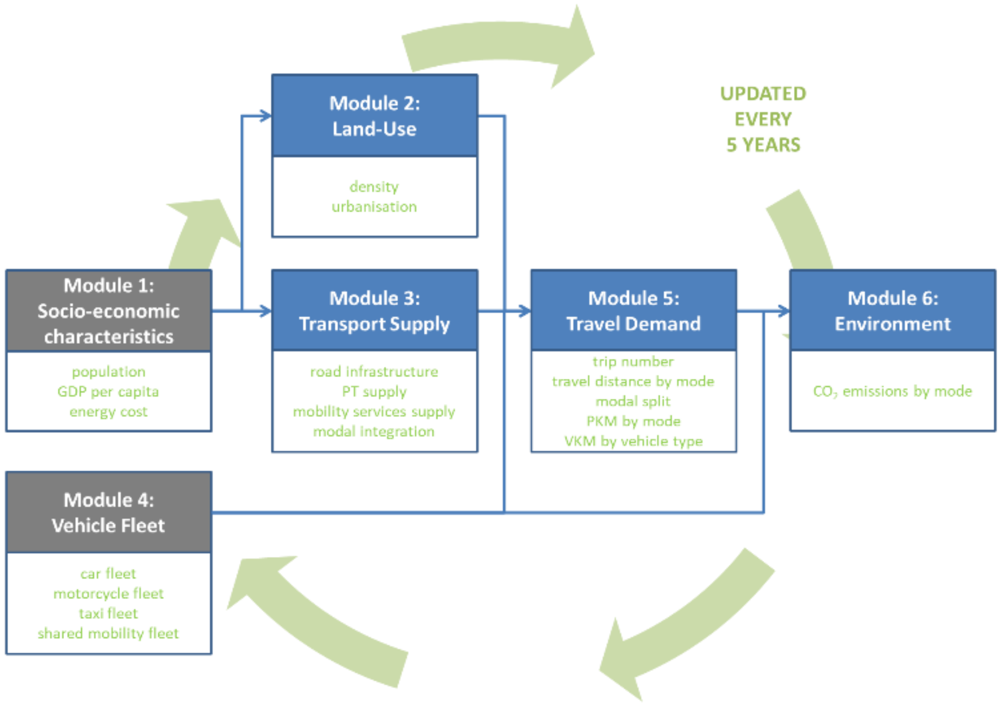


Source: ITF



ITF urban passenger model: environment





ITF urban passenger model: additional indicator groups

Congestion

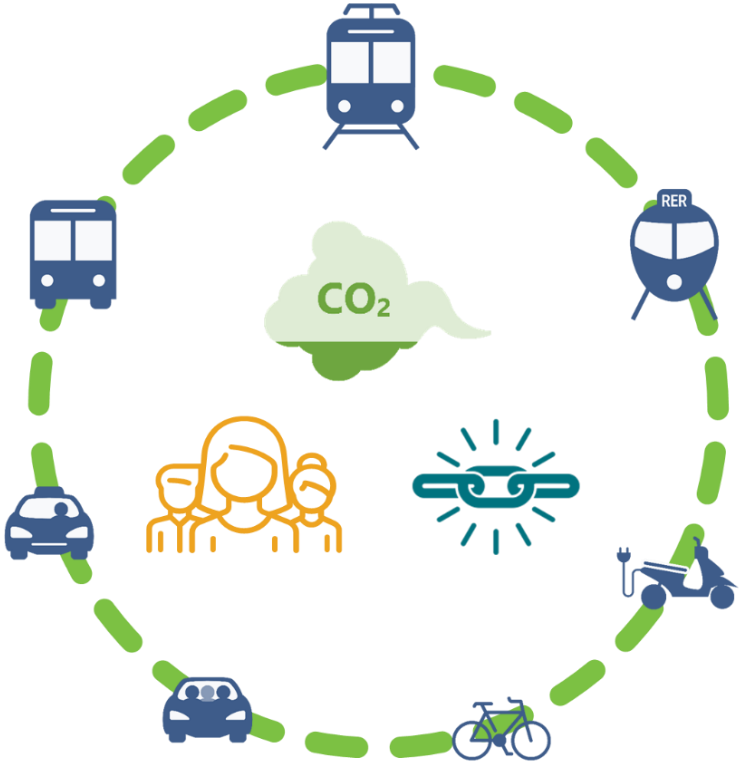
Reliability

Safety

Accessibility

Affordability

Equity and inclusion



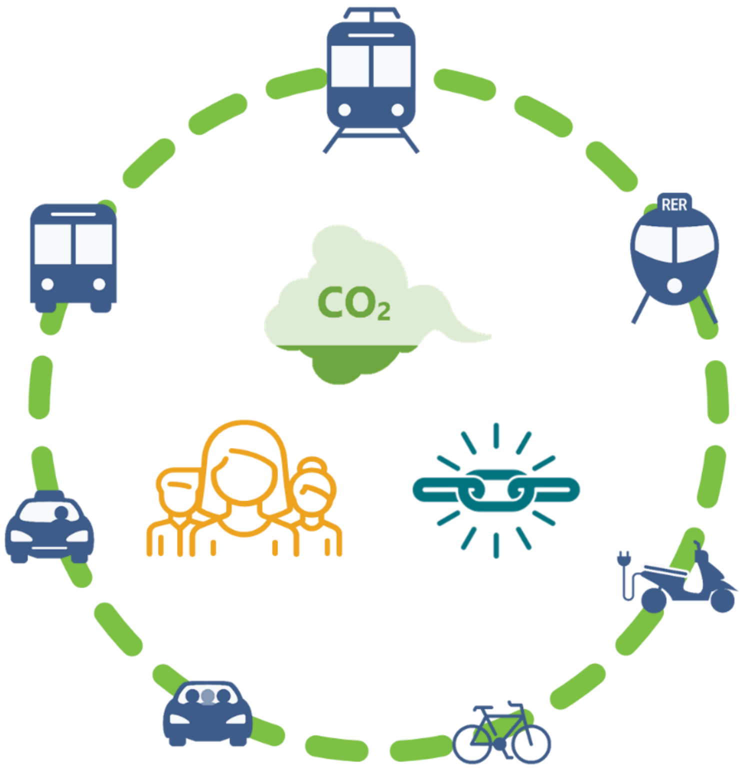
Thank you for your attention

Yaroslav Kholodov
yaroslav.kholodov@itf-oecd.org

2 rue André Pascal
F-75775 Paris Cedex 16

International Transport Forum

OECD



Transport Modelling to Support Policy Making

Develop Decarbonising Pathways for Urban Passenger Transport: the ITF approach

11 January 2022

Yaroslav Kholodov, Transport Modeller/Analyst, ITF

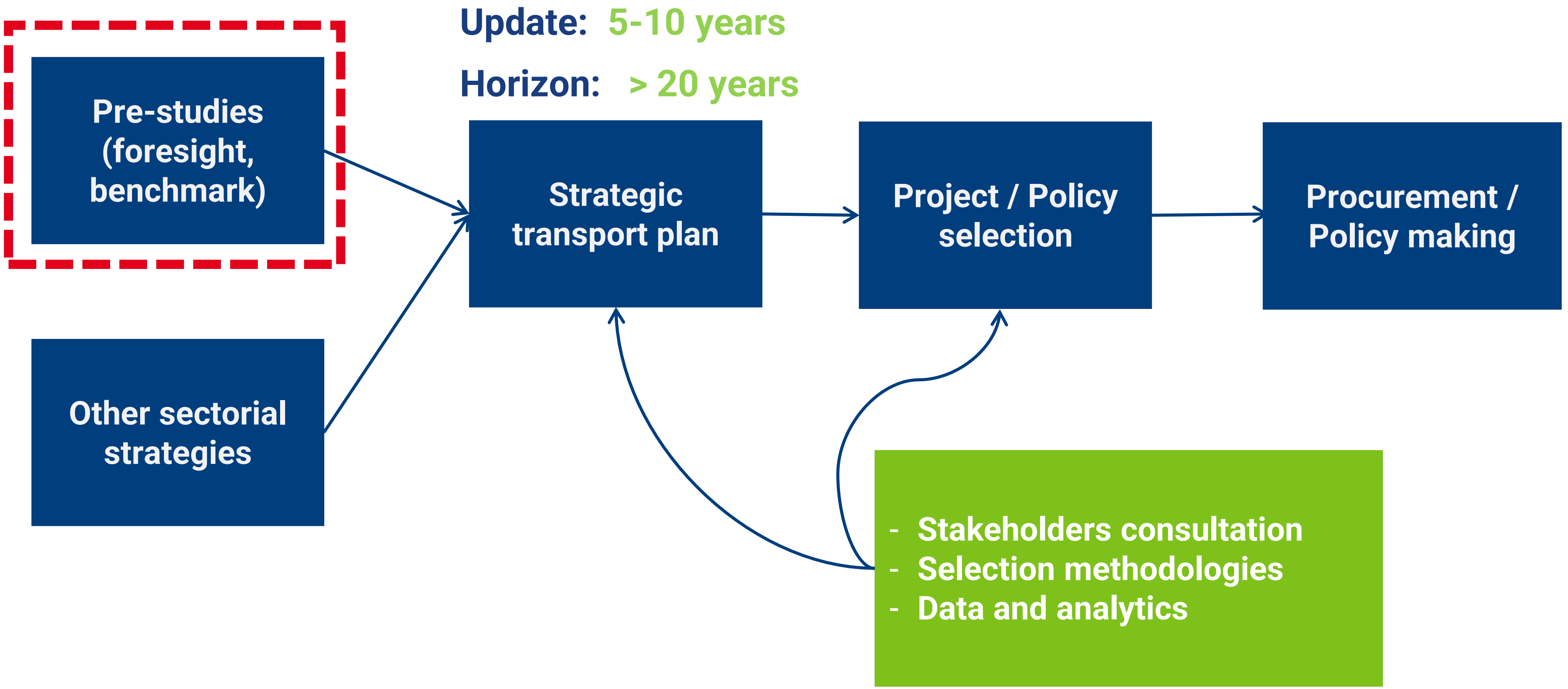
Presentation structure

Quantitative policy analysis framework

Case study on transport policy assessment in India

Quantitative policy analysis framework

Setting up transport roadmaps



Estimating exercise

All the content produced is the result of estimations, it is not a forecast

The quality/accuracy of estimation is dependent on the input data and the relevance of the initial assumptions

Objective: assess the future evolution of urban passenger transport and its impact on the environment, and test policy measures and alternative development scenarios

Field approach

The key for a good estimation: be in close touch with the field

Connect & Engage with local stakeholders

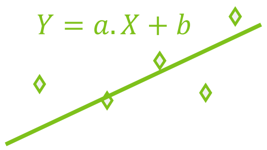
Experience the system with a field trip

Check regularly the assumptions with relevant sources

Core of the estimation process: data

Observed data

Data points from direct observation, may not exist or fully represent the study area



Synthetic data

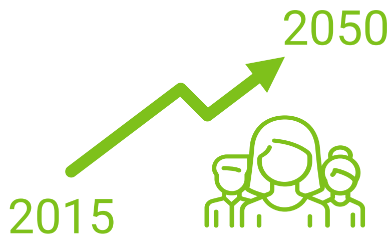
Data estimated from other « similar » cases

Assumption checking

Consistency of the input data

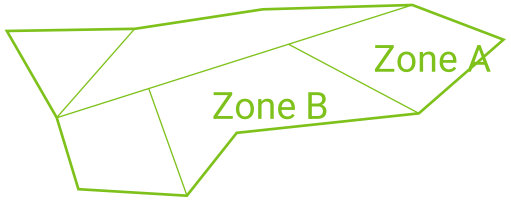
Data types

Socio-economic



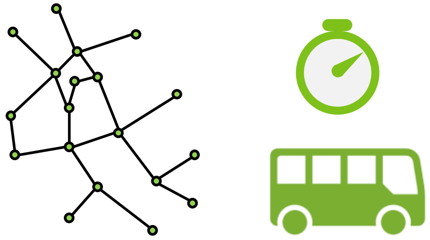
- Population
- Gender
- Age
- Income
- GDP

Geographic



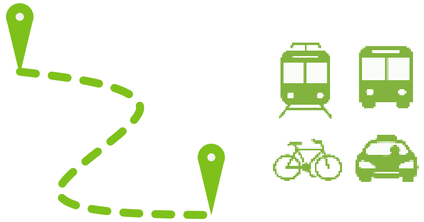
- Boundaries
- Zonal composition
- Area size
- Population density
- Land use composition

Transport supply



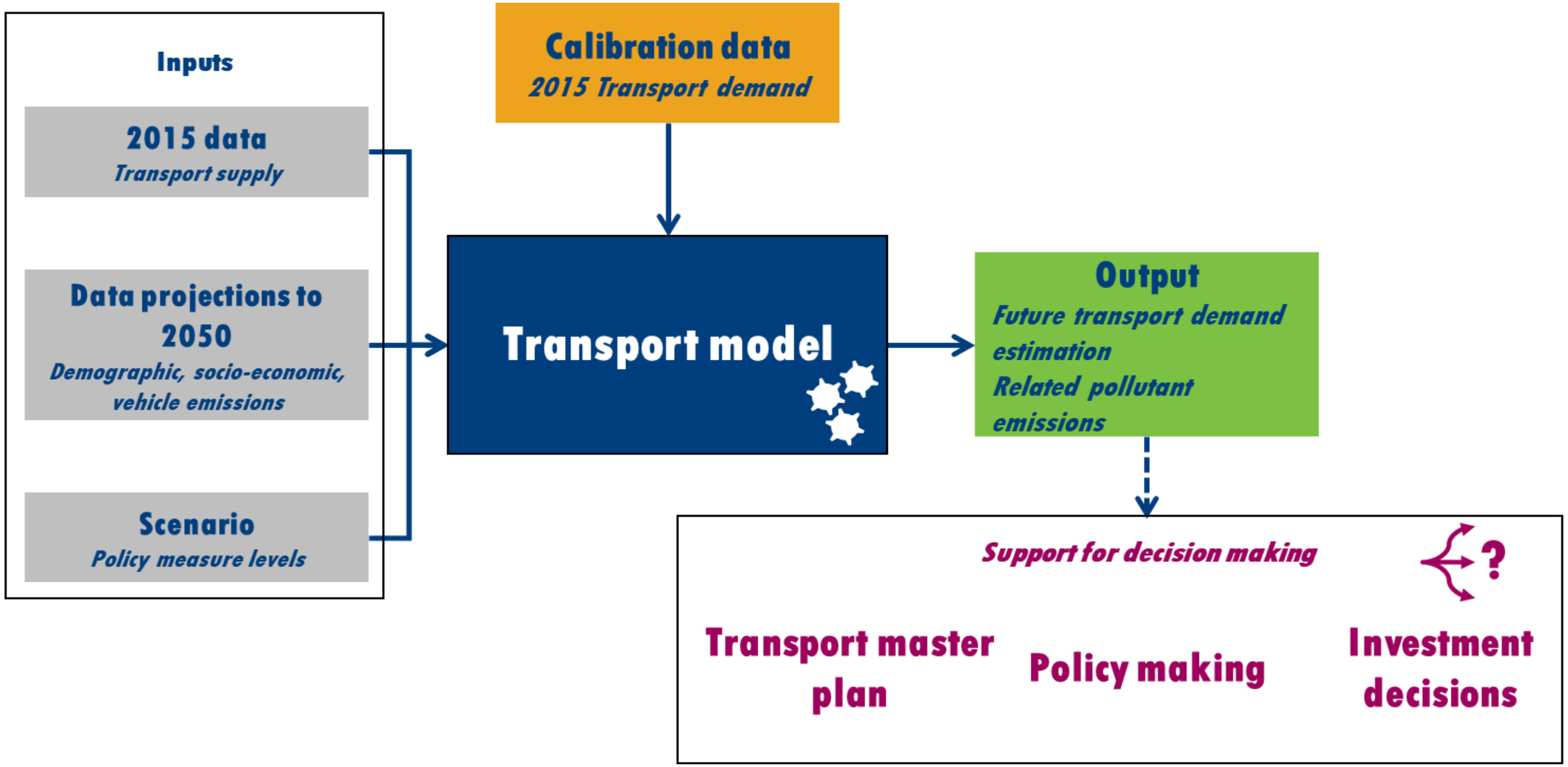
- Road infrastructure
- Parking costs
- PT network
- PT service characteristics

Transport demand

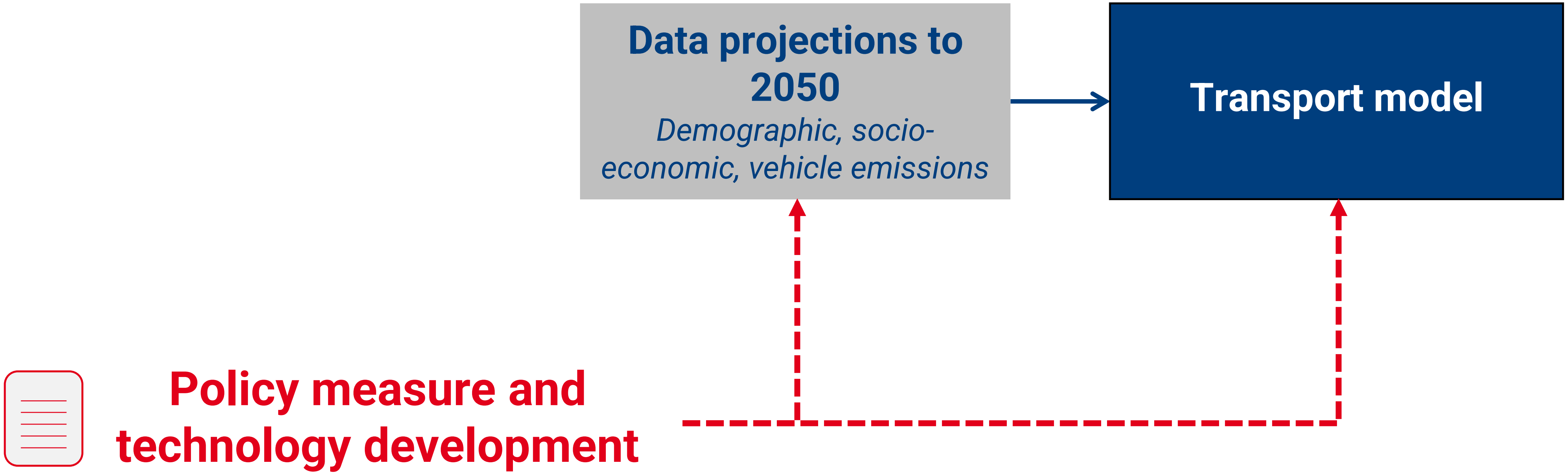


- OD-matrix
- Trip length
- Trip duration
- Travel purpose
- Modal split

Quantitative policy analysis



Accounting for policy measures and technological developments



Accounting for policy measures and technological developments

Example 1: Prioritising public transport

- Increase the speed of PT modes interacting with road modes

↓

- Increase the attractiveness of PT and decrease the attractiveness of other motorised private modes in the model

Example 2: Development of electric vehicles

- Increase the penetration rate of EV in the vehicle fleet

↓

- Update the average TTW emissions in the data 2050 projections

Scenario development

Scenario

Policy measure levels

- Policy measure/ technology development 1
- Policy measure/ technology development 2
- .
- .
- .
- Policy measure/ technology development X

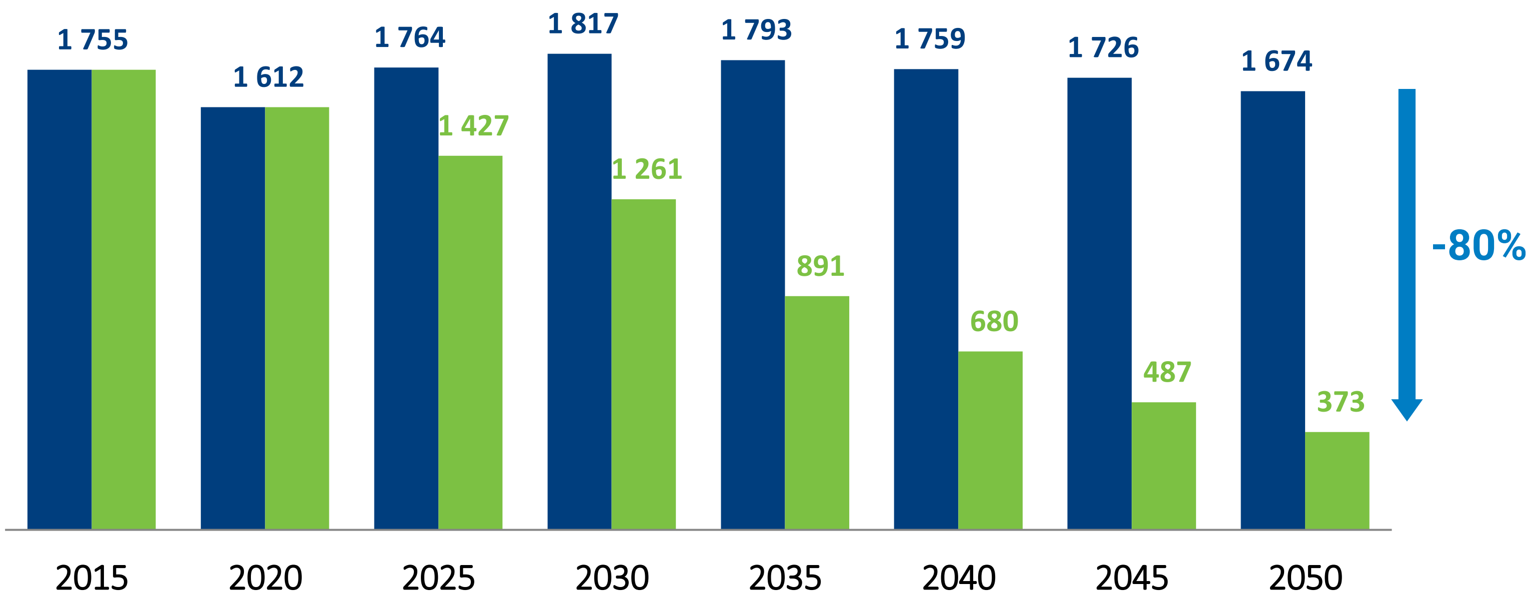
- Investigation to determine expectations for future policy measure levels
- Initial proposition by ITF based on the Global urban passenger model and data provided
- Validation by local stakeholders

Scenario setting: Baseline vs Alternative

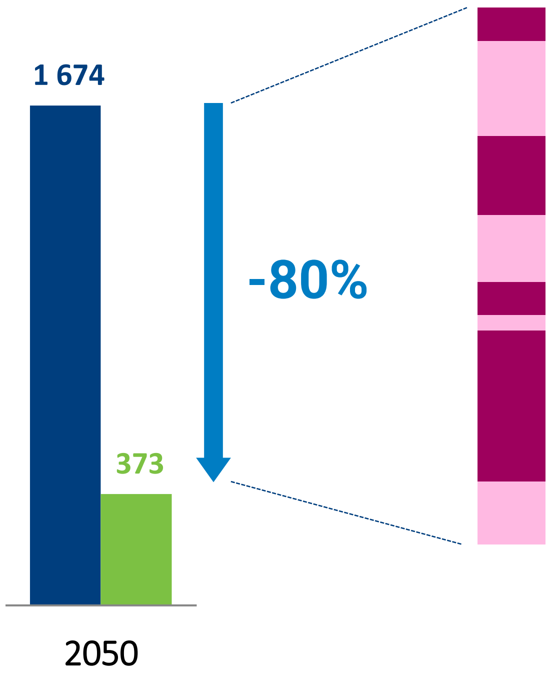
Global urban passenger CO_2 emissions
(Million tonnes CO_2)

Current trajectory
(*Recover* scenario)

Ambitious policies + leveraged recovery
(*Reshape+* scenario)



Policy impact: sensitivity analysis



X% from Policy measure / technology development 1

Y% from Policy measure / technology development 2

.
.
.

Z% from Policy measure / technology development 8

Case study on transport policy assessment in India

Introduction

- **Excel-based policy simulation tool to identify cost-efficient urban mobility pathways for mitigating CO_2 emissions in Indian cities**

- **Policies that can be tested with the tool:**
  - Transport infrastructure investment
  - Urban area growth
  - Demand-management measures
  - Vehicle technology
  - Shared mobility

- **Joint work between the World Bank and the International Transport Forum with local data and technical support provided by TERI**

Study and model scope

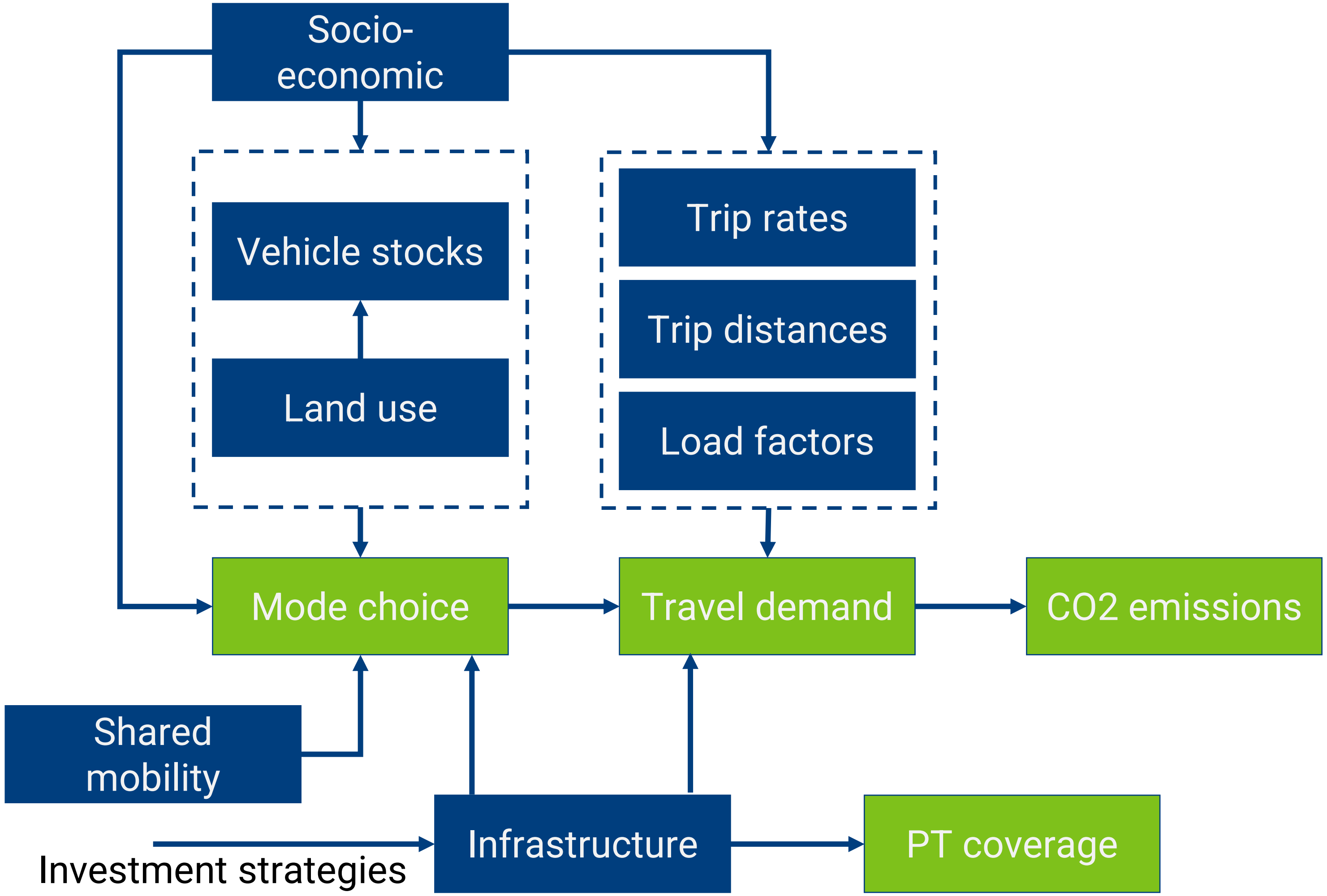
UA pop (2011)	City Tier	NO. of Cities	Cities Included
>8 Million	I	5	Mumbai, Delhi, Bangalore, Kolkata, Chennai
4 - 8 Million	II	4	Hyderabad, Ahmedabad, Pune, Surat
1 - 4 Million	III	44	Jaipur, Lucknow, Vijayawada, etc.
0.5 -1 Million	IV	55	Amaravati, Mathura, Bhubaneswar, etc.

- **Analysis for all cities (population >500K) in India**
  - Exhaustive city-specific data collection by TERI for 108 cities
- **The model captures aggregate relationships**
  - It simulates the overall long-term trend for each city
  - The outputs are best interpreted by city class
- **Relationships between variables are calibrated**
  - From observed data whenever possible

Data inputs

Socio-economic	Population, income
Land use	Urban area size
Infrastructure	Total road length, cycling lane length, footpath length
Vehicle fleet data	Formal/informal bus fleet, registered cars/two-wheelers, car/two-wheeler ownership, registered taxis
Vehicle technology	Load factors, fuel share, emission factors
Fuel price	Petrol, diesel, CNG prices
Mass transit	Metro/BRT length, metro/BRT ridership, load factors, public transport fares
Transport investment	Transport budget, metro/BRT capital investment and operation costs, bus fleet and infrastructure costs
Travel patterns	Trip rate, modal share, mode-specific trip length

Model framework



Sub-models

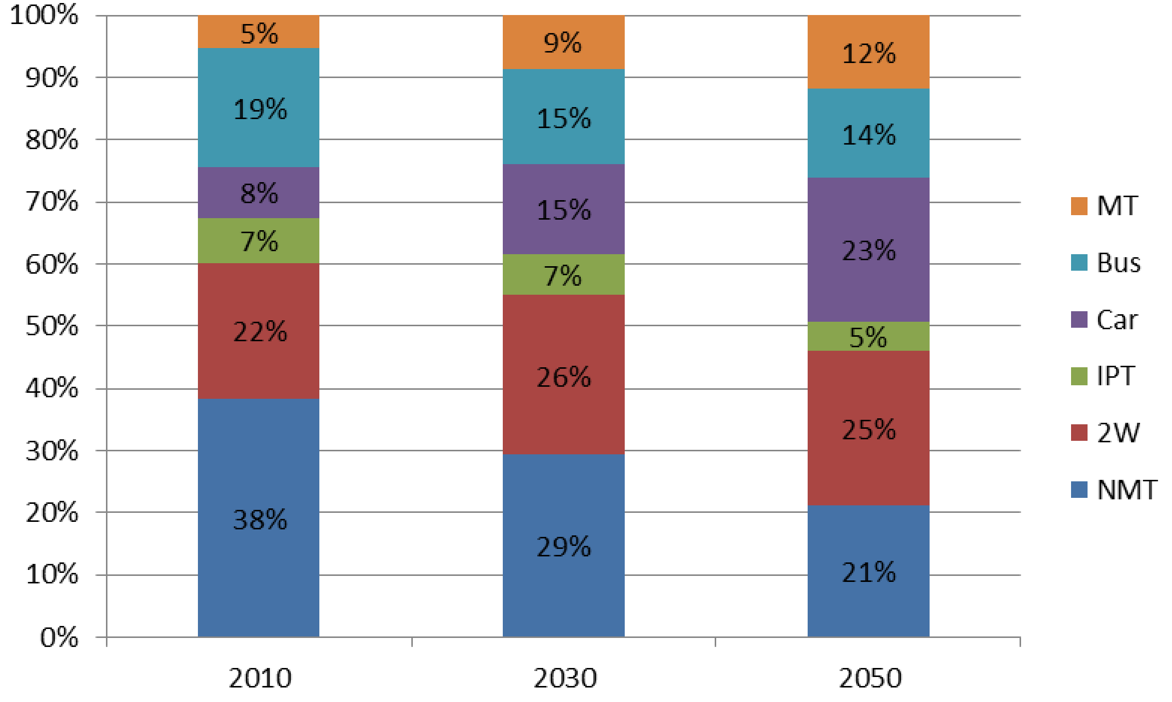
Sub-models	Baseline scenario	Alternative scenario
Modal split	A discrete choice model estimates the aggregate impact of urban socio-economic development, vehicle ownership, density, infrastructure supply, public transport provision and pricing indicators on the modal split of a city	Same model, with different inputs
Vehicle ownership	Several regression models estimated for car, 2W, 3W and taxi based on per capita income and population	Same model, with different inputs
Formal & private buses	Urban area size and GDP explain the number of formal buses in a city., private bus per capita is a function of income	The number of formal buses is a result of the amount invested in bus supply
Transport infrastructure	Different regression models explain infrastructure supply using population, GDP per capita and urban area size	Various investment strategies result in the adjusted total network length
Trip rate & distance	They are modelled as functions of GDP per capita and area size	No change
Urban area	Urban area size is a function of population	Different growth rates can be set

Baseline scenario: definition

BASELINE

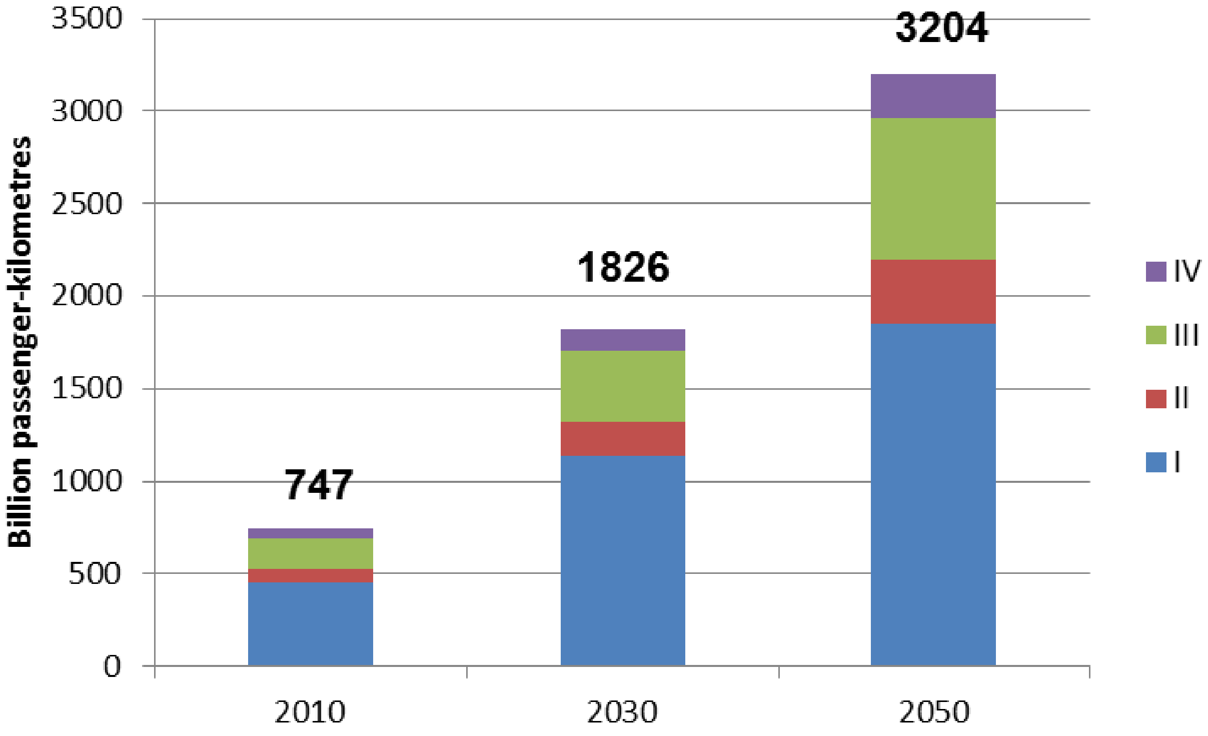
- No additional measures to influence travel demand or CO_2 emissions
- Only existing and planned policy interventions between 2015 and 2050
- 250 000 million rupees per year are spent on metro network construction and expansion
- The scenario constitutes a business-as-usual reference

Baseline scenario: mode shares



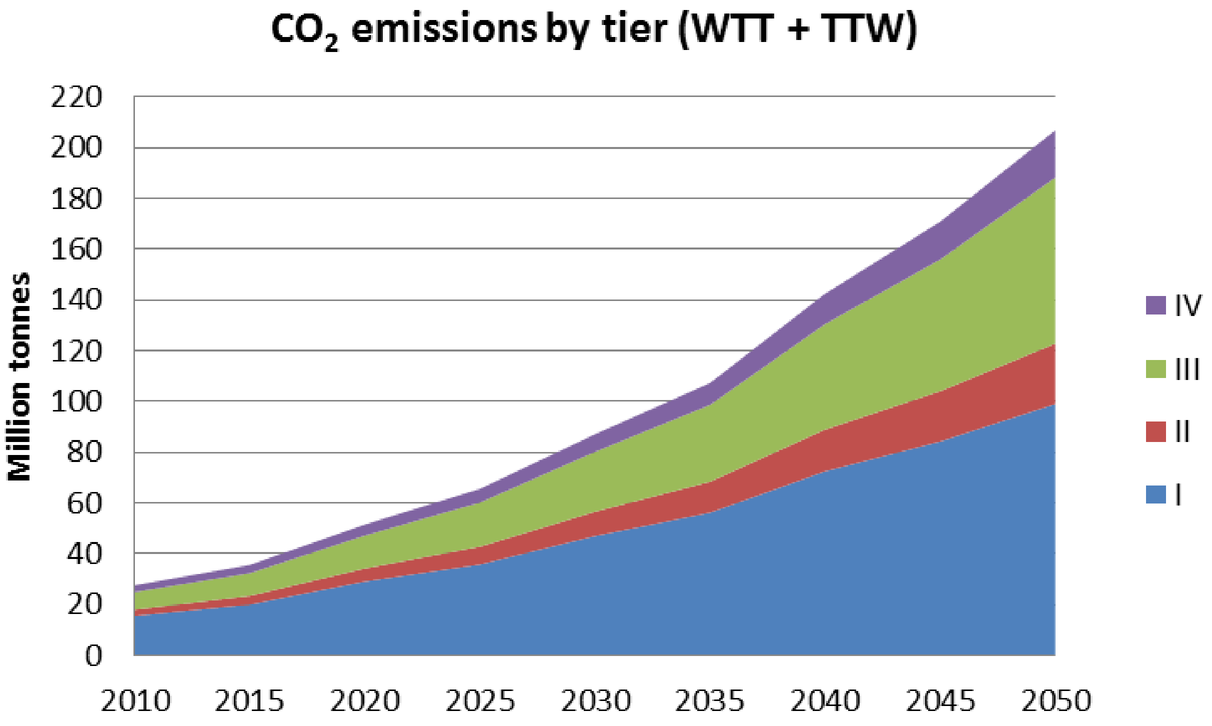
- NMT, Bus and IPT decrease continuously
- Growing distance and income push urban mobility towards private modes (from 30% to 48%)
- Private cars grow most, the mode share in 2050 is almost triple that of 2010
- The share of 2W continues to rise until it stabilises around 2040 where a slight declining trend is expected
- Current and planned mass transit projects contribute significantly to the share of MT

Baseline scenario: travel demand



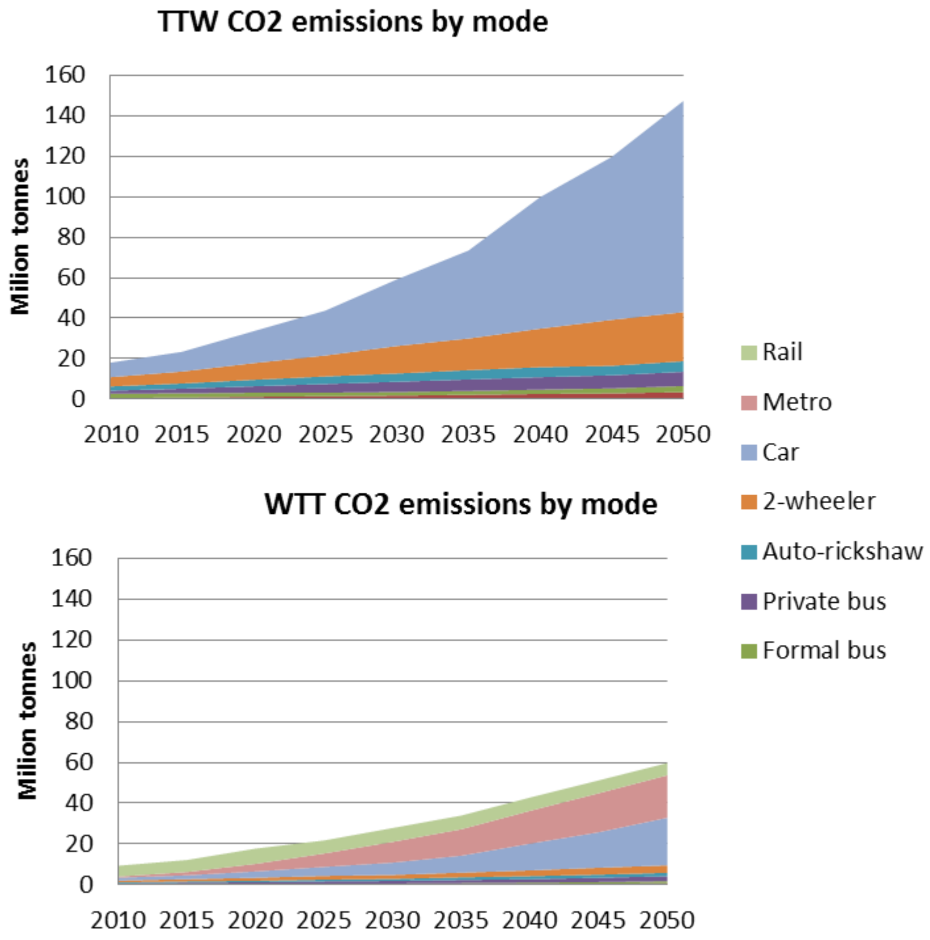
- Passenger demand will quadruple by 2050
- Highest increase occurs in Tier I and Tier III

Baseline scenario: CO2 emissions by tier



- CO2 emissions in 2050 is nearly eight times the 2010 level
- Larger cities emit much more due to the prevalence of cars
- This effect decreases over time, with cities from Tier III catching up especially

Baseline scenario: CO2 emissions by mode



- Private car is the main contributor to the increase in TTW CO2 emissions
- Share of WTT in the total emissions goes down (from 35% in 2010 to 29% in 2050)
- Metro and rail are the main contributor to the WTT emissions (60% in 2010 and 45% in 2050)
- Without clean electricity, mode shift to metro will not transform into CO2 savings

Note: Not all WTT emissions are attributable to India (e.g. oil transport)

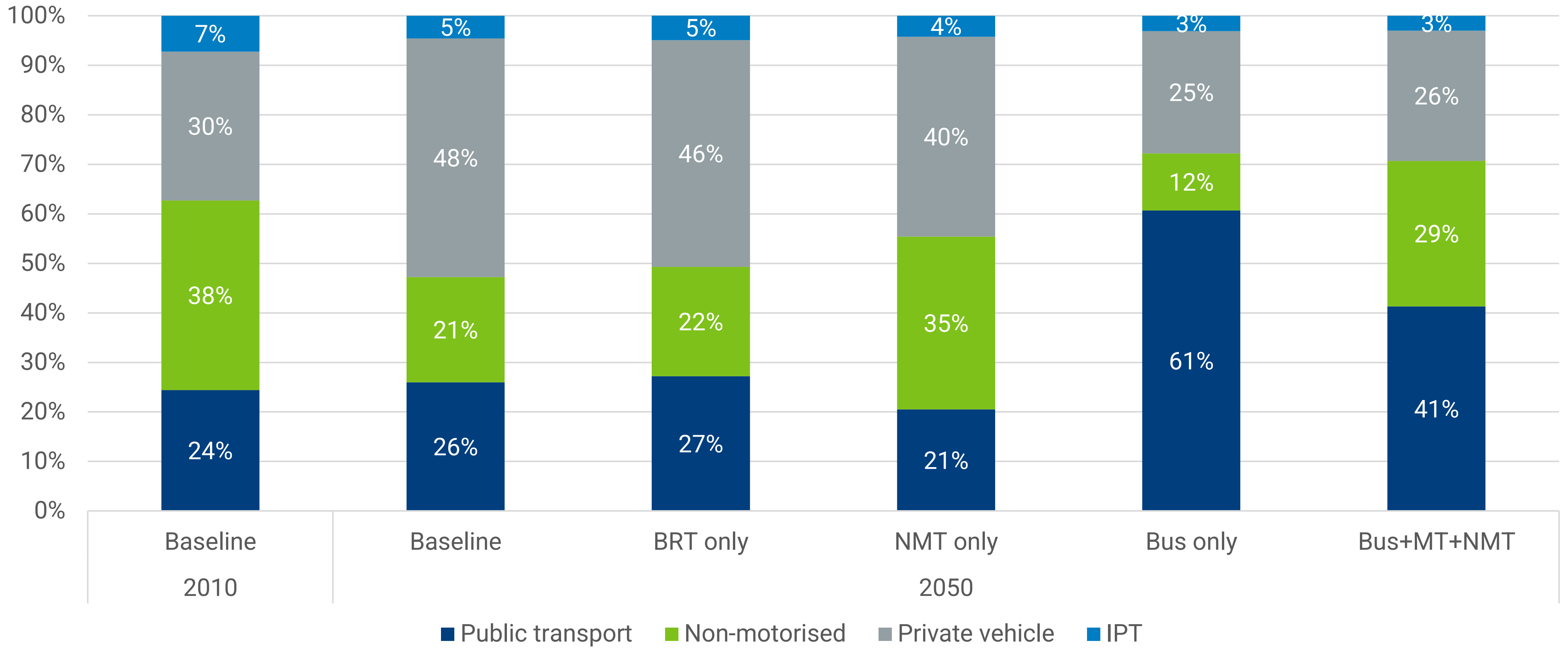
Investment scenarios: definition

INVESTMENT

- All input is equal to the baseline scenario
- One difference: allocation of transport investments
- 250 000 million rupees per year are assigned to different infrastructure types of their combinations
- Effect on infrastructure supply for bus, metro, BRT, footpath and bike lane

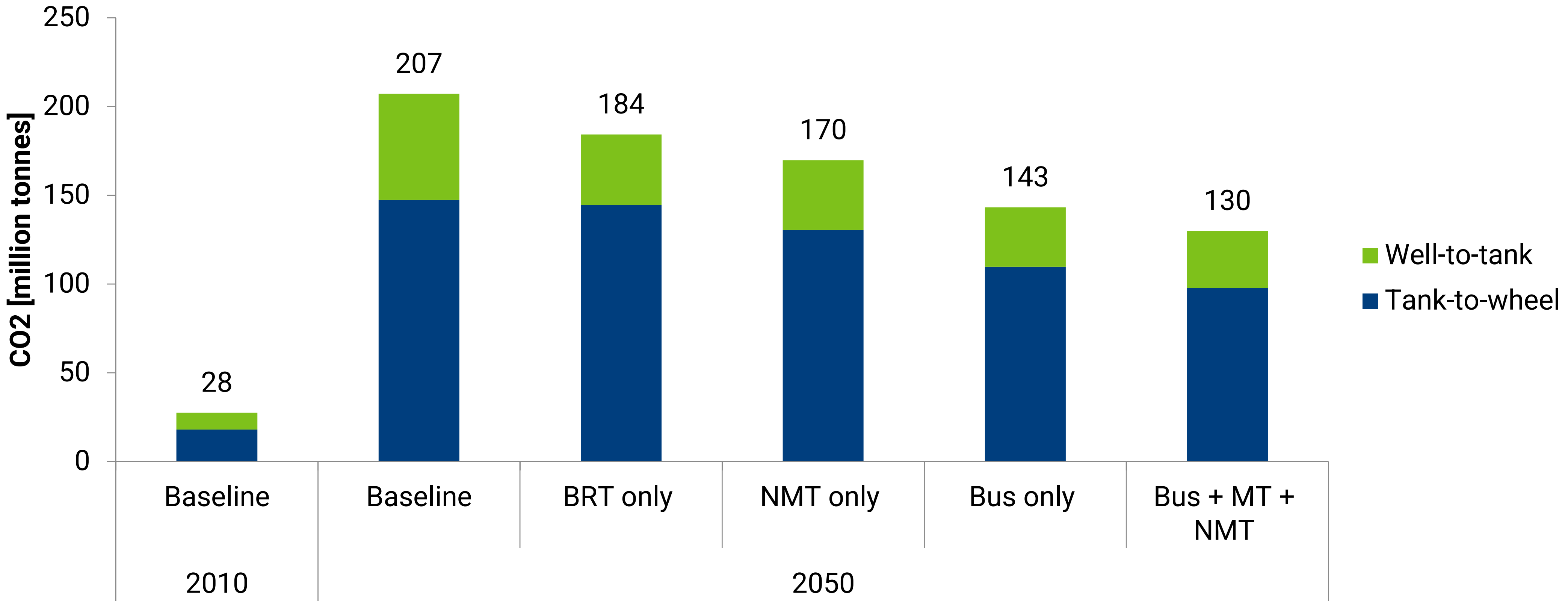
Investment scenarios: mode shares

- Bus and mixed scenarios give more sustainable mode shares



Investment scenarios: CO_2 emissions

- Mixed investment strategy has the highest CO_2 mitigation potential in cities



Investment scenarios: key takeaways

- Combination of mode investments yield superior outcome - integration
- Encourage low-cost and high-impact bus and NMT investments in combination with or without mass transit
- Investing in mass transit in isolation is suboptimal
- Focus on Tier 3 cities with differentiated strategies compared to Tier 1 & 2

Land use & fuel price scenarios: definition

LAND USE

FUEL PRICE

Land use scenario

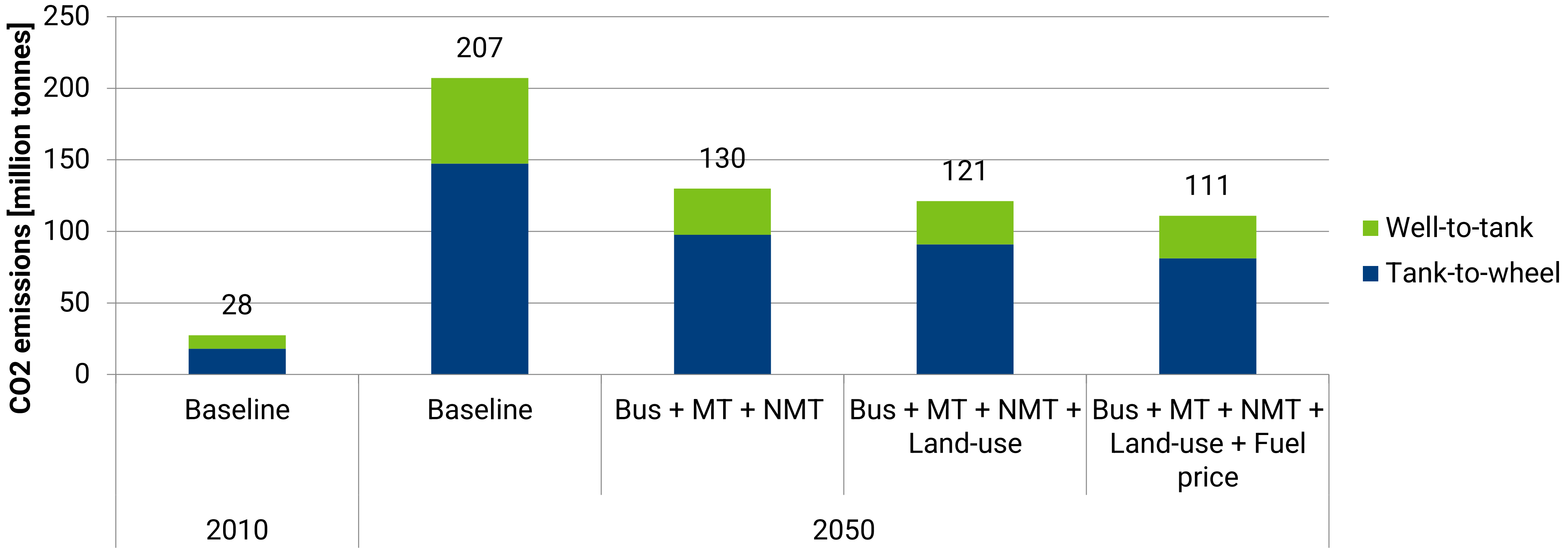
- On top of the "Bus + MT + NMT" scenario
- Urban sprawl is controlled from 2025 onwards

Fuel price scenario

- On top of the "MT + NMT + Land use" scenario
- Growth in fuel price is higher than the baseline, leading the price double in 2050

Land use & fuel price scenarios: CO2 emissions

- Higher fuel price reduces the use of private mode and further reduces the CO2 emissions by 10mt in 2050, reaching 46% lower than the baseline



Shared mobility scenarios: definition

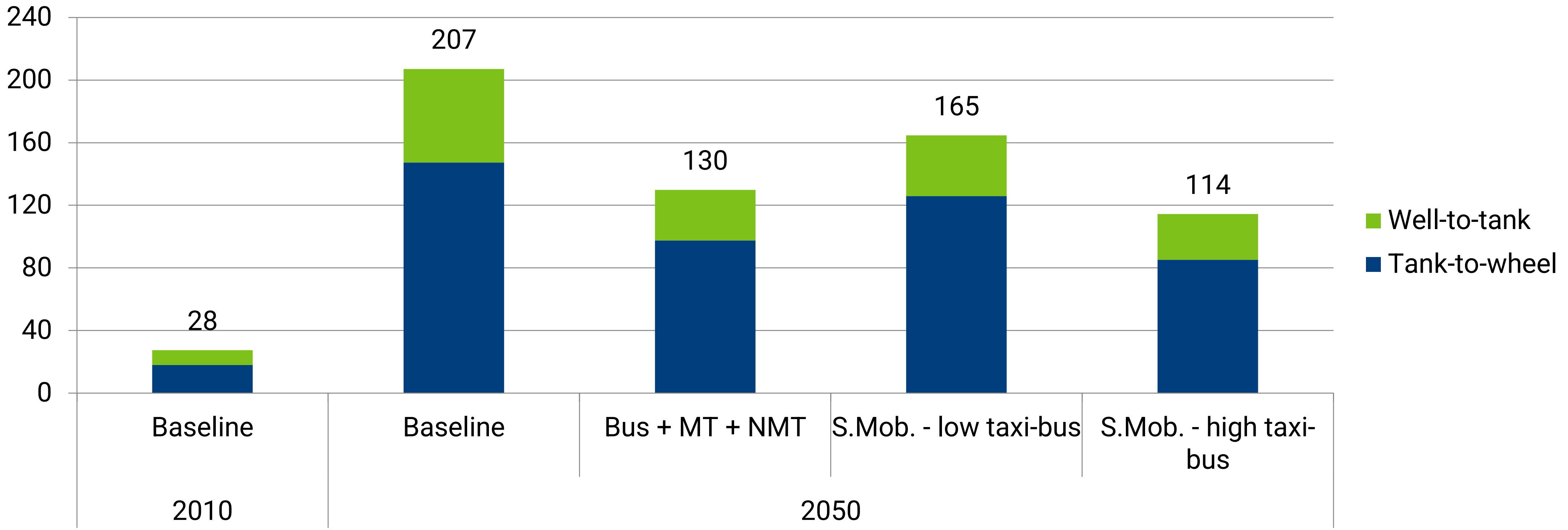
SHARED MOBILITY

Modal shift from other modes to shared mobility is based on:

- Findings from ITF studies in Lisbon, Helsinki and Auckland
- Each simulation study was also complemented by a survey and focus group
- Base year average modal split in Indian cities

Shared mobility scenarios: CO2 emissions

- Introducing a shared-taxi service (4 pax) only has the risk of increasing CO2 emissions
- CO2 benefits can be achieved when a taxi-bus service (16 pax) takes high percentage



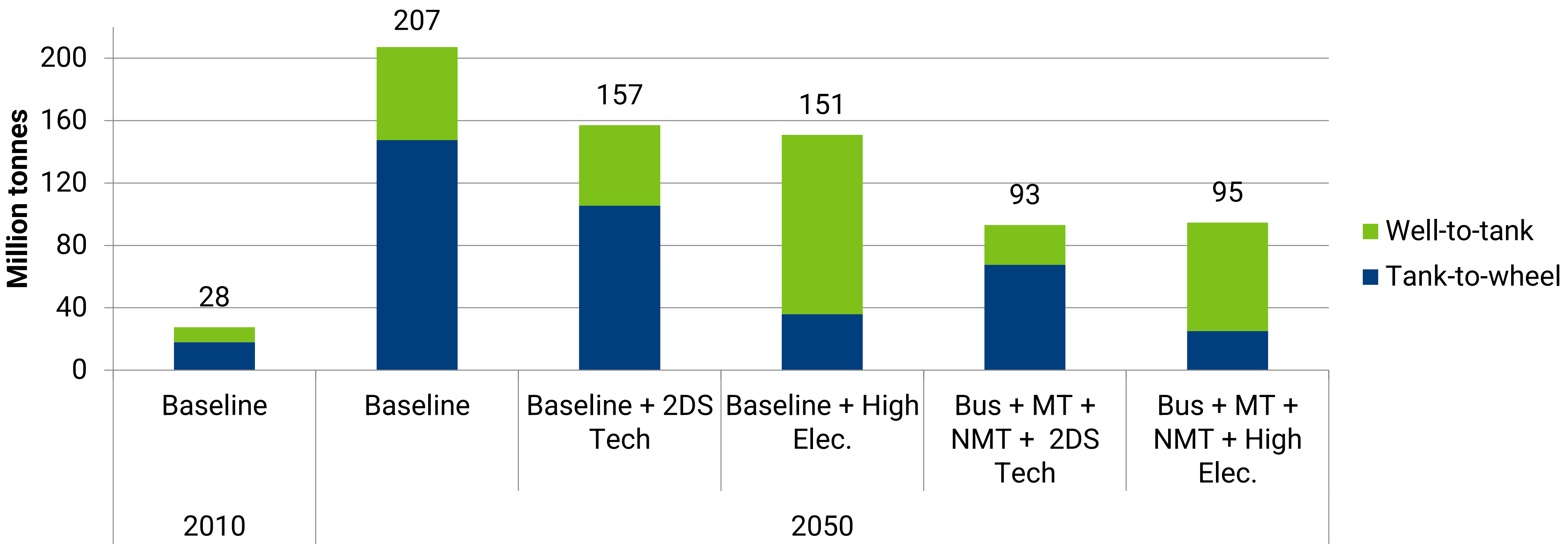
Vehicle technology scenarios: definition

VEHICLE TECH

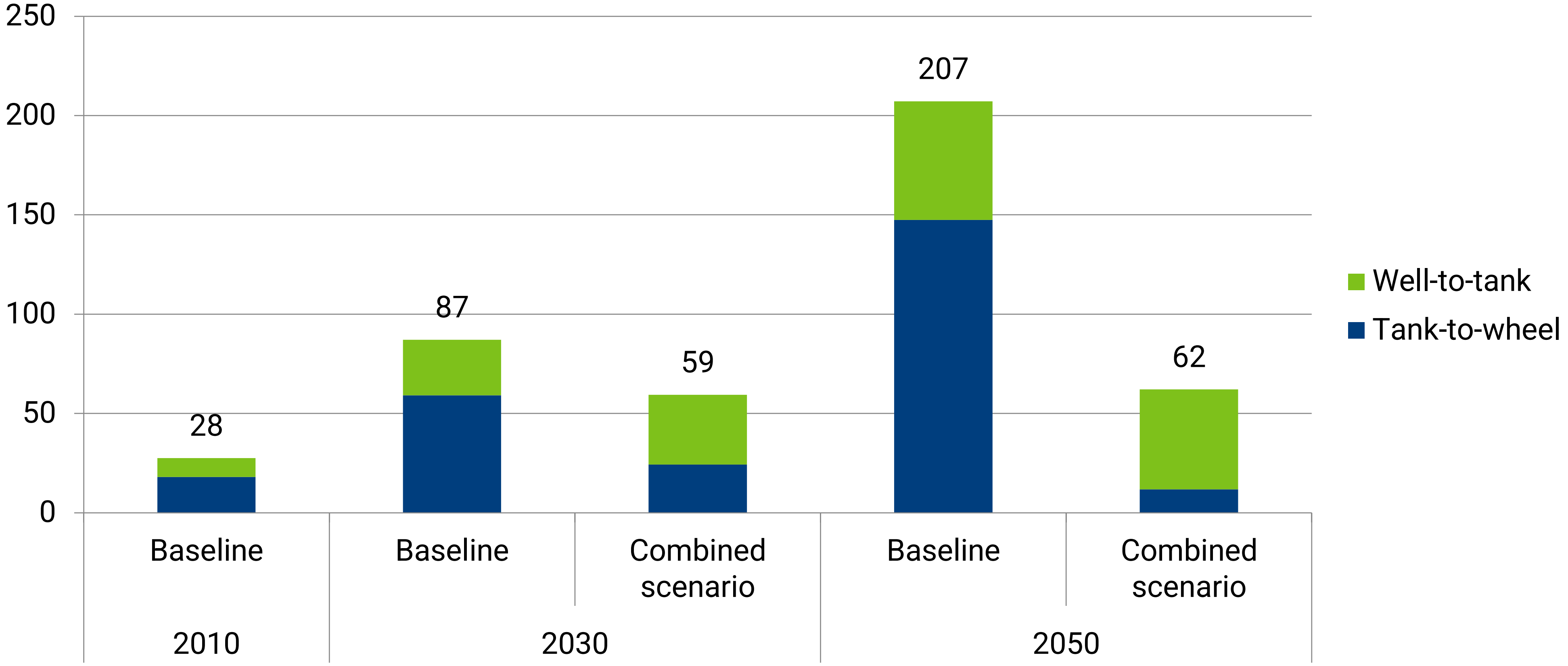
- On top of the “Bus + MT + NMT” scenario
- IEA’s 2DS pathways for vehicle technology and energy production & distribution
- High electrification targets set by the policy maker (with baseline WTT emission factors)

Vehicle technology scenarios: CO_2 emissions

- Combining the mixed strategy with 2DS/High electrification can address both CO_2 and sustainable mobility objectives
- Focus next on clean source of electricity in high electrification scenario

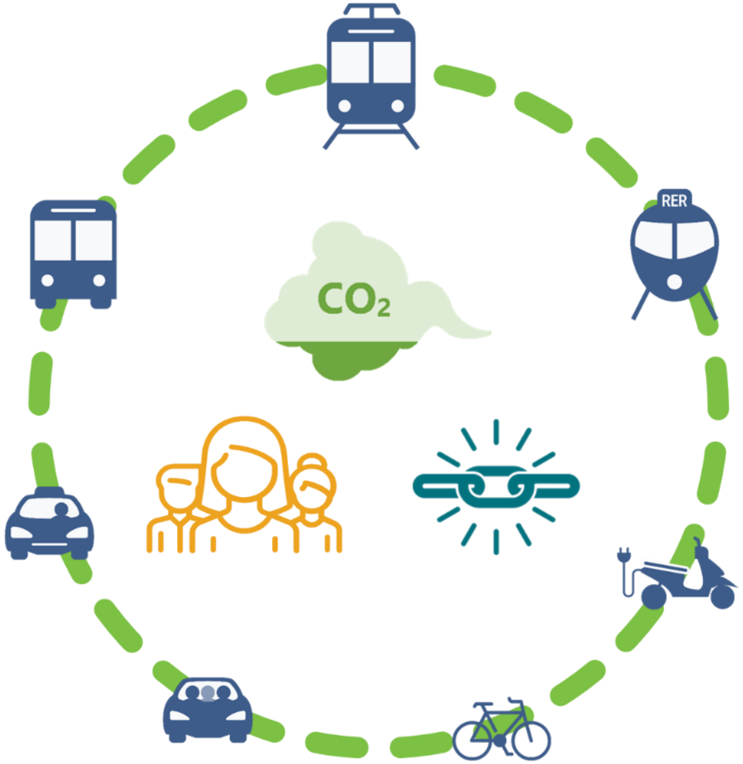


Combined scenario: CO_2 emissions



Key takeaways for maximised impact

- Operationalize all policy levers together
- Focus on the integrated multimodal urban transport system
- Control urban footprint expansion for compact cities
- Emphasize high occupancy shared mobility
- Promote electric mobility as a part of the larger urban transport strategy
- Greening the grid is essential for realising electric mobility benefits



Thank you for your attention

Yaroslav Kholodov
yaroslav.kholodov@itf-oecd.org

2 rue André Pascal
F-75775 Paris Cedex 16

Immediate Next Steps

- **Stakeholder consultation and data collection**
  - Finalise the **list of key stakeholders**
  - Finalise the compiling of **list of data items** needed
  - Preparation of stakeholder consultation guidance/questions

- **Planning for fact-finding mission**
  - February, 2022
  - Launch workshop planning (2 days)
    - ✓ Venue, catering, interpretation
    - ✓ Session design
    - ✓ Session speakers
  - Bilateral stakeholder meetings
    - ✓ Deep dive on specific questions
    - ✓ Further information and data collection