2. Where to start: Calculating energy use in transport and the fundamental "avoid-shift" policies for energy efficiency

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IEA #energyefficientworld

Calculating energy use and avoid-shift policies for energy efficiency

Till Bunsen-IEA, Julie Cammell-IEA

- Calculating energy use in transport
  - Data collection and modelling for evaluating transport energy efficiency indicators
  - The ASIF approach of the IEA Mobility Model for calculating transport energy use
- Understand the drivers and demands of energy use in transport, and the role of "avoid and shift" policies in influencing energy demand.

What avoid-shift policies have been tried in your country/city; what has worked; and what have been the barriers to success?

Calculating energy use in transport

Why calculate transport energy use?

Understanding characteristics of transport energy demand (and activity) across alternative transport modes is key to informed policy making

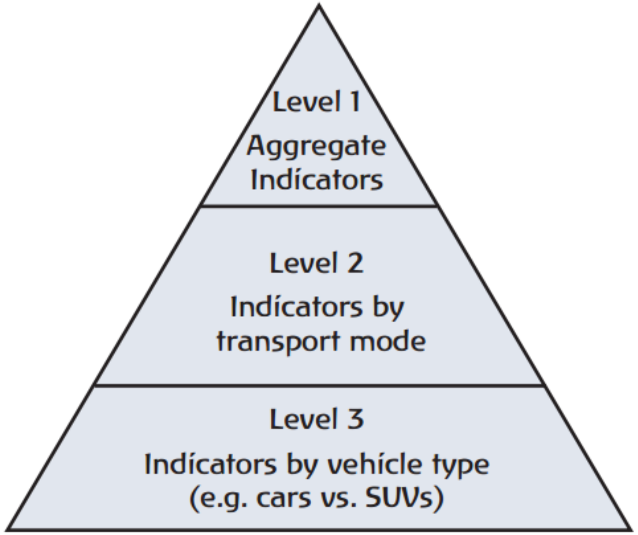
How much does the transport sector contribute to a country's energy demand?

Is freight transport more energy efficient by ship or by rail?

What are the implications from the trend to larger passenger cars for transport energy demand?

Using energy efficiency indicators for policy making

Figure 6.5* • *Detailed indicators pyramid for passenger transport



How much does the transport sector contribute to a country's energy demand?

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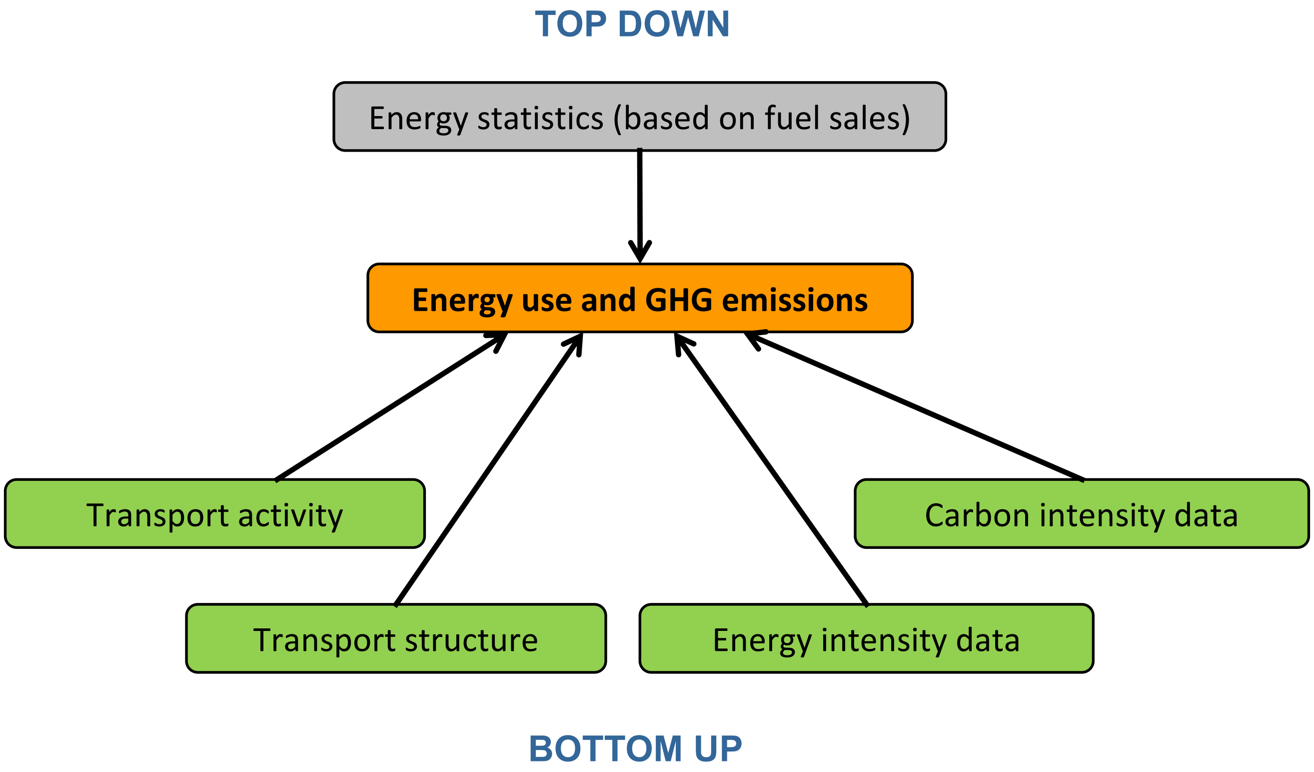
What are the implications from the trend to larger passenger cars for transport energy demand?

Using energy efficiency indicators faces a trade off between usefulness of information and data collection requirements

Transport modelling complements data collection



Transport modelling provides detailed insights of sector dynamics which can inform policy design

The ASIF approach of IEA's Mobility Model (MoMo)


Distance travelled × **Vehicle stock** × **Energy intensity** = **Energy consumption**

- Vehicle ***A**ctivity*
- the ***S**tructure* of the organization of vehicle across services, modes, vehicle classes and powertrain groups
- the *energy **I**ntensity* of each of the vehicles in this structure

… allow to calculate ***F**uel consumption*

The ASIF approach of IEA's Mobility Model (MoMo) makes possible to estimate transport fuel consumption by vehicle type and fuel

Linking activity and fuel use – ASIF approach

Distance travelled ✖ Vehicle stock ✖ Energy intensity = **Energy consumption**

Energy consumption ✖ **Emission factor** = **Transport GHG emissions**

The ASIF approach makes possible to estimate transport fuel consumption at sector level

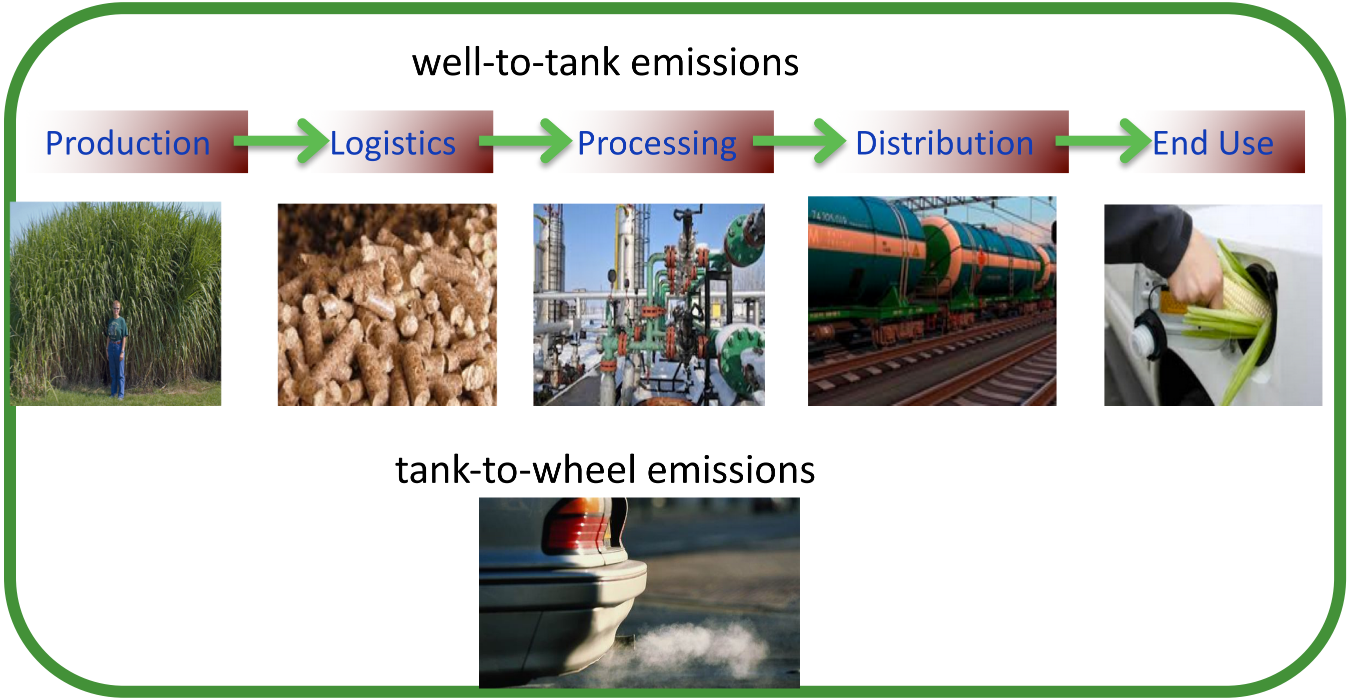
Apply emission factors to quantify climate impacts of fuel consumption

ASIF Approach: Well-to-wheel versus tank-to-wheel

Well-to-wheel: tank-to-wheel emissions + well-to-tank emissions

Using the example of biofuels…

Well-to-wheel



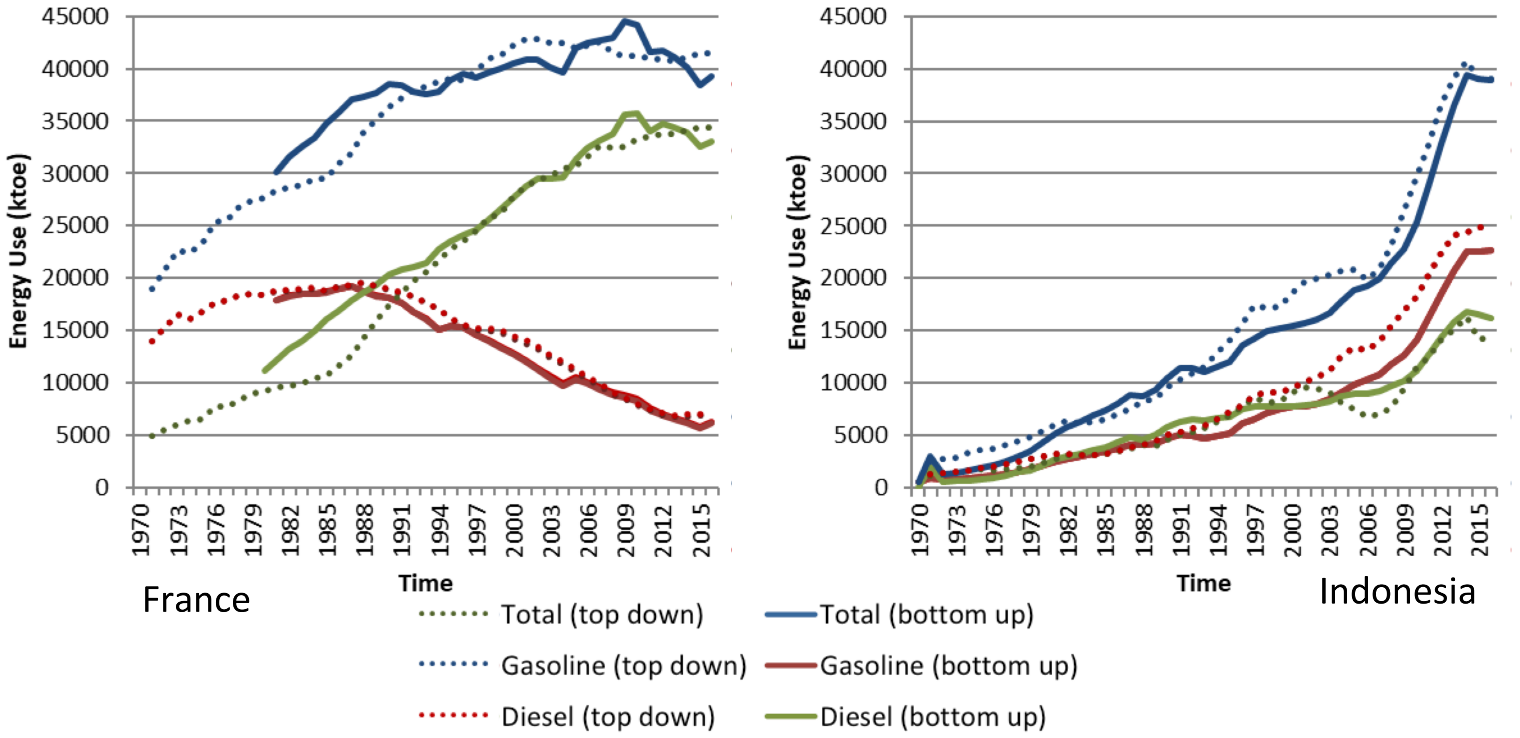
Describing service level efficiency of transport activity

Vehicle activity × Occupancy factor = Passenger transport activity / Energy consumption

Vehicle activity × Load factor = Freight transport activity / Energy consumption

The indicators for passenger transport activity (pkm) and freight transport activity (tkm) allow comparison of transport energy efficiency per unit service provided across modes or regions

Comparing results from transport modelling and data collection



Dual results of the two complementary transport analysis approaches provides high degree of certainty

"Avoid-shift" policies for energy efficiency

Transport policies for energy efficiency

1. **The drivers of demand in transport**

2. Influencing the evolution of energy demand in transport (policies)

   - The role of transport and energy policies: *Avoid*, *Shift*, *Improve*
   - Evaluating policy impacts in transport & energy models

In small groups, brainstorm the factors that drive transport energy demand globally

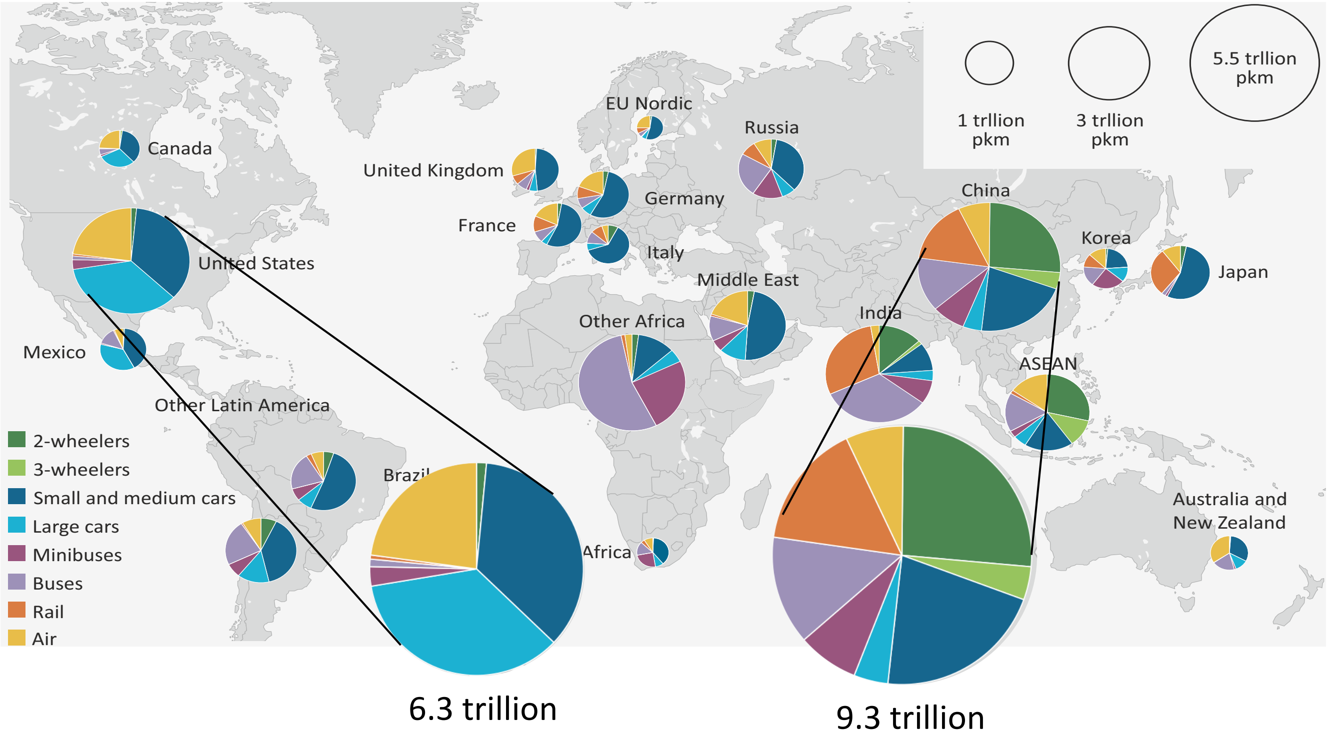
- *For passenger transport*
- *For freight transport*

Transport Demand Drivers

Transport activity (pkm, tkm), vehicle activity (vkm), and vehicle stock are largely determined by:

- GDP and population linked with transport activity and modal choice
  - GDP per capita ←→ personal vehicle ownership & modal choice
  - Economic output (GDP) ←→ tonnes transported
- The cost of driving and moving goods
  - ***Effects*** of price changes on average passenger travel and loads
- Structural elements in the transport system
  - ***Passenger***: role of public transport in urban areas
  - ***Freight***: economic and trade structures
- Transport demand/modal choices subject to a travel time budget (TTB) constraint

Transport Activity: Modal Choice



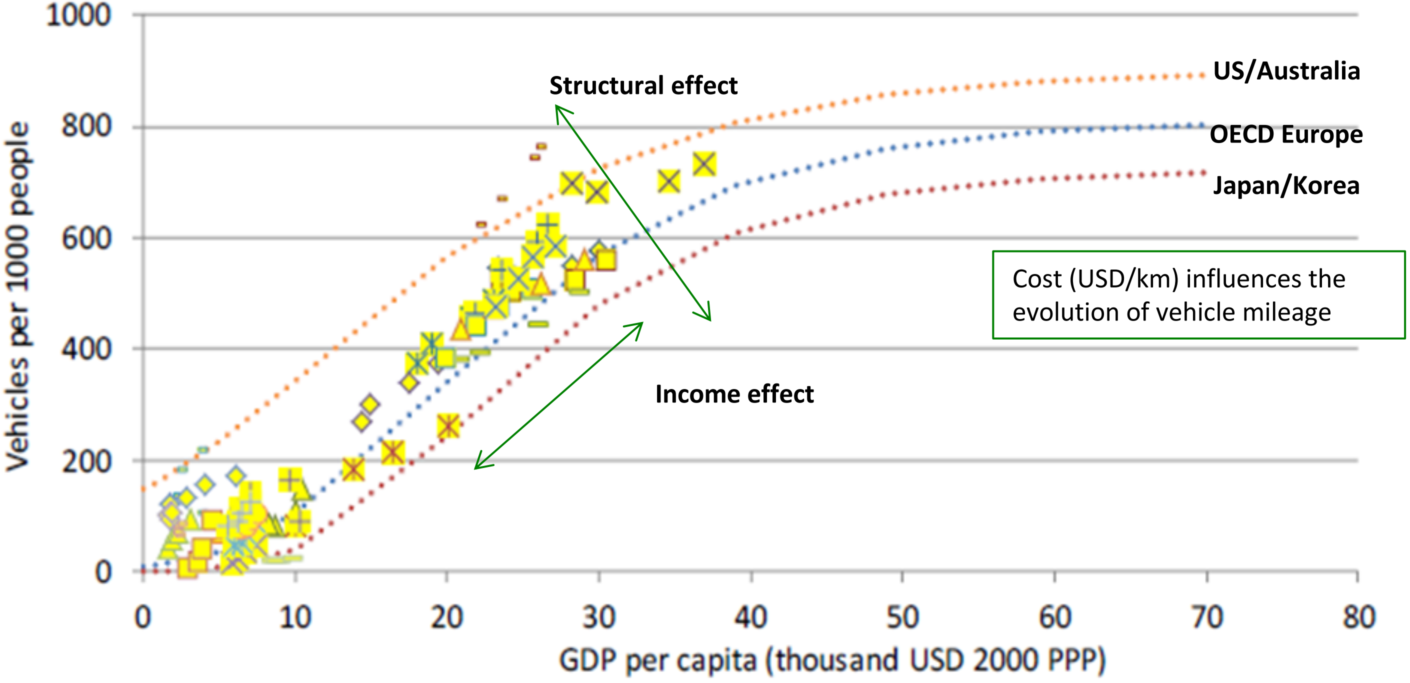
This map is without prejudice to the status of or sovereignty over any territory, to the delineation of international frontiers and boundaries, and to the name of any territory, city or area.

Source: Energy Technology Perspectives 2016

What (economic, geographic, political) characteristics drive the differences shown?

Transport Demand Drivers: Passenger vehicle ownership

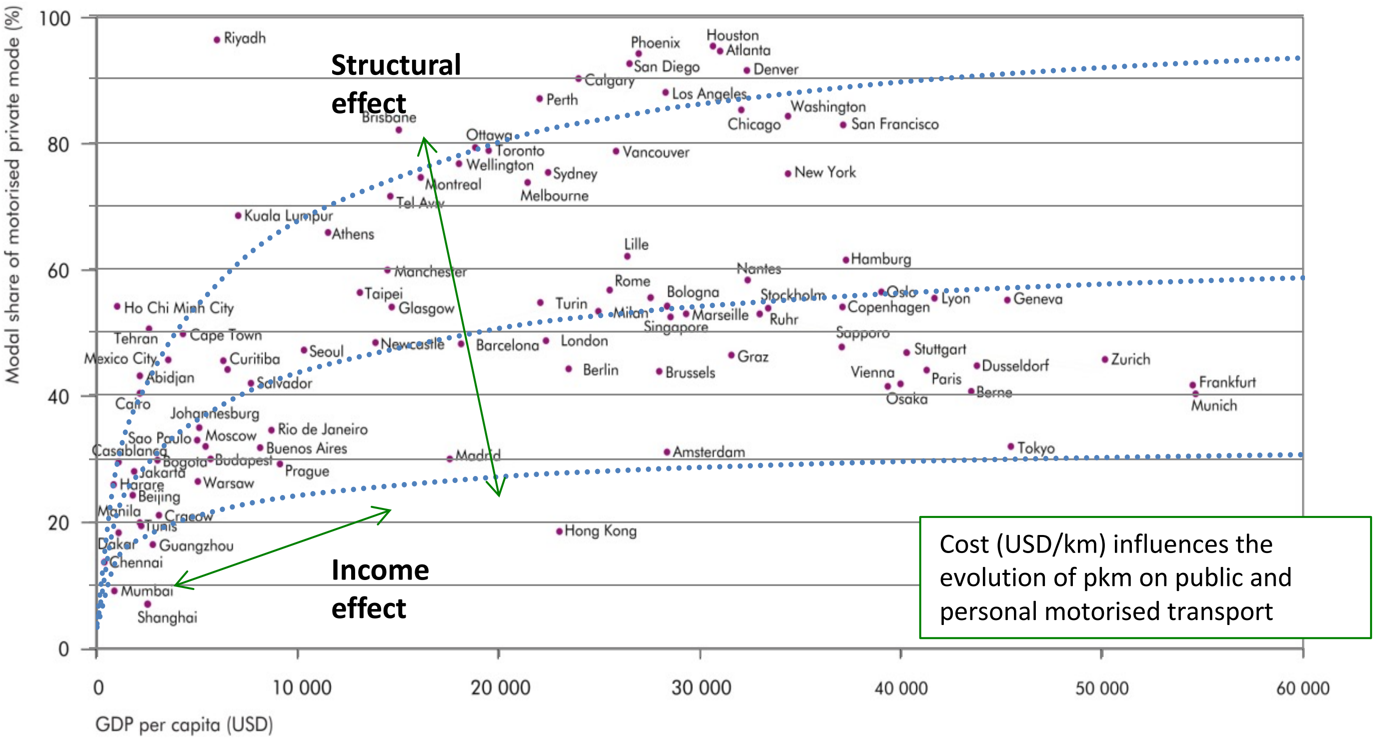
Motorised personal vehicles ownership and GDP



Sources: elaboration of national and international databases, building on the information referenced in UNECE, 2012

Transport Demand Drivers: Passenger vehicles modal choice

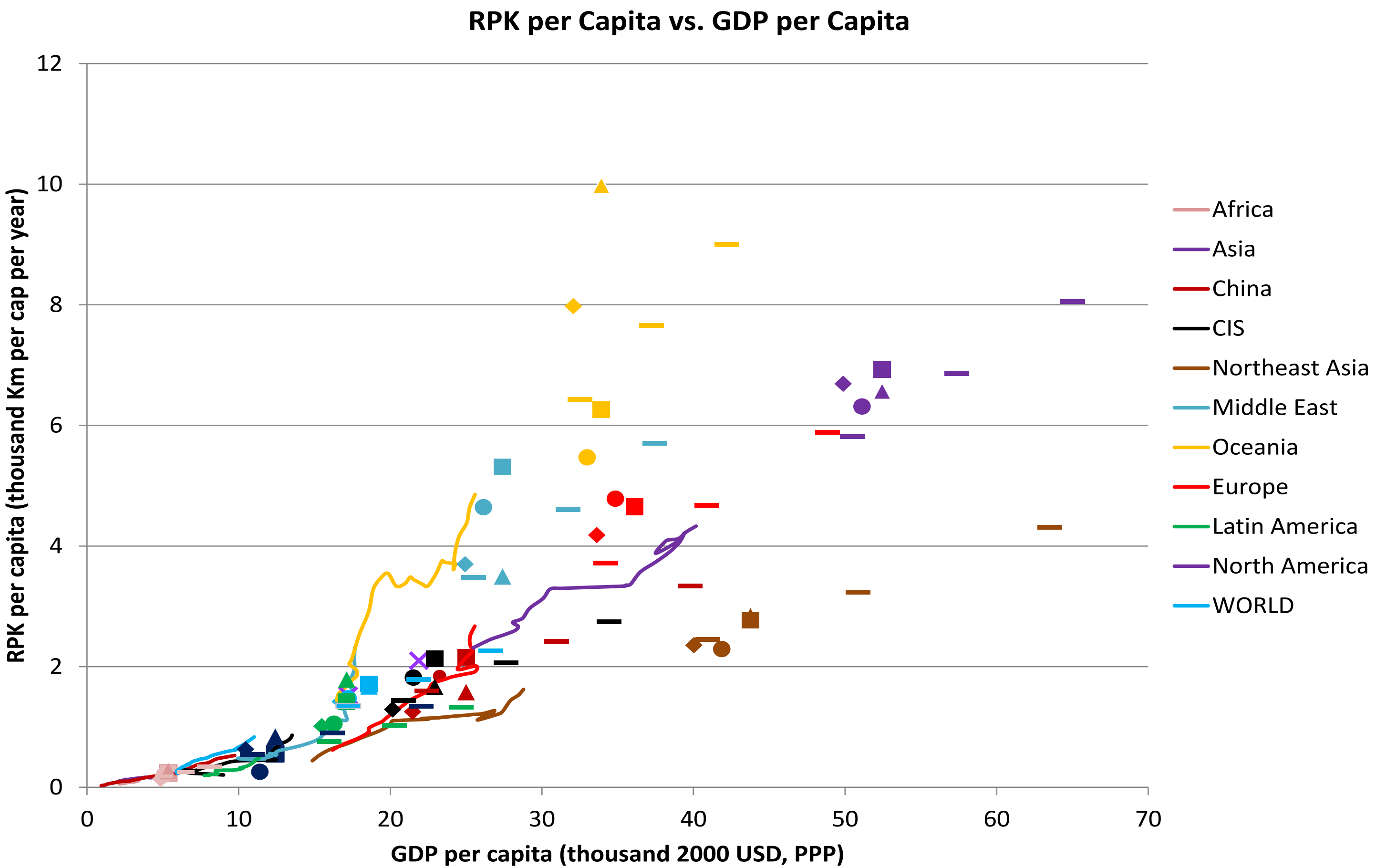
Modal share of personal vehicles in total personal and public transport



Source: elaboration of UITP, quoted by IEA, 2008

Transport Demand Drivers: Passenger aviation

Aviation: the fastest growing mode of passenger transport



Source: ETP 2017

Transport Demand Drivers: Freight

Freight transport activity (tkm) proportional to GDP

Driven by:

- the trade-related nature of the economy

(e.g. free trade vs. low imports and exports)

- the origin/destination of goods

(e.g. changes in destination of exports)

- the type of goods transported

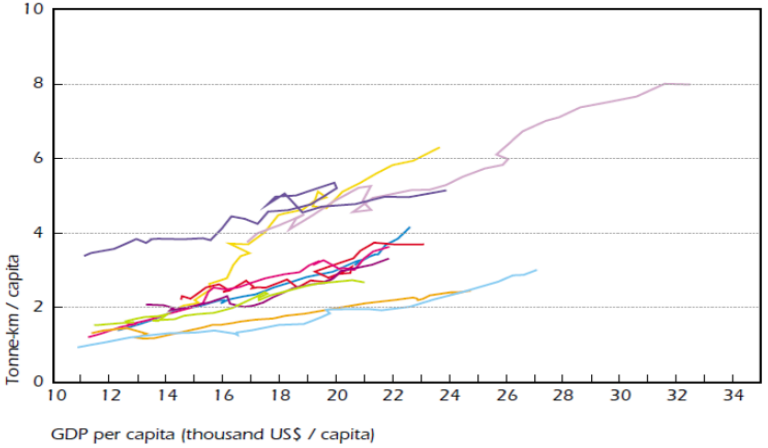
(e.g. importance of manufacturing industry vs. primary material extraction and trade)

- Modal competitiveness

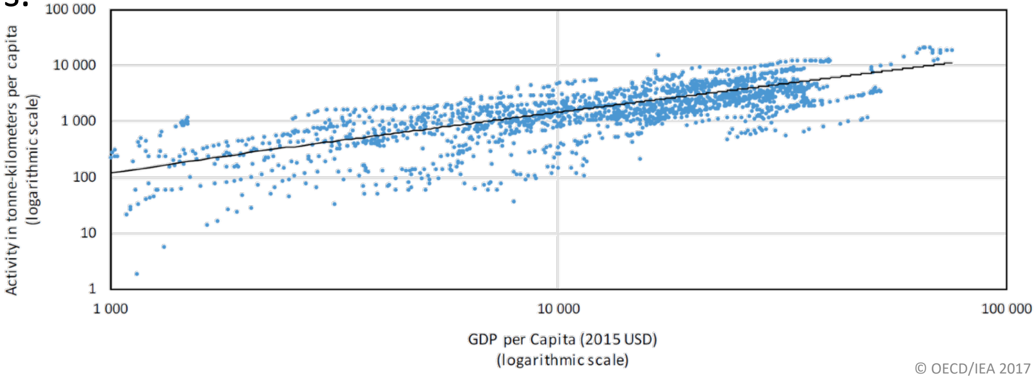
(e.g. availability of sea/water links)

- Cost of moving goods

Overall freight transport activity and GDP



Road freight transport activity and GDP



Transport Demand Drivers: Freight

Freight transport by mode

In terms of ***activity***

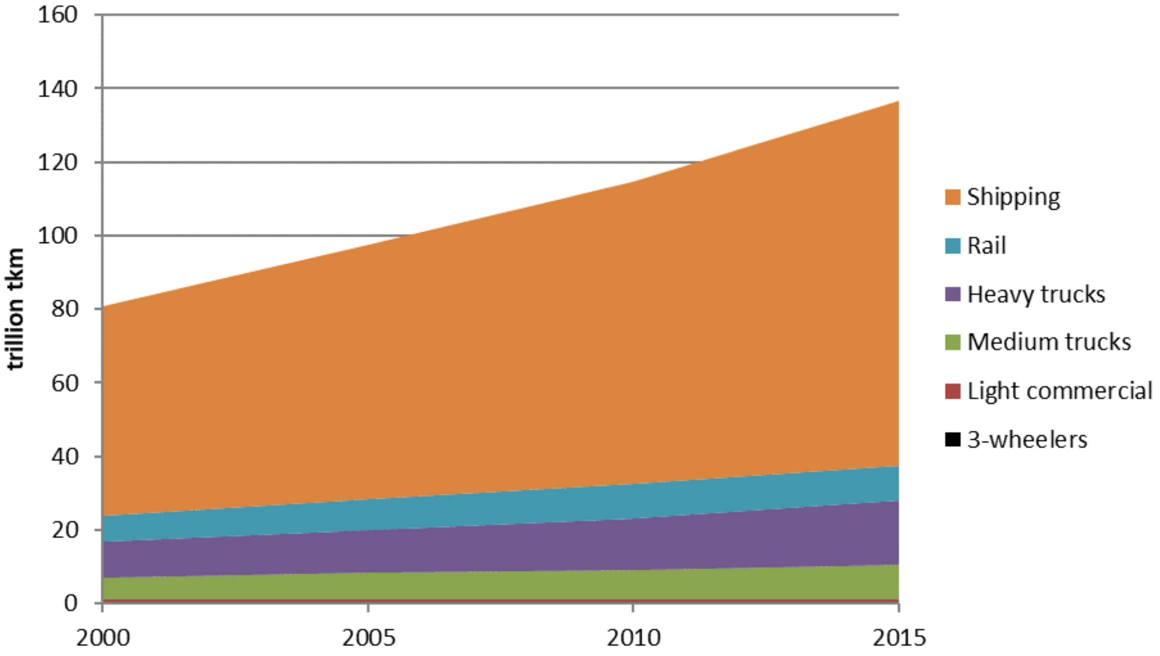
- Shipping dominates over all other modes

- Rail is only highly used in a few countries

As a share of domestic land transport, rail constitutes a notable fraction in:
- United States (33%)
- China (35%)
- Russia (58%)
- India (32%)

(values derived from IEA Mobility Model

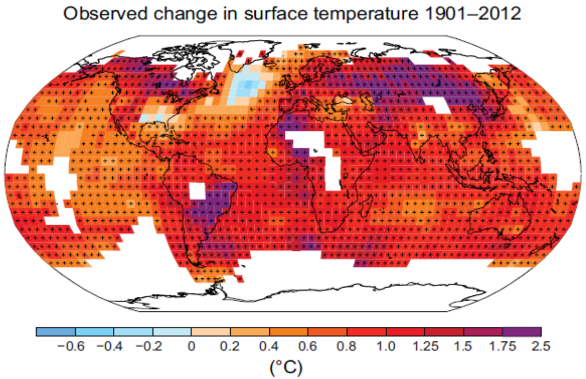
Freight activity (trillion tonne-kilometres) by mode



Transport policies for energy efficiency

1. The drivers of demand in transport
2. **Influencing the evolution of energy demand in transport (policies)**
   - **The role of transport and energy policies: *Avoid*, *Shift*, *Improve***
   - Evaluating policy impacts in transport & energy models

Transport and Energy Policies: Why are they needed?



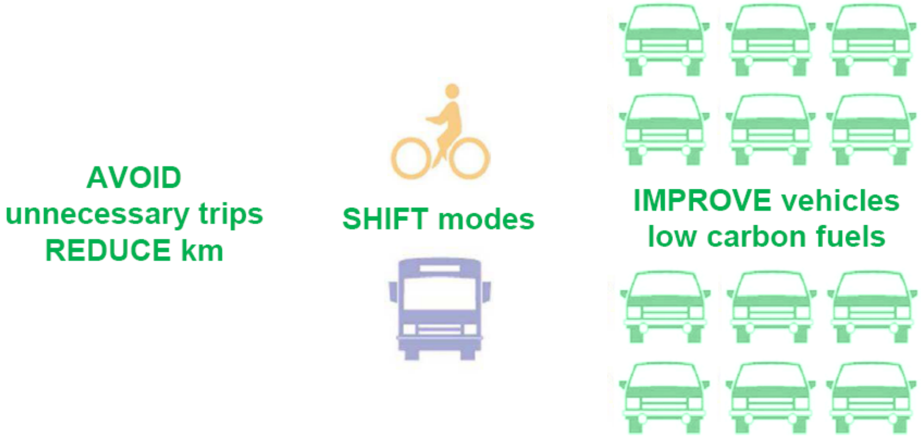
Transport and Energy Policies: Why are they needed?

- To weaken negative impacts of transport activity on others (externalities)
  - Damage to the environment – GHG, local pollutants
  - Health related issues – Local pollutants, noise
  - Time loss - Congestion / Queuing / Waiting
- To try to provide equal access to mobility
  - Basic principle that individual should be able to move freely
  - Social equity
- To have safe and secure trips – reduce accidents

Supply or Demand problem?

"The great intellectual black hole in city planning, the one professional certainty that everyone thoughtful seems to acknowledge, yet almost no one is willing to act upon"

Jeff Speck (author of *Walkable City)*



- Avoid unnecessary travel
  - Urban design & transport integration in land use planning
    - Shorter trips in high density, mix-use cities
  - Congestion pricing and other fees (e.g. parking): higher transport costs reduce total pkm
  - Logistics: better use of available capacity reduces total tkm

https://www.itdp.org/what-we-do/eight-principles/

Shift travel to more efficient modes

- Urban design & transport **integration in land use planning**
  - transit-oriented developments promoting walking, cycling and the use of public transport
- Congestion pricing, access restrictions, parking fees targeting primarily more energy-intensive modes, combined with subsidies for public transport
- Travel demand management to avoid traffic peaks
- Logistics and intermodal terminals: wider potential for co-modal goods transport

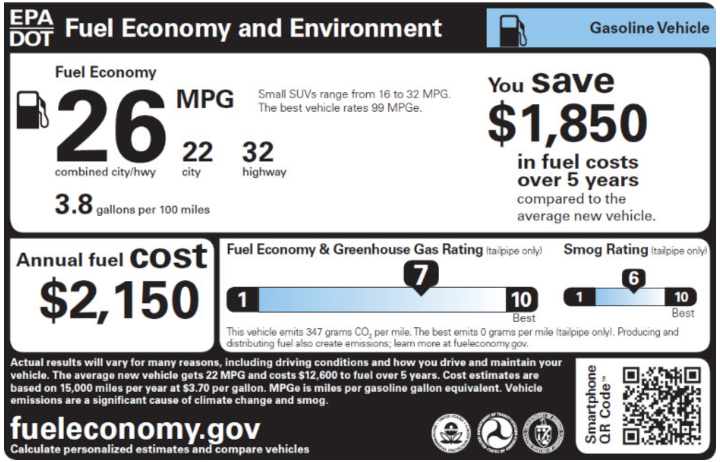
Move Windhoek: http://www.sutp.org/en/projects/namibia-move-windhoek-sustainable-trban-transport.html

Improve the energy efficiency of each mode

- **Standards/regulations** (e.g. on fuel economy, pollutant emissions, vehicle speed) and **fiscal charges/incentives** to promote the introduction of energy efficient and more sustainable technologies on vehicles in all modes (market pull)

- Support **research** to reduce the costs of advanced vehicle technologies (technology push)

- Support **behavioral changes** resulting in more efficient use of vehicles (high occupancy, energy efficient driving) and virtuous consumer choices to contain costs (e.g. smaller vehicles)



https://www.fueleconomy.gov/feg/Find.do?action=bt1

Transport and Energy Policies

		Regulation	Monetary incentive	Information
National	Avoid			
	Shift			
	Improve			
Local level	Avoid			
	Shift			
	Improve			
Tried within your country	Avoid			
	Shift			
	Improve			

Transport and Energy Policies

		Regulation	Monetary incentive	Information
National	Avoid			Promotion of teleconferencing and provision of IT infrastructure to support
	Shift			
	Improve	Fuel efficiency standards Pollutant emission regulations	Tax incentives for purchase of efficient vehicles Fuel taxation/removal of subsidies	Car labelling based on fuel use or emissions Eco-driving campaigns
Local level	Avoid	Land use planning regulation Optimising logistics for freight		
	Shift	Subsidies for public transport	Congestion pricing Parking fees	
	Improve	Speed limits	Inclusion/exclusion from congestion charging	
Tried within your country	Avoid			
	Shift			
	Improve			

Transport and Energy Policies: Avoid/Shift

- Urban design & transport integration in land use planning
- Compact development policy
- Long term goal but near term planning



Transport and Energy Policies: Land use planning for avoid/shift

Example: Carbon footprints (residential emissions only) in different neighborhoods in Toronto, Canada

East York - 1.31 tCO2e/cap (residential only)

High-density apartment complexes within walking distance to a shopping center and public transit:

1,31 tCO2e/capita

Etobicoke - 6.62 tCO2e/cap (residential only)

High-density single family homes close to the city center and accessible by public transit:

6,62 tCO2e/capita

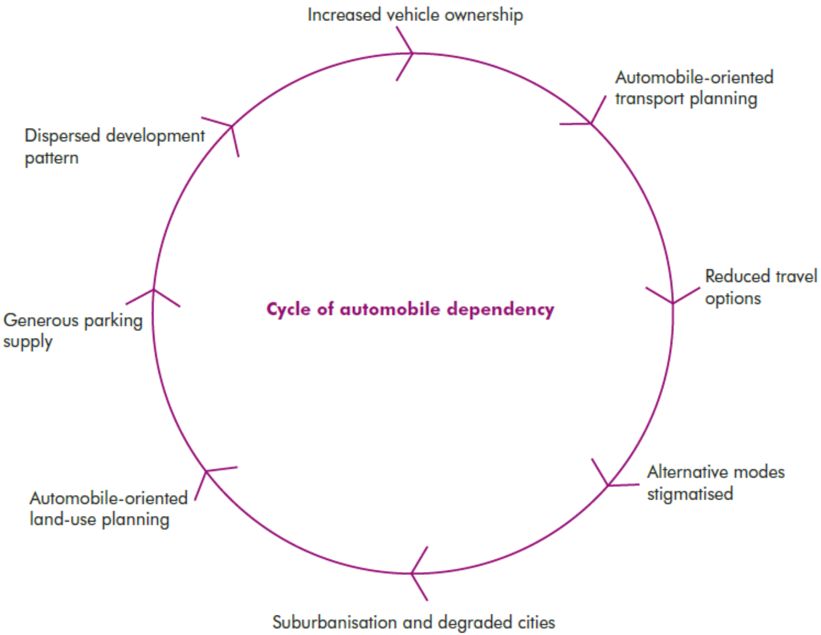
Whitby 13.02 tCO2e/cap (residential only)

Suburbs with large, low-density single family homes that are distant from commercial activity and public transit:

13,02 tCO2e/capita

Transport and Energy Policies for Avoid/Shift

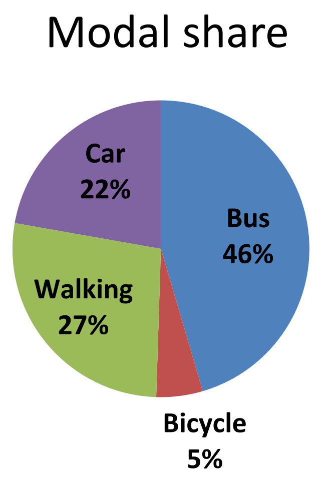
- Road/congestion pricing
- Environment zones
- Parking fees



Transport and Energy Policies: Example of avoid/shift

Curitiba, Brazil

Innovative land use planning integrated with transport planning



Source: IPPUC, 2009

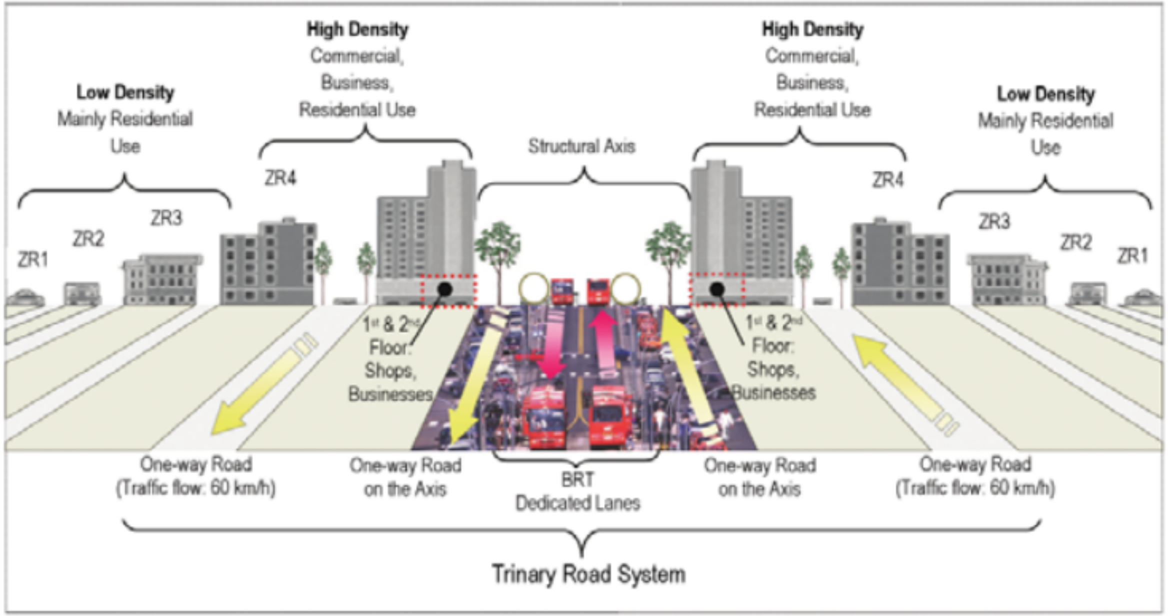
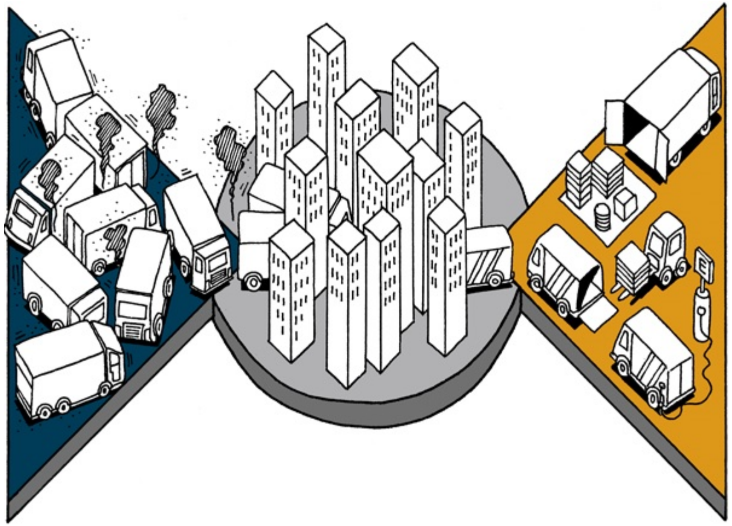


Figure 3.7 The Trinary Road System in Curitiba

Source: Author compilation (Hinako Maruyama) based on IPPUC (2009a), Hattori (2004), and pictures supplied by IPPUC.
Note: km/h = kilometers per hour.

Transport and Energy Policies: Avoid/shift logistics

- Logistics
- Information technology
- Intermodal terminals/hubs
- Road pricing & access restrictions
- Enable teleworking



Transport and Energy Policies: Shift to public transport

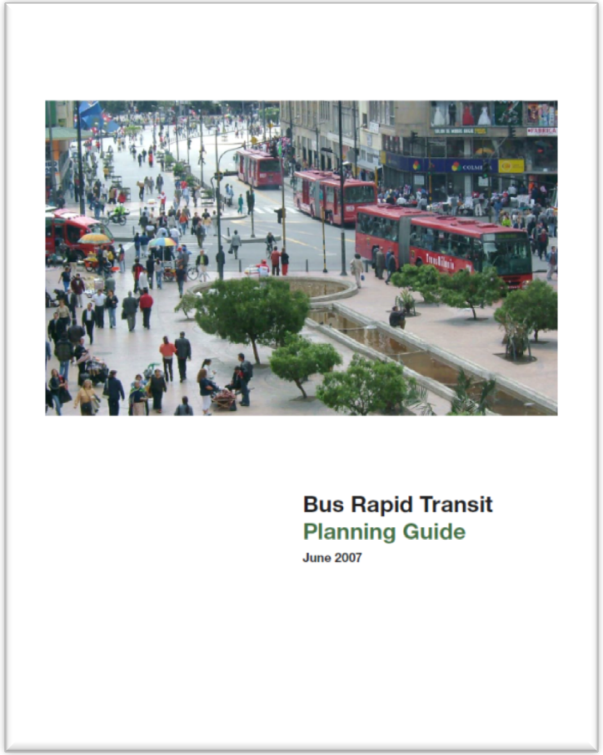
- Increasing the public transport capacity
- Improving the quality of public transport
- Pricing policies targeting primarily more energy-intensive modes can be combined with subsidies for public transport

Transport and Energy Policies: Bus rapid transit (BRT)

- Bogota's BRT a reference: 100+ systems in world today (including cities in Columbia, Ecuador, China, India, Brazil….)

- Significant CO_2 reduction
  25% - 39% (IEA estimate).

- Advantages: improved fuel efficiency, higher speeds and less stop-and-go traffic on dedicated routes.



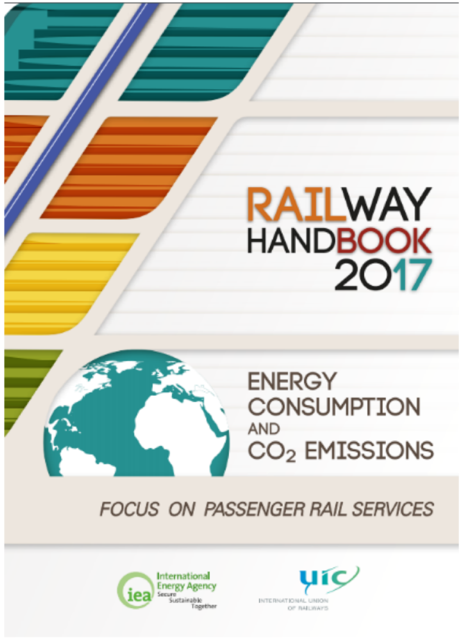
More on BRT planning and development:

https://go.itdp.org/display/public/live/Bus+Rapid+Transit+Planning+Guide

https://www.itdp.org/wp-content/uploads/2014/07/BRT-Standard-2014.pdf

Transport and Energy Policies: Shift to rail

- Rail carries 6% of global passenger transport activity – but only accounts for 4% of CO_2 emissions
- Rail energy intensity (MJ per pkm) decreased 30% between 2000 and 2010 – and can improve more in the future
- HSR is excellent alternative to short flights – but only a handful of countries are planning new HSR lines



Check out the UIC/IEA Rail handbook: https://uic.org/IMG/pdf/handbook_iea-uic_2017_web2-2.pdf

Transport and Energy Policies: Car sharing

- Limitations: requires users to be within convenient distance

- Participation in car sharing on average reduces car travel by 3000 km/year

- More formal programmes, like Paris Autolib' entering market. Reduced risk is attracting non-drivers to programme.

Transport and Energy Policies: Non-motorised transport (NMT)

Cycling

- Infrastructure provisions:
  lanes, parking, traffic signals

- Funding / cycling mode relationship:
  - Amsterdam: US$ 39/resident, Cycling 35%,
  - USA: US$ 1.5/resident, Cycling 1%.

- Bicycle "sharing" (rental) services

- Viable alternative for short trips

- Best suited for densely populated city centers

Transport and Energy Policies: Non-motorised transport (NMT)

Walking

- Pedestrian infrustructure, amenities and services are often neglected.
- Pedestrian friendly policies:
  - Safe sidewalks
  - Well marked, respected crossings
  - Car-free zones
  - Traffic calming measures
- Walkability Index

Transport and Energy Policies: Summary

- High-density environments with good transit use less energy
- Building cities from scratch is not possible
- Fast-growing countries can (and need to) do that (leapfrogging)
- Time frame to alter urban design is very long: > 50 years
- Integrated measures needed for effective results
- Bigger effects to be seen over the long term
- Local regulations should not inhibit beneficial forms of teleworking

➥ In depth action takes time but investment is worth it!

Transport & Energy Policies

From historical observations to projections of transport demand and energy use

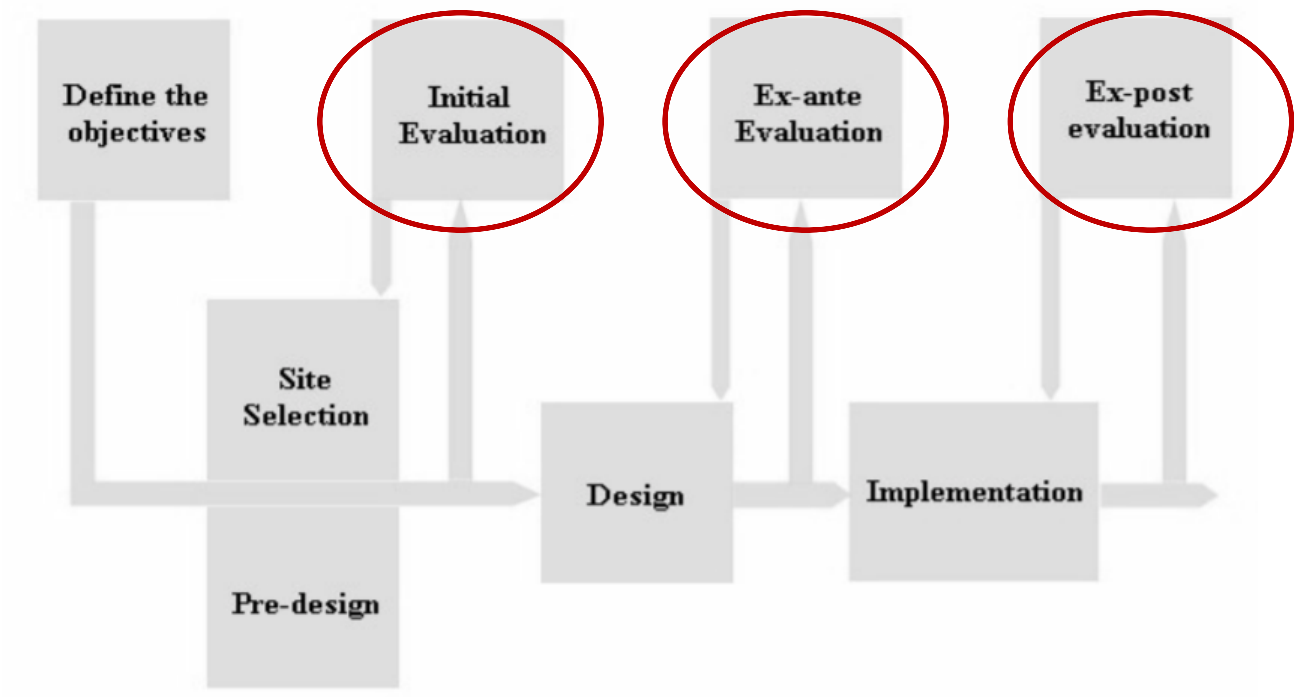
1. The drivers of demand in transport

2. Influencing the evolution of energy demand in transport (policies)

   - The role of transport and energy policies: *Avoid*, *Shift*, *Improve*

   - **Evaluating policy impacts in transport and energy models**

Transport & Energy Policies: Evaluation steps



Source: Maestro - https://trimis.ec.europa.eu/sites/default/files/project/documents/maestro.pdf

Why does evaluation matter?

www.iea.org

IEA

Supplementary slides

The ASIF calculation is based on Laspeyres identities

$$F = \sum_i F_i = A \sum_i \left(\frac{A_i}{A}\right)\left(\frac{F_i}{A_i}\right) = A \sum_i S_i I_i = F$$

F	total ***F***uel use
A	vehicle ***A***ctivity (expressed in *vkm*)
F_i	fuel used by vehicles with a given set of characteristics (***i***) (e.g. segments by service, mode, vehicle and powertrain)
$A_i / A = S_i$	sectoral ***S***tructure (same disaggregation level)
$F_i / A_i = I_i$	energy ***I***ntensity, i.e. the average fuel consumption per *vkm* (same disaggregation level)