The IEA Mobility Model;
an introduction and considerations on ACES

Summary of MoMo assumptions, methods, and results

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Outline

I. The IEA Mobility Model

- A brief history, summary of data sources, the historic database
- Flowcharts of data linkages
- Summary of capabilities
- Regional resolution
- Modal and vehicle type characterisation

II. Summary of recent results

- Scenarios in Energy Technology Perspectives 2017 (ETP 2017)
- Excerpted figures and key messages from: ETP 2017, Global EV Outlook 2017 (GEVO 2017), and from workshop and conference presentations

III. Key parameters and methods to be revisited for ACES

Outline

I. Summary of the Mobility Model

A brief history of the Mobility Model (MoMo)

2003 World Business Council for Sustainable Development and the Sustainable Mobility Project (SMP) transport model

Scenarios exploring transport energy use, CO_2 and pollutant emissions, safety and

2004 materials use

SMP model developed further as IEA Mobility Model (MoMo)

MoMo data used for the IEA ETP analysis and ETP 2006

2006 Deeper analysis of vehicle technology potential, including PHEVs

Elasticities of travel and ownership with respect to GDP and oil prices

2008 Early development of modal shift scenarios

Vehicle, fuel and infrastructure costs

2012 Cooperation with UIC on rail data

Expanded coverage of countries and regions

2015 New approach for passenger demand generation and policy insights

Urban and non-urban transport assessment fully integrated

2016 Updated aviation module

Updated shipping module

2017 Extension to 2100

New approach for freight demand generation

The IEA Mobility Model (MoMo) – What is it?

A spreadsheet model of global transport

- focus on vehicles, transport activity and energy use
- also covers emissions, infrastructure and materials use
- Analysis of scenarios and projections to 2060 (mostly back-casting and "what-if")

(extension from 2060-2100 is complete but is current a simple extrapolation of trends)

World is divided in 29 regions, including several specific countries

- All G20 countries except Saudi Arabia, as well as regional blocks (e.g. ASEAN, EU and non-EU Nordics, EU 7, Latin America, sub-Saharan Africa, OETE…
- Urban and non-urban disaggregation (following UN and national definitions)

MoMo contains a large amount of data on technology and fuel pathways

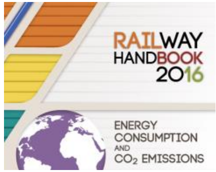
- Full evaluation of life-cycle greenhouse gas emissions: with and without (I)LUC
- Cost estimates for new light-duty vehicles (LDV), fuels and fuel taxes
- Estimates of transport sector expenditures to 2050: vehicles, fuels and infrastructure
- Module on material requirements for LDV manufacturing

The IEA Mobility Model (MoMo) – What is it?

The analytical tool used for projections of transport activity, energy demand and CO_2 emissions in the IEA

An essential tool for activities on:

- Energy Efficiency: Global Fuel Economy Initiative (GFEI)
- Energy Technology: Electric Vehicle Initiative (EVI)
- Cooperative Efforts: Railway Handbook on Energy Consumption and CO_2 emissions with International Union of Railways



MoMo is shared with:

- Other Directorates in the IEA (e.g. WEO; EEfD)
- the International Transport Forum, who uses it for the formulation of its Transport Outlook
- "MoMo partners", i.e. sponsors – mainly from the private sector – that provide Voluntary Contributions and/or in-kind support

Who supports the work: MoMo partners

ExxonMobil
HONDA
TOTAL
MIT
MICHELIN
NGK SPARK PLUGS | NTK TECHNICAL CERAMICS
Statoil
NAVIGANT ECOFYS
BOSCH
TOYOTA
BR
WWF
ClimateWorks FOUNDATION
icct THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION
ifp
ITDP Institute for Transportation & Development Policy
KAPSARC King Abdullah Petroleum Studies and Research Center
bp
Carbon Tracker Initiative
UC DAVIS ITS
RENAULT NISSAN

The MoMo historical database - Data sources:

IEA statistics: country-level energy demand by mode (road, rail, aviation, shipping) and by fuel over time

Road: national statistical offices, vehicle manufacturers associations, vehicle registers, ministries, statistical yearbooks…

- Country-level data on stock, new registrations, mileage and fuel economy, urban & non-urban resolution
- Main focus of the model due to high energy use
- Passenger and Freight modes: 2- & 3-wheelers, PLDVs, LCVs, MFTs and HFTs
- Desegregation by power train types using gasoline, diesel, electricity, and gas

Rail: country level data from UIC, urban from UITP and ITDP datasets combined

- Rail: light rail, metro, heavy rail (electric, diesel)

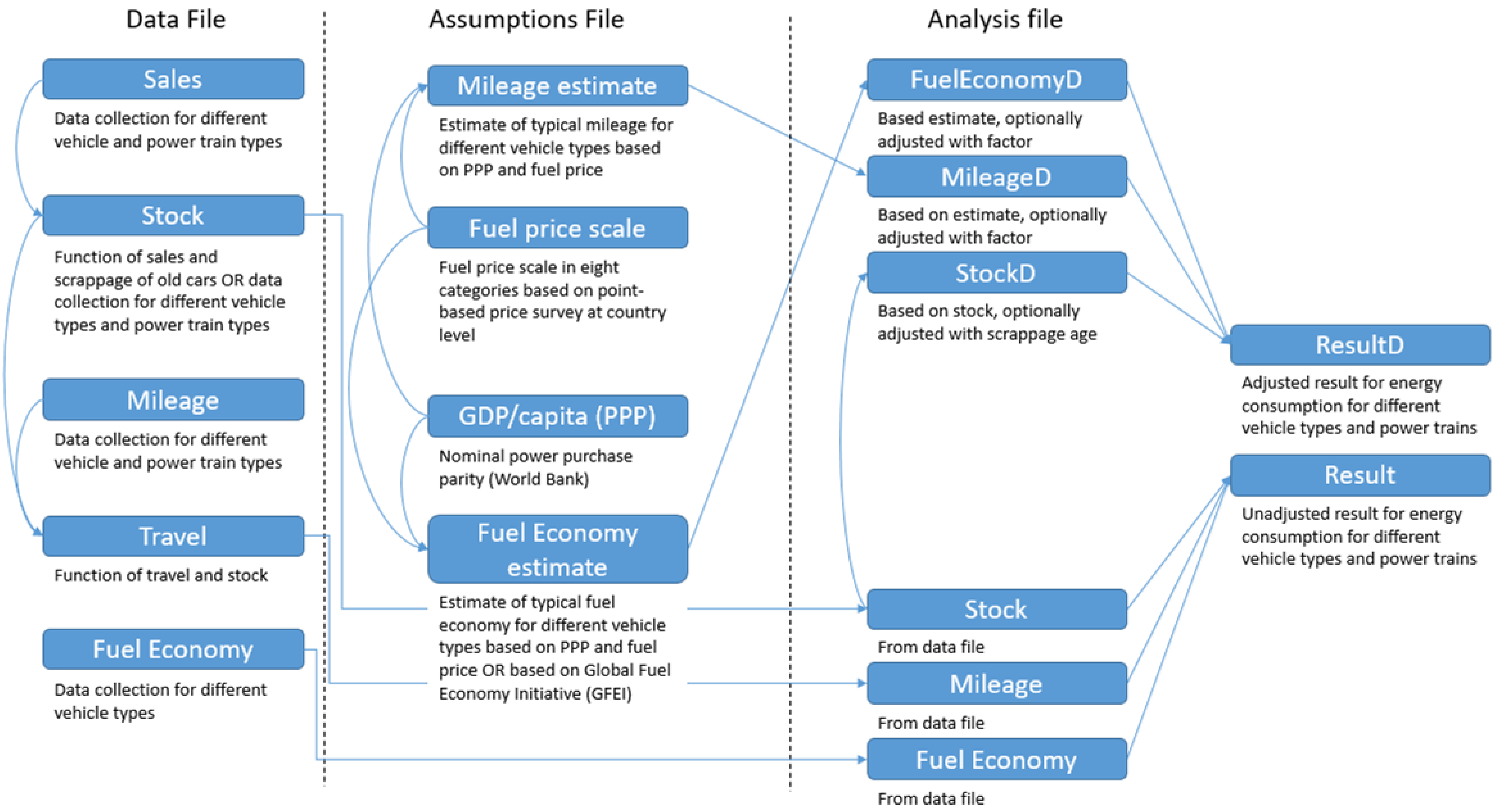
Aviation: data from ICAO and JADC, as well as Boeing, Airbus, ICCT

- Commercial aircraft

Shipping: activity from UNCTAD, IMO, activity projections based on ITF modelling

- International maritime ships (container, general cargo, oil tankers, bulk carriers, other)

The MoMo historical database – conceptual flowchart:



Regional Coverage

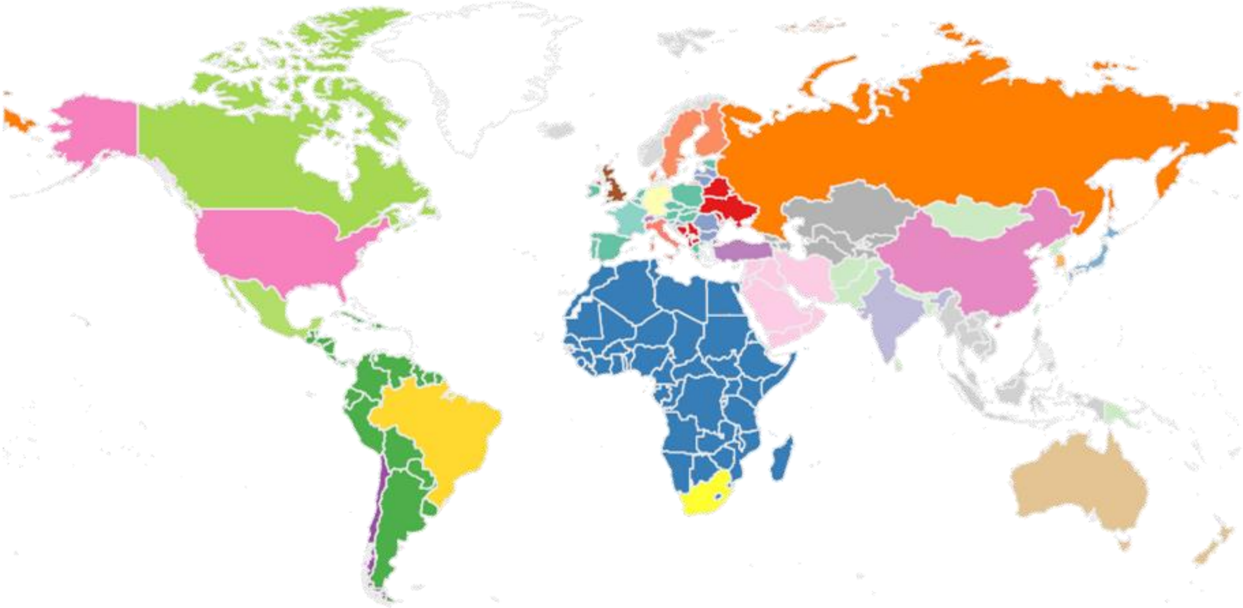
Historic Database
44 countries & regions

Annual time steps
Minimal coverage of 1990-2016
Some regions extend from 1970-2016

Algeria	Argentina	ATE
Australia	Brazil	Canada
Chile	China	Croatia
Denmark	EU 7	EU18-EUG4
France	Finland	Germany
Iceland	India	Indonesia
Israel	Italy	Japan
Korea	Malaysia	Mexico
Middle East	New Zealand	Norway
ODA	OETE	Other Africa
Other ASEAN	Other Latin America	
Philippines	Russia	
South Africa	Spain	Sweden
Switzerland	Thailand	Turkey
UK	USA	Vietnam
Being added:		
Morocco	Egypt	Ukraine

Mobility Model
29 countries & regions

All G20 countries (except Saudi Arabia),
plus other countries and regional aggregates
5 year time steps
Analysis focuses on 2015-2060



Powertrain coverage, by mode

Road vehicles:

- Gasoline ICE
- Diesel ICE
- Gasoline HEV
- Diesel HEV
- Plug-in Gasoline hybrid
- Plug-in Diesel hybrid
- Battery Electric
- CNG
- LNG
- Hybrid fuel cell
- Hydrogen fuel cell

Vehicle types

Passenger Vehicles (i.e. for passenger transport):

	Light-duty	Heavy-duty
2&3 / 4 Wheelers		
2 Wheelers		
3/4 Wheelers		
PLDVs		
Passenger Cars		
Passenger Light Trucks		
Mass Transport		
Minibuses		
		Buses
		BRT (Bus Rapid Transit)

Commercial Vehicles (i.e. for freight transport):

Light-duty	Heavy-duty
3/4 Wheelers (for freight)	
LCVs (light commercial vehicles) [<3.5 tonnes GVW]	
	Medium trucks [3.5 - 15 t GVW]
	Heavy trucks [>15 t GVW]

Rail:	electric, diesel	light rail, metro, intercity passenger & freight, HSR
Aviation:	jet fuel, CTL, F-T biofuels	commercial aircraft
Shipping:	HFO, diesel, biodiesel, LNG, H2	multiple ship types

MoMo estimates energy demand based on ASIF approach

ASIF (Activity, Structure, Intensity → Fuel use) approach

- 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

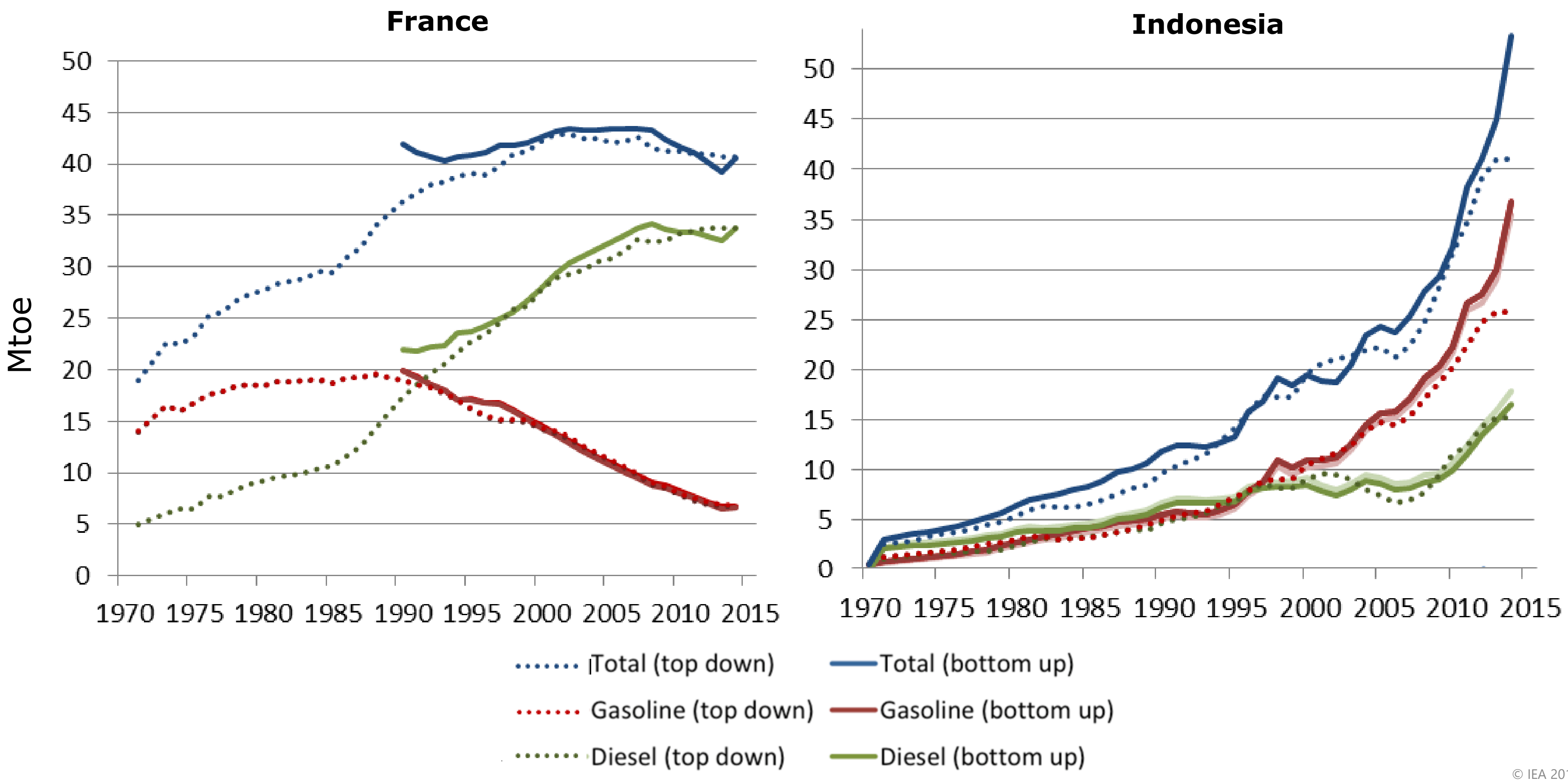
... allow the estimation of ***F**uel consumption*

The calculation is based on Laspeyres identities

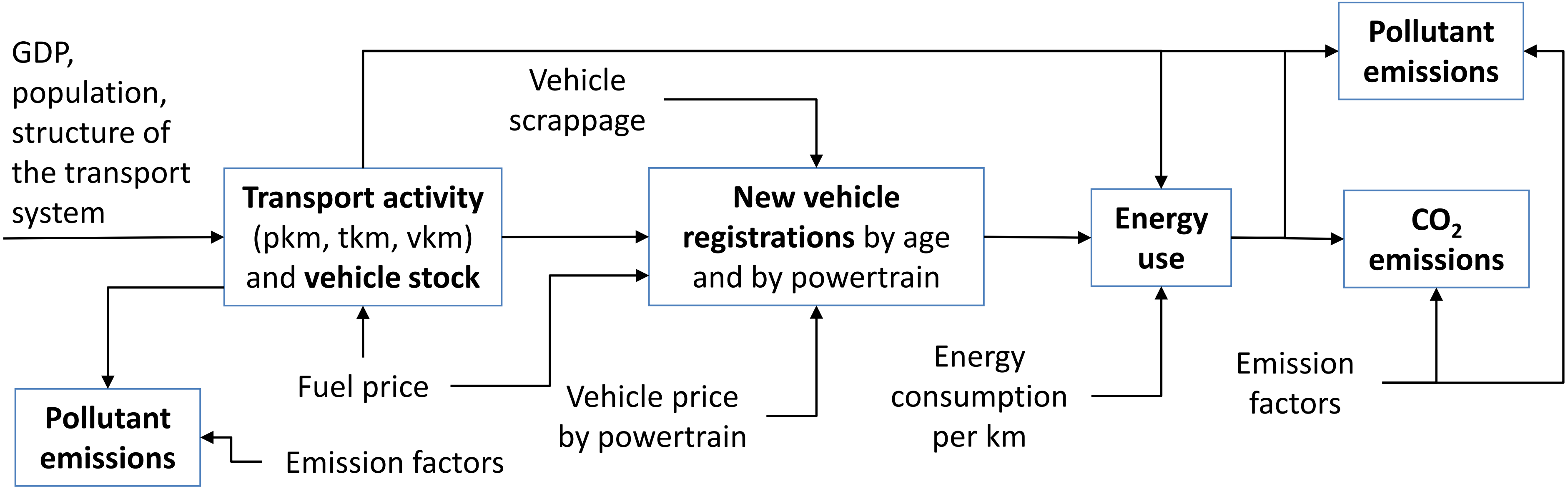
$$F = \sum_i F_i = A \sum_i \left(\frac{A_i}{A}\right)\left(\frac{F_i}{A_i}\right) = A \sum_i S_i I_i = F$$

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. average fuel consumption per *vkm* (same disaggregation level)

Historic results are calibrated with IEA World Energy Balances

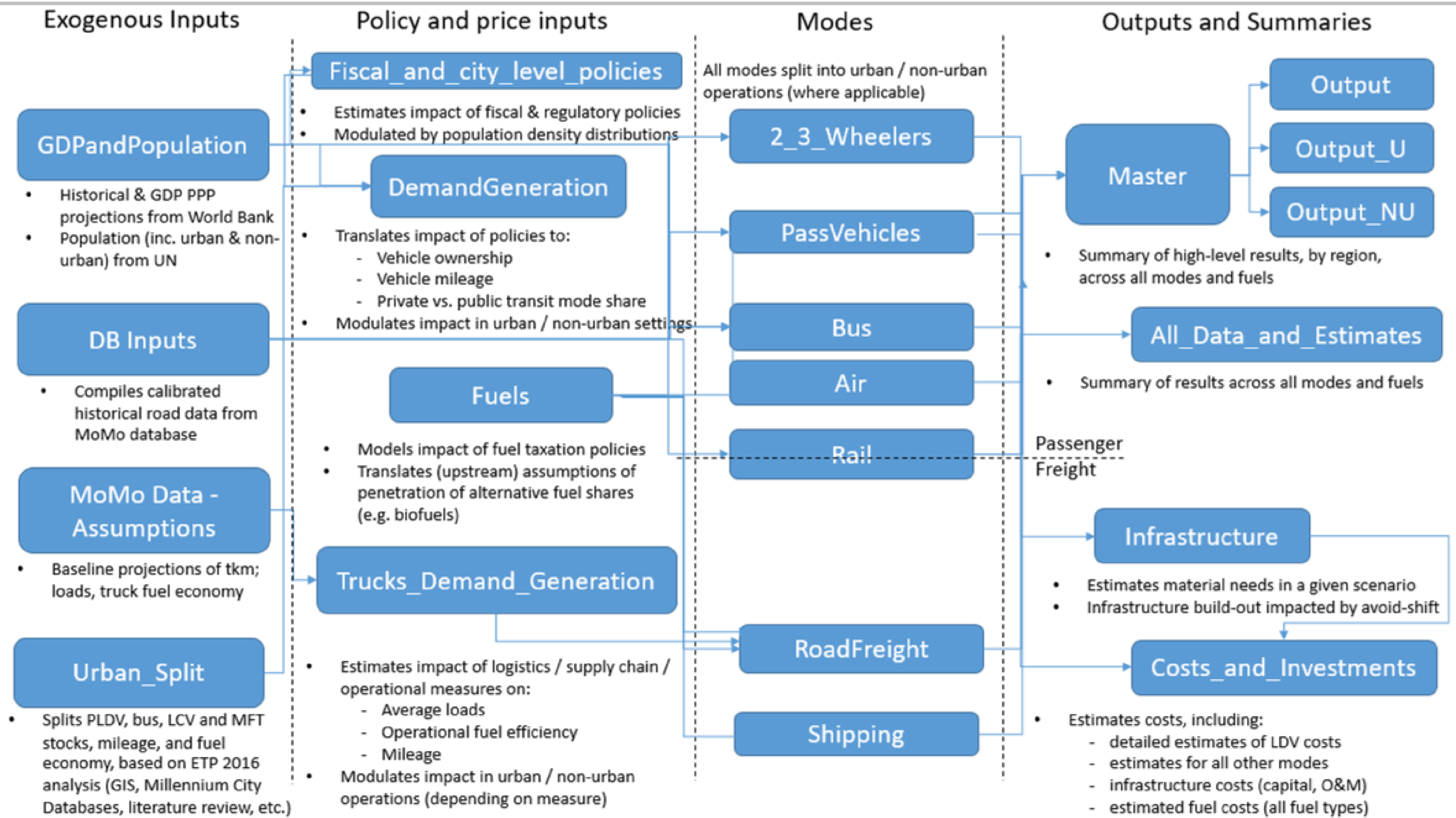


The IEA Mobility Model (MoMo) – simplified model structure



- Generation of transport activity (pkm, tkm, vkm) and vehicle stock
- Derivation of new vehicle registrations by powertrain, characterisation of vehicles by age
- Calculation of the energy use, by fuel
- Estimation of CO_2 and pollutant emissions

The IEA Mobility Model – a network of spreadsheets



Analytical capabilities

MoMo has a user interface that allows

- What-if scenario building and back-casting
- Use of elasticities for ownership and mileage
- Mode shift scenario building for passenger travel

MoMo also estimates material requirements and emissions

- Analysis of future vehicle sales (e.g. EVs, fuel cells) and how they impact materials requirements (e.g. precious metals) is possible (currently being expanded / updated)
- Full life-cycle analysis for GHG emissions from LDVs (including manufacturing) can be calculated

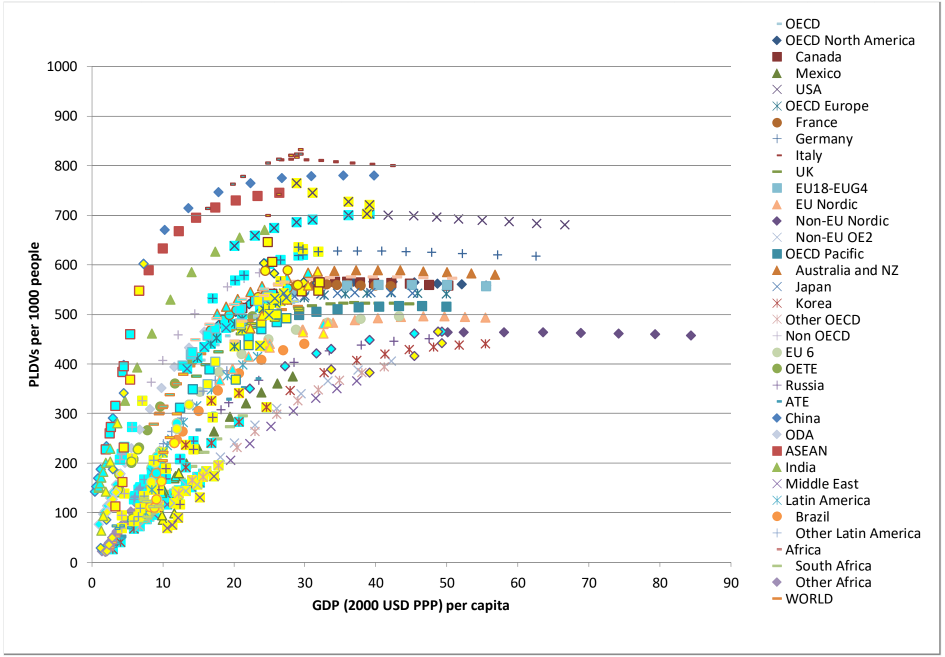
Recent MoMo capacity developments include

- Urban & non-urban travel splits using data from a global set of mobility surveys
- Land transport infrastructure requirements in support of travel demand growth
- Fuel cost, T&D, storage and distribution infrastructure assessment
- Cost estimations from vehicle, fuel and infrastructure investments

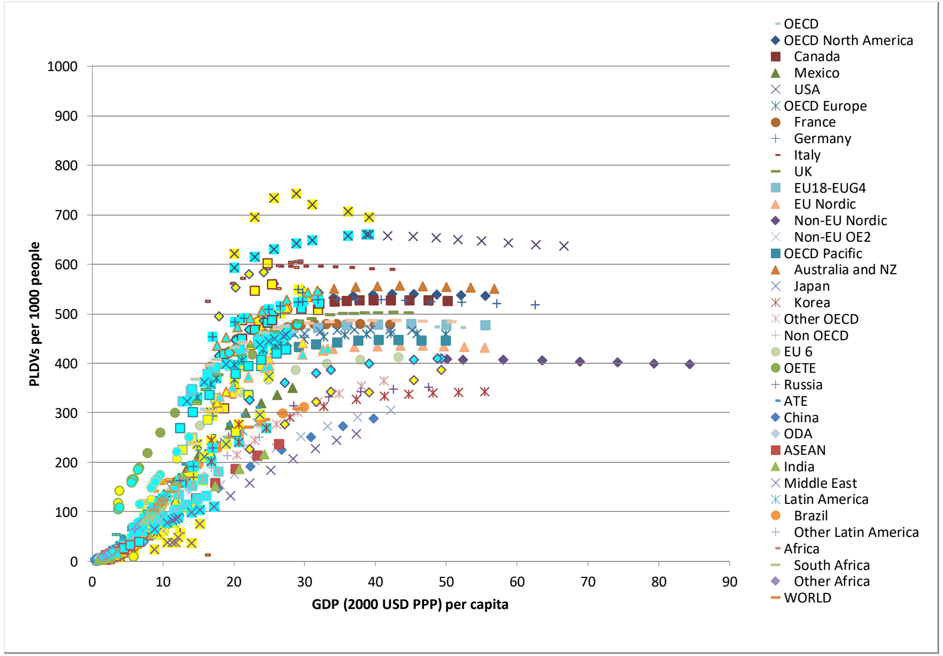
Passenger demand generation

Ownership – data shown refer to urban areas

Personal vehicles [including 2-wheelers]



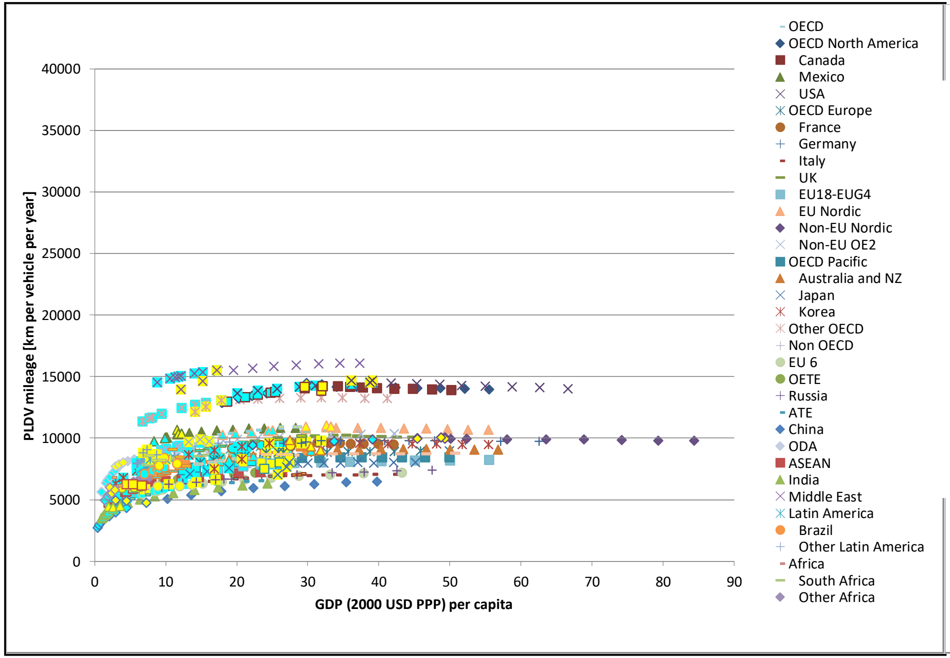
PLDVs



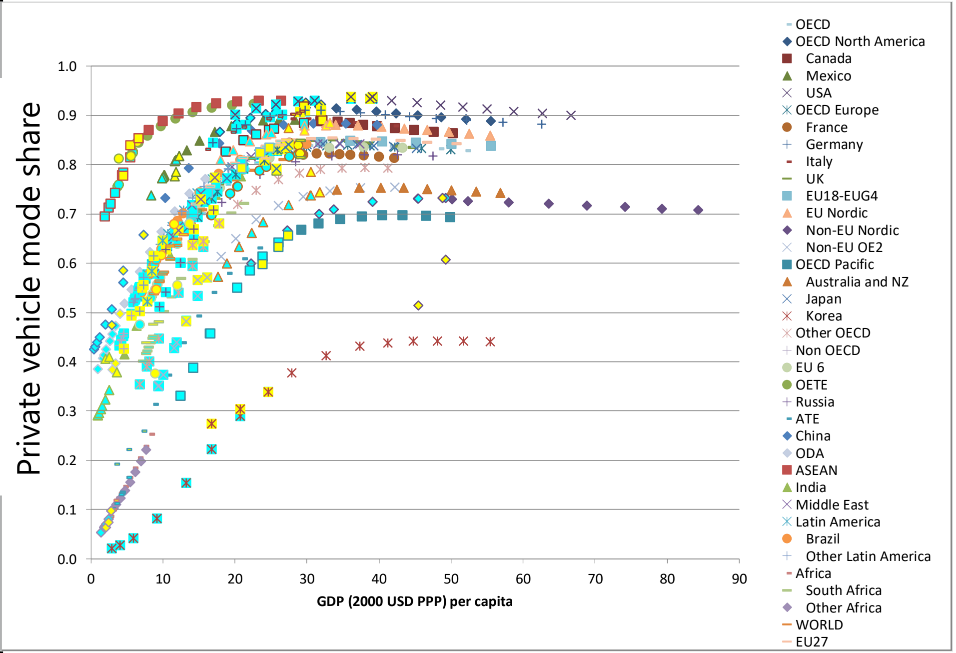
Passenger demand generation

Other relationships (selected examples) – urban data

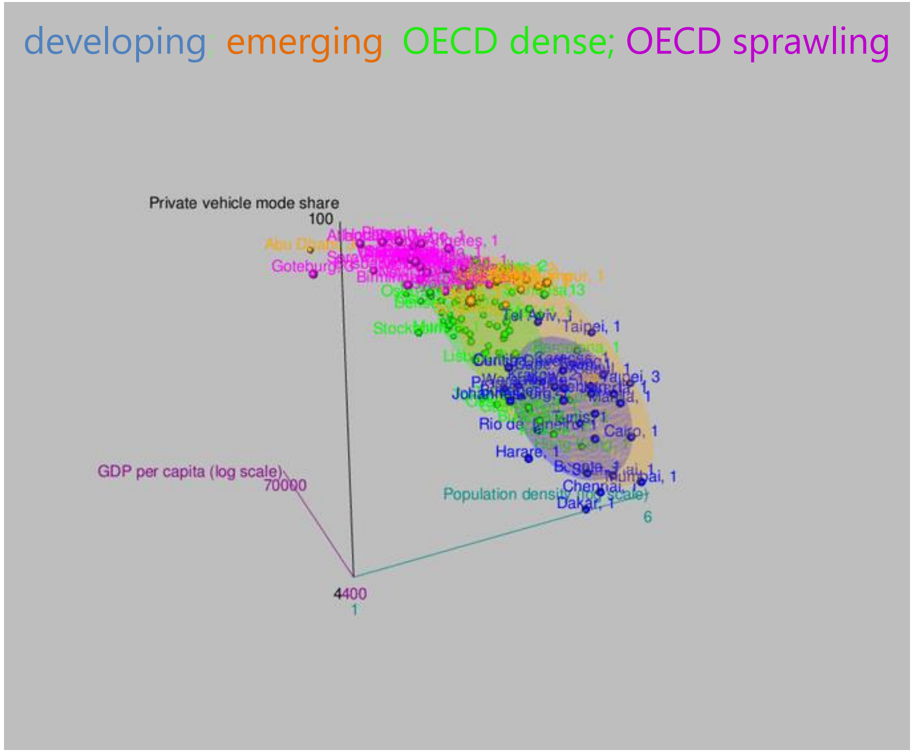
Personal vehicle mileage

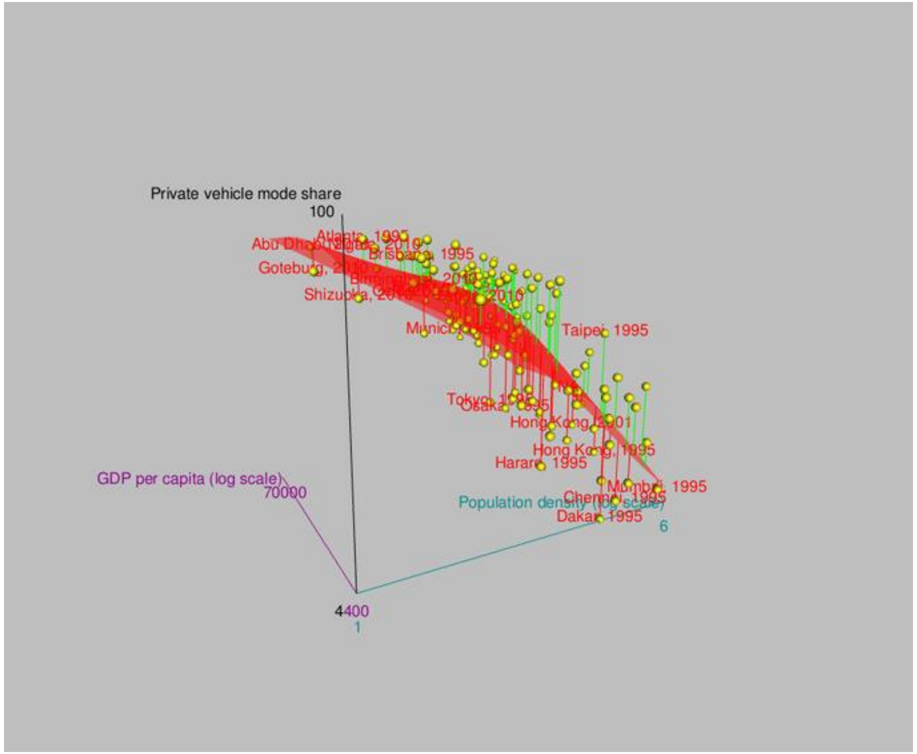


Pkm share on PT



Passenger transport activity in some global metropolises, 1995, 2005, & 2015

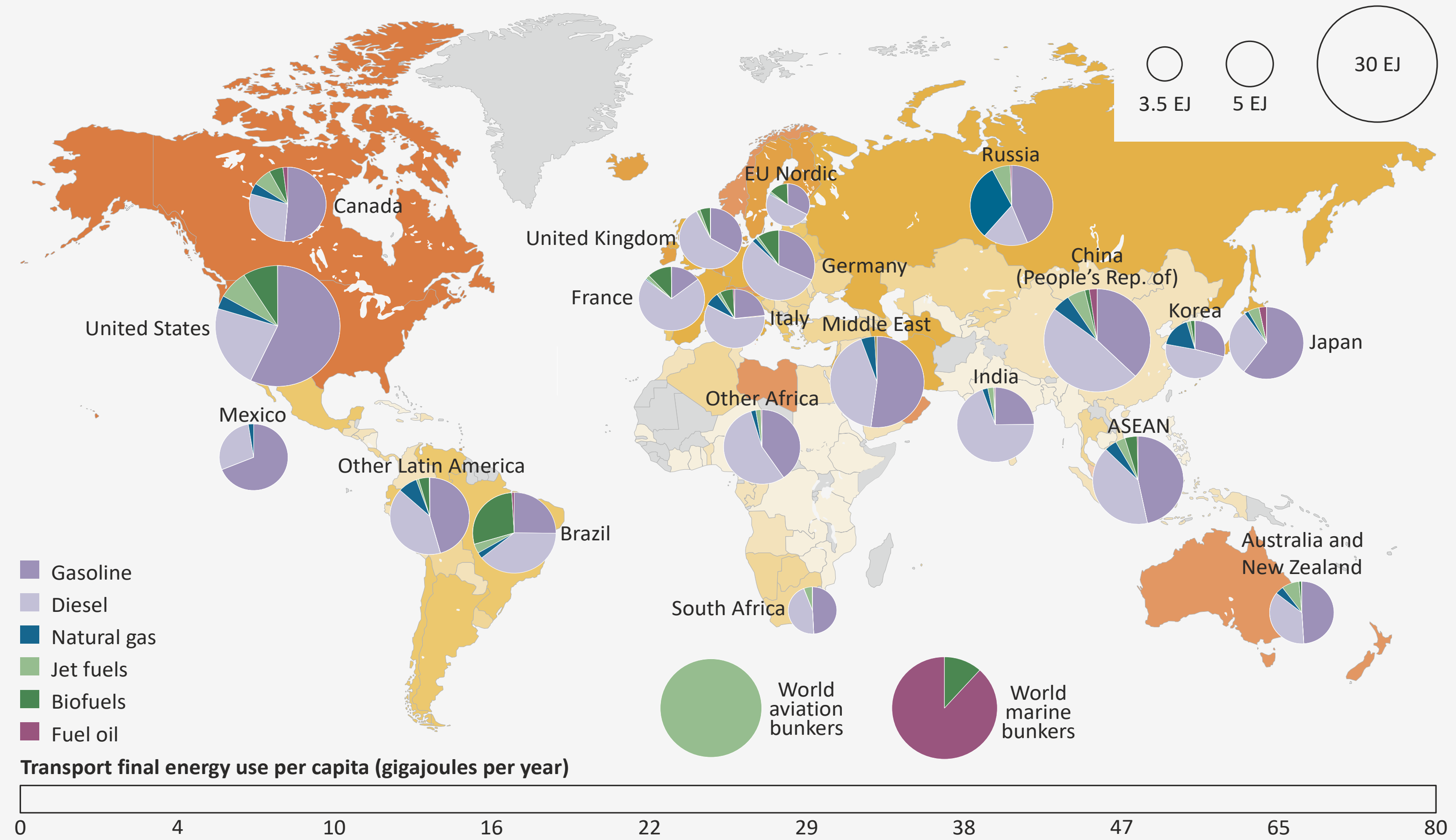




Strong correlations exist at the city level between population density and private vehicle modal shares.

II. Summary of recent results

Per capita transport energy use by country and by fuel, 2015

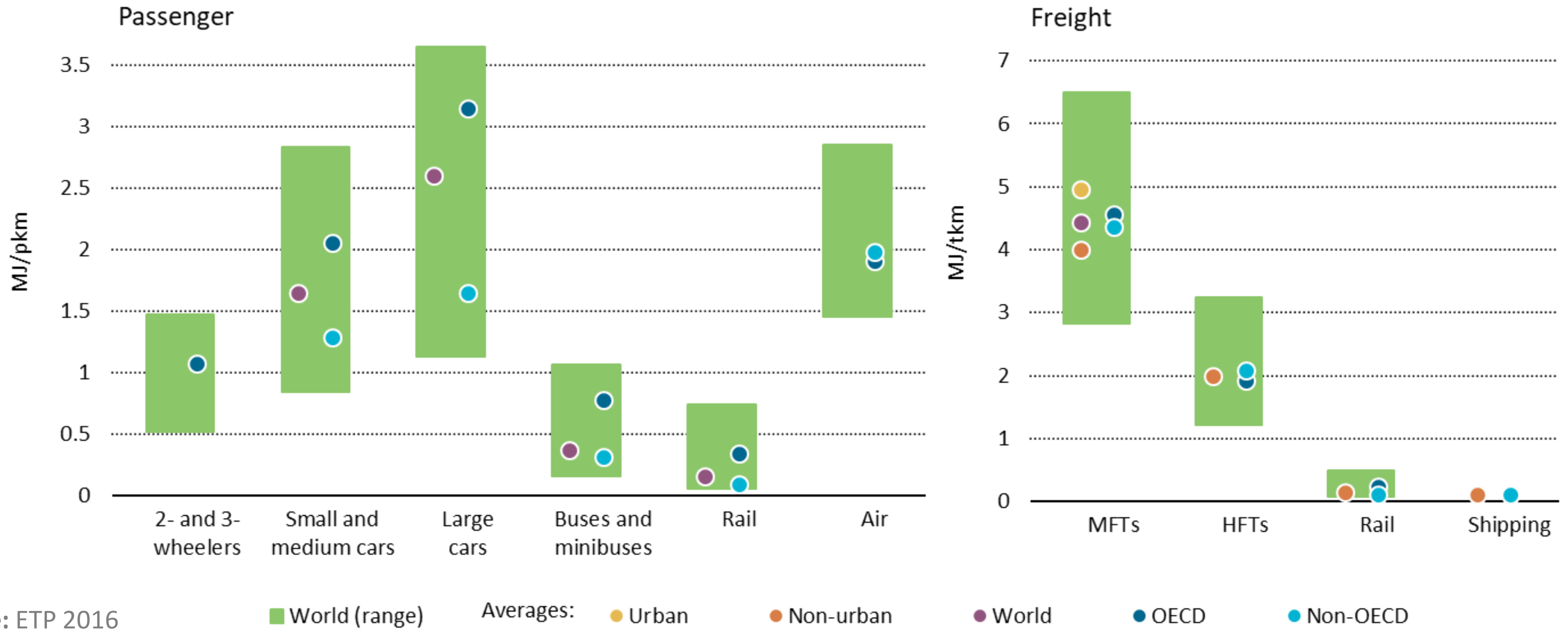


This map is without prejudice to the status of or sovereignty over any territory, to the delineation of international frontiers and boundaries, and to the name of any territory, city or area.

Source: ETP 2016

Transport activity: modal choice

Energy intensity of different modes of transport, 2015

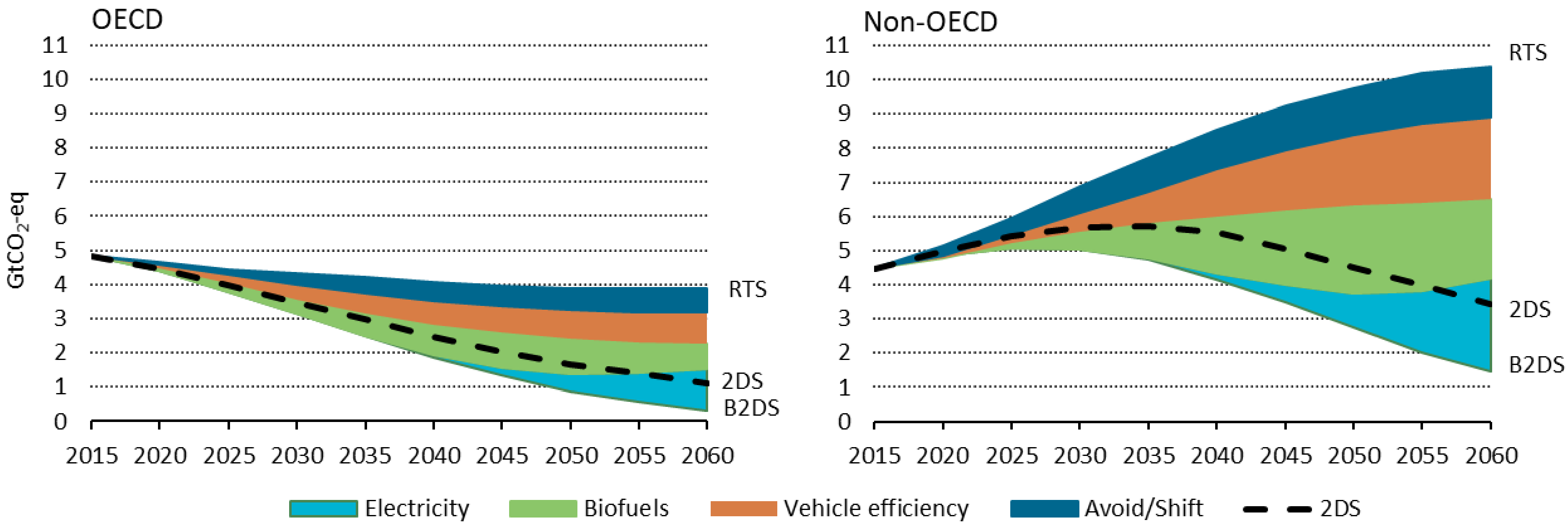


Source: ETP 2016

Air and light road passenger modes are more energy intensive than public ('mass') transport.
Light and medium road freight modes are more energy intensive than large road vehicles, rail and shipping.

Measures are needed across the developed and developing world

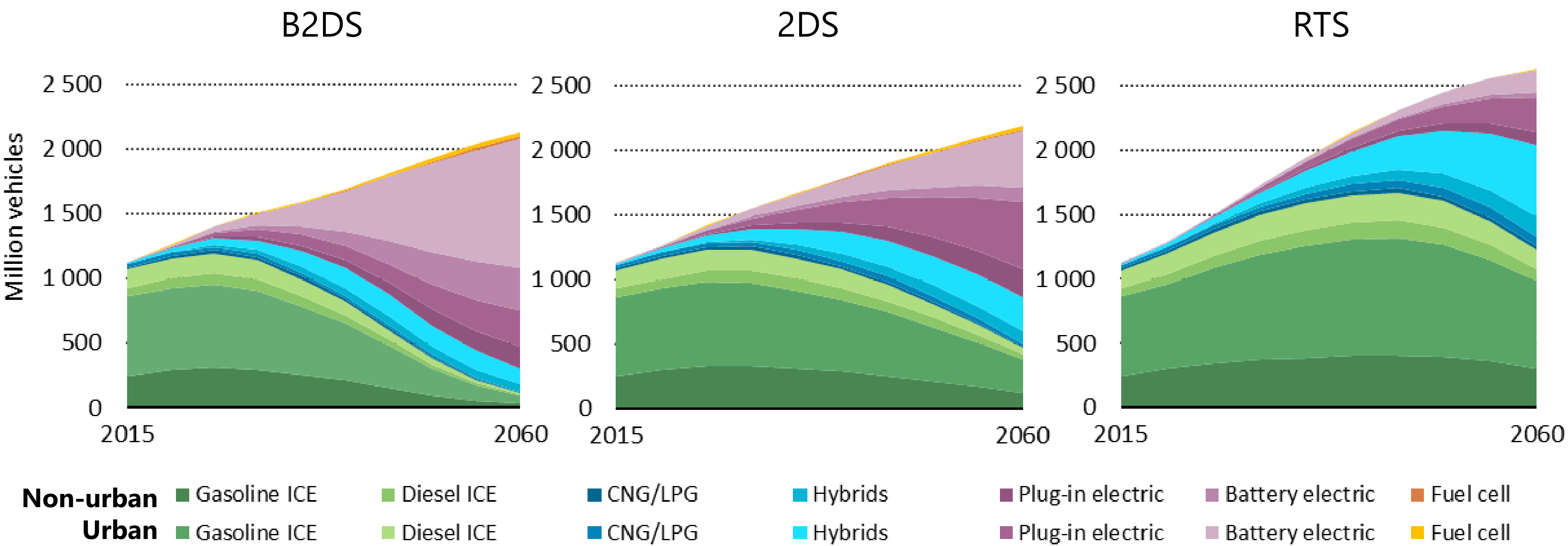
Well-to-wheel greenhouse gas emissions in OECD and non-OECD countries by scenario, 2015-2060



B2DS target requires alternative transport fuels, efficient vehicles, and changed transport behavior
Emission reductions of 90 percent (OECD) and 66% (non-OECD) below 2015 levels are needed

Rapid electrification of light-duty fleet drives deep decarbonisation

Global technology penetrations in the Light-Duty Vehicle (LDV) stock by scenario, 2015-2060



By 2060, the share of alternative powertrain vehicles in the global LDV stock will reach 94% in the B2DS and 77% in the 2DS.

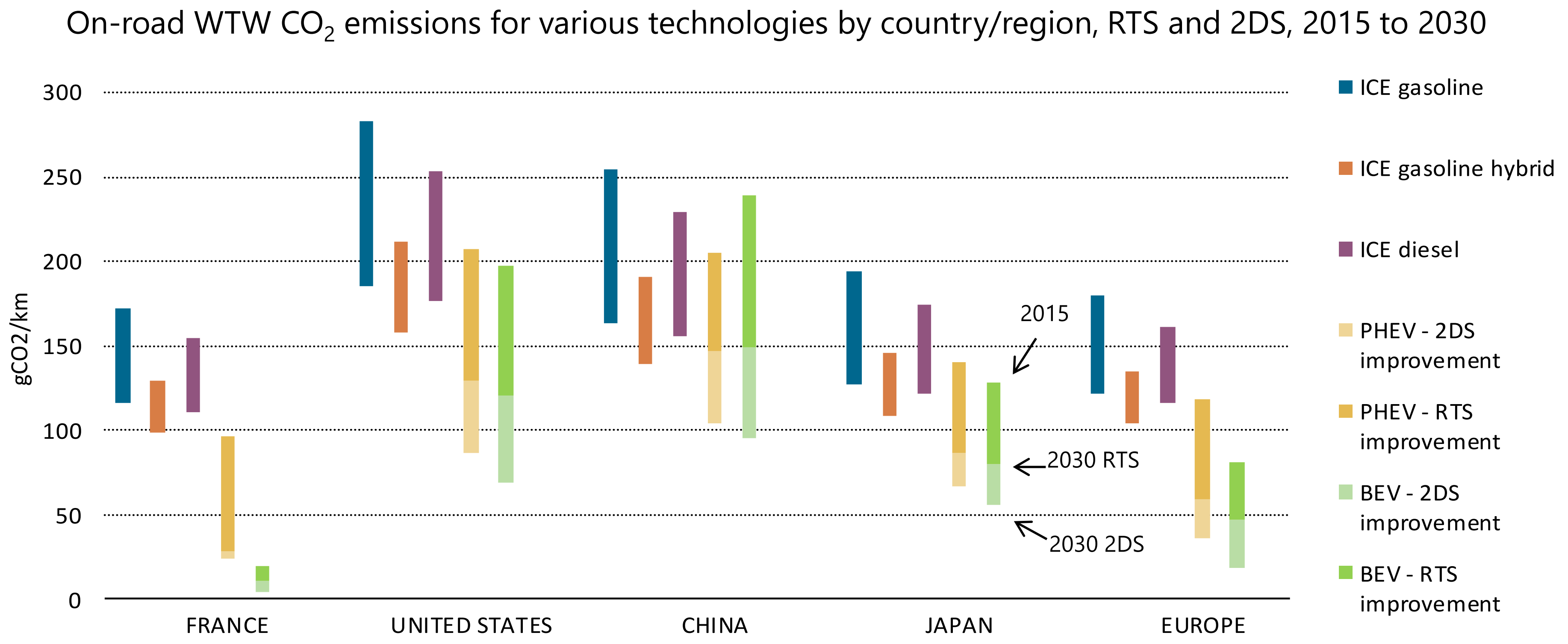
Scenario definitions

The ***Reference Technology Scenario (RTS)*** provides a baseline scenario that takes into account existing energy- and climate-related commitments by countries, including Nationally Determined Contributions pledged under the Paris Agreement. The RTS — reflecting the world's current ambitions — *is not consistent with achieving global climate mitigation objectives, but would still represent a significant shift from a historical "business as usual" approach.*

The ***2°C Scenario (2DS)*** and the ***Beyond 2°C Scenario (B2DS)*** each sets out a rapid decarbonisation pathway in line with international policy goals. The 2DS has been the main climate scenario in the ETP series for many years, and it has been widely used by policy makers and business stakeholders to assess their climate strategies. For the first time, the B2DS looks at how far known clean energy technologies could go if pushed to their practical limits, in line with countries' more ambitious aspirations in the Paris Agreement.

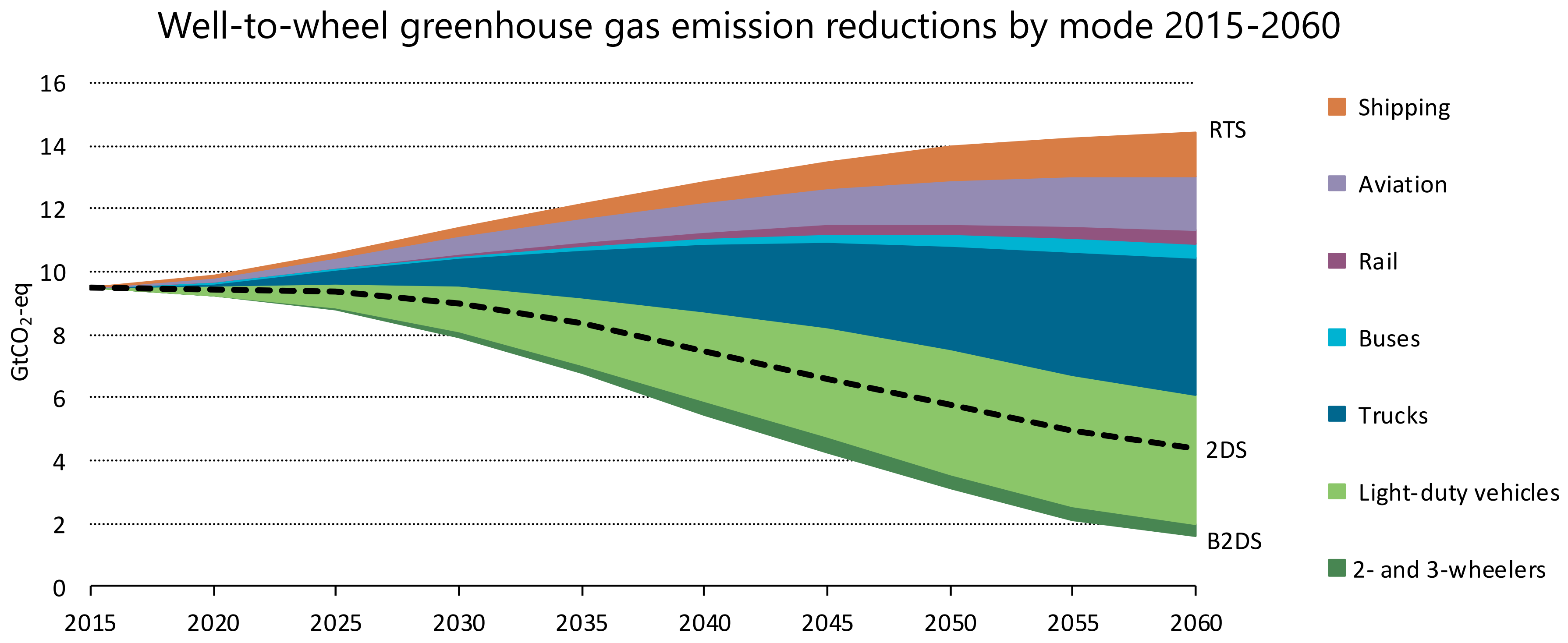
- **The RTS is aligned with the WEO NPS at a high level**
- **The 2DS may be merged with the WEO Sustainable Development Scenario (SDS) in the near future**
- **The 2DS has an energy sector budget of 1170 Gt CO_2, and the energy system reaches (near) net carbon neutrality in the 2080s**
- **The B2DS has an energy sector budget of 750 Gt CO_2, and the energy system reaches net carbon neutrality around 2060**

Coupling EVs with renewable power can transition transport to near-zero CO_2 emissions



If coupled to low-carbon power, the high energy efficiency of EVs offers prospects for substantial CO_2 emissions reductions. This complements their air quality, energy security and noise reduction benefits.

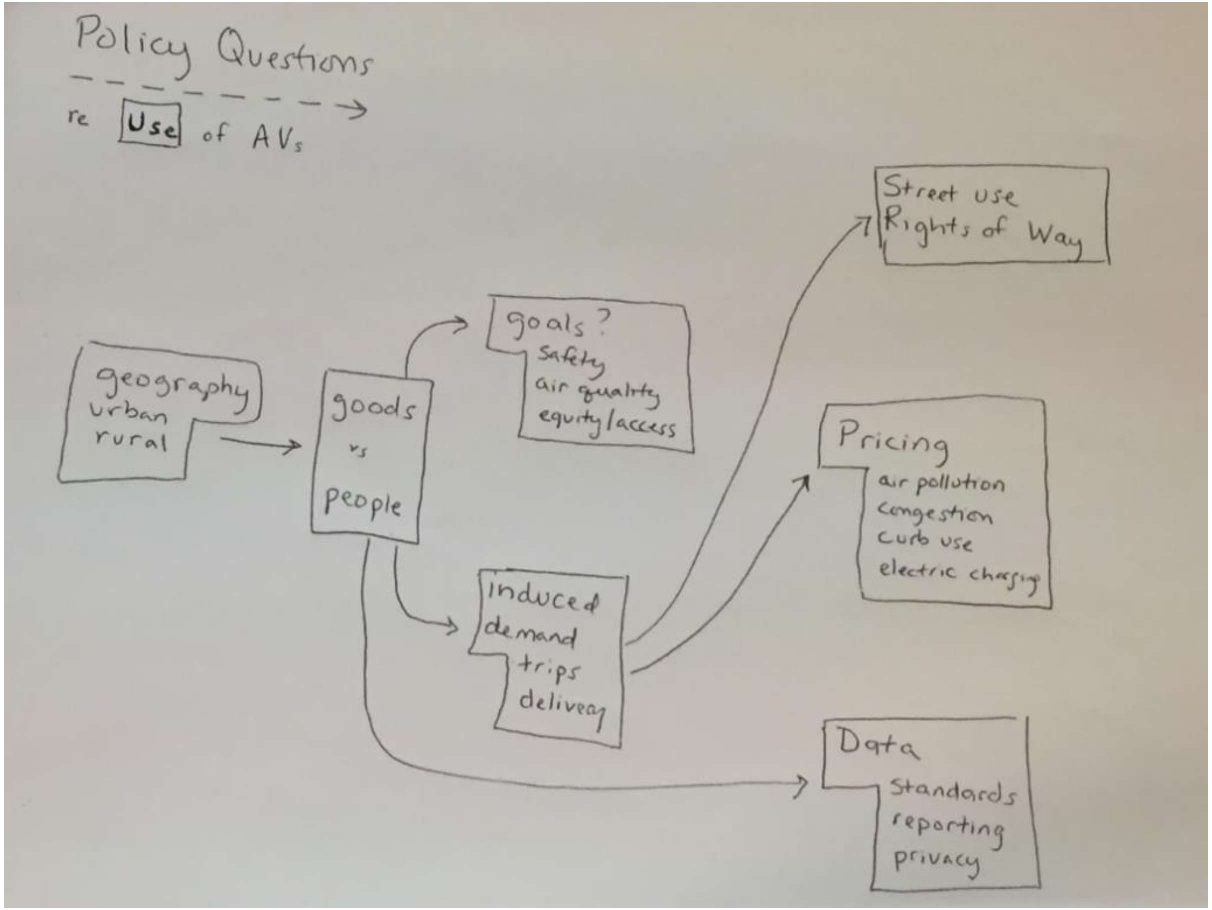
Ambitious policy action is needed across all transport modes



The Beyond 2°C Scenario envisages GHG reduction by 89% below 2015 emission levels
The 2°C Scenario maps an emission decrease of 54% over the same period

III. Approaches that need to be revisited to better model ACES

thanks to Robin Chase for summarizing many of the key aspects



Passenger vehicle use cases lead to usage profiles

	Human driver	Autonomous driven
Privately owned		
Mobility service fleets		

Four quadrants simplify key impacts of shifts in major parameters that can be addressed within MoMo