Energy Technology Perspectives

Sustainable Transport in an era of Urbanization

National and local policies to promote sustainable transport

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International Energy Agency
Secure Sustainable Together

Energy Technology Perspectives

ETP 2016

- Published ***since 2006***

Energy & GHG emission futures under three main scenarios:

- ***6DS***, ***4DS*** and ***2DS***
  - 6DS: 'static baseline'
  - 4DS: current strategies and recent pledges extended to 2050
  - 2DS: CO_2 emission mitigation scenario

Addressing sustainable development: action in all sectors is needed

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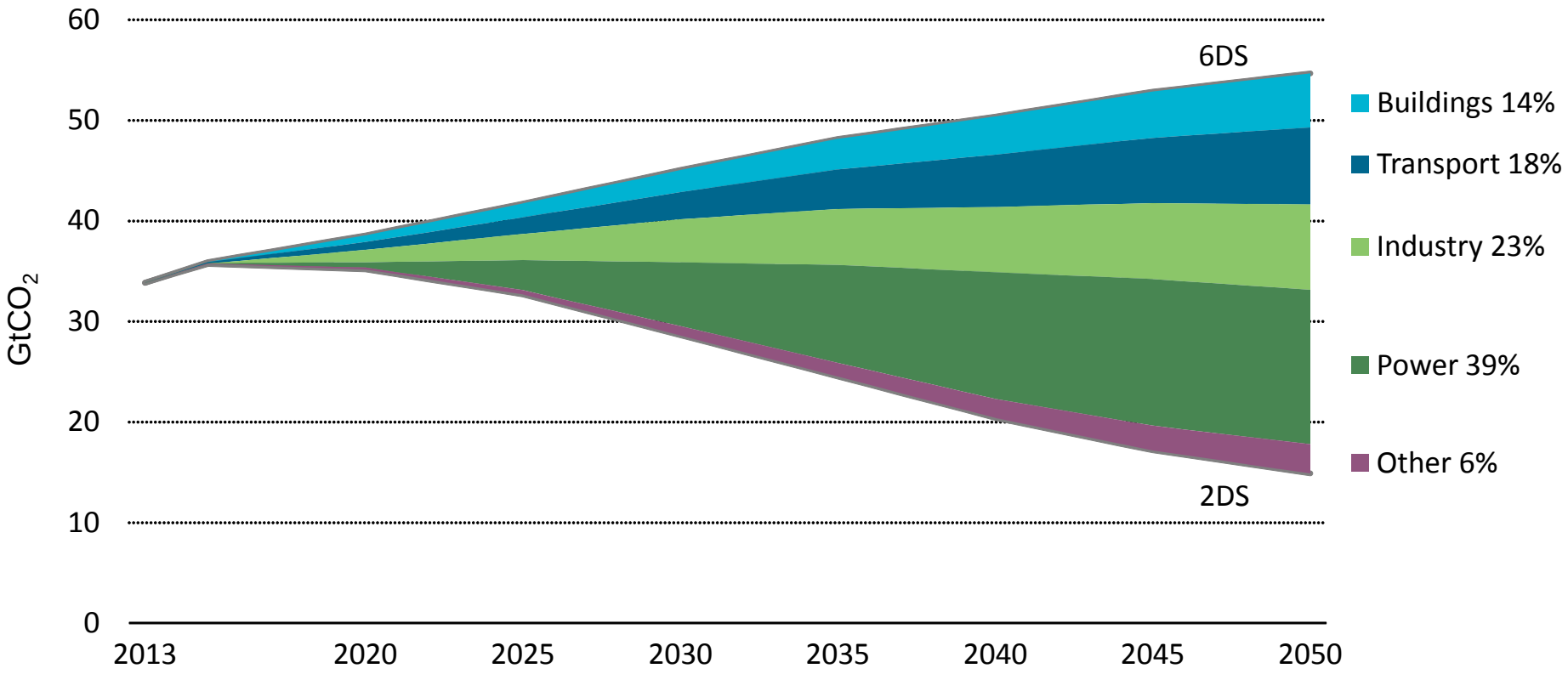

End-use sectors and supply-side sectors each provide around half of the cumulative reductions between the 6DS and 2DS.

Action in cities will be critical

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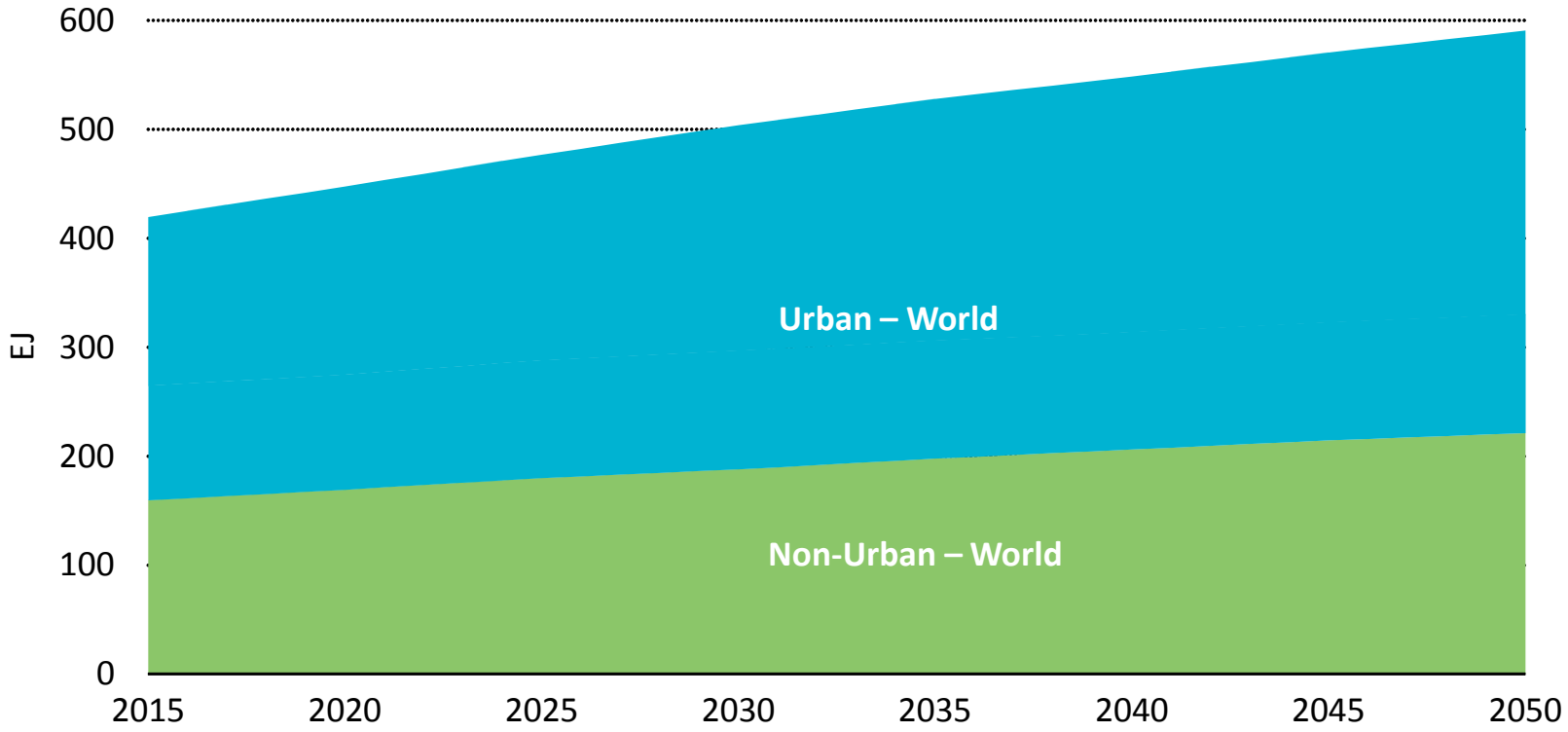
Final energy demand in the 4DS



Action in cities will be critical, notably in emerging and developing economies

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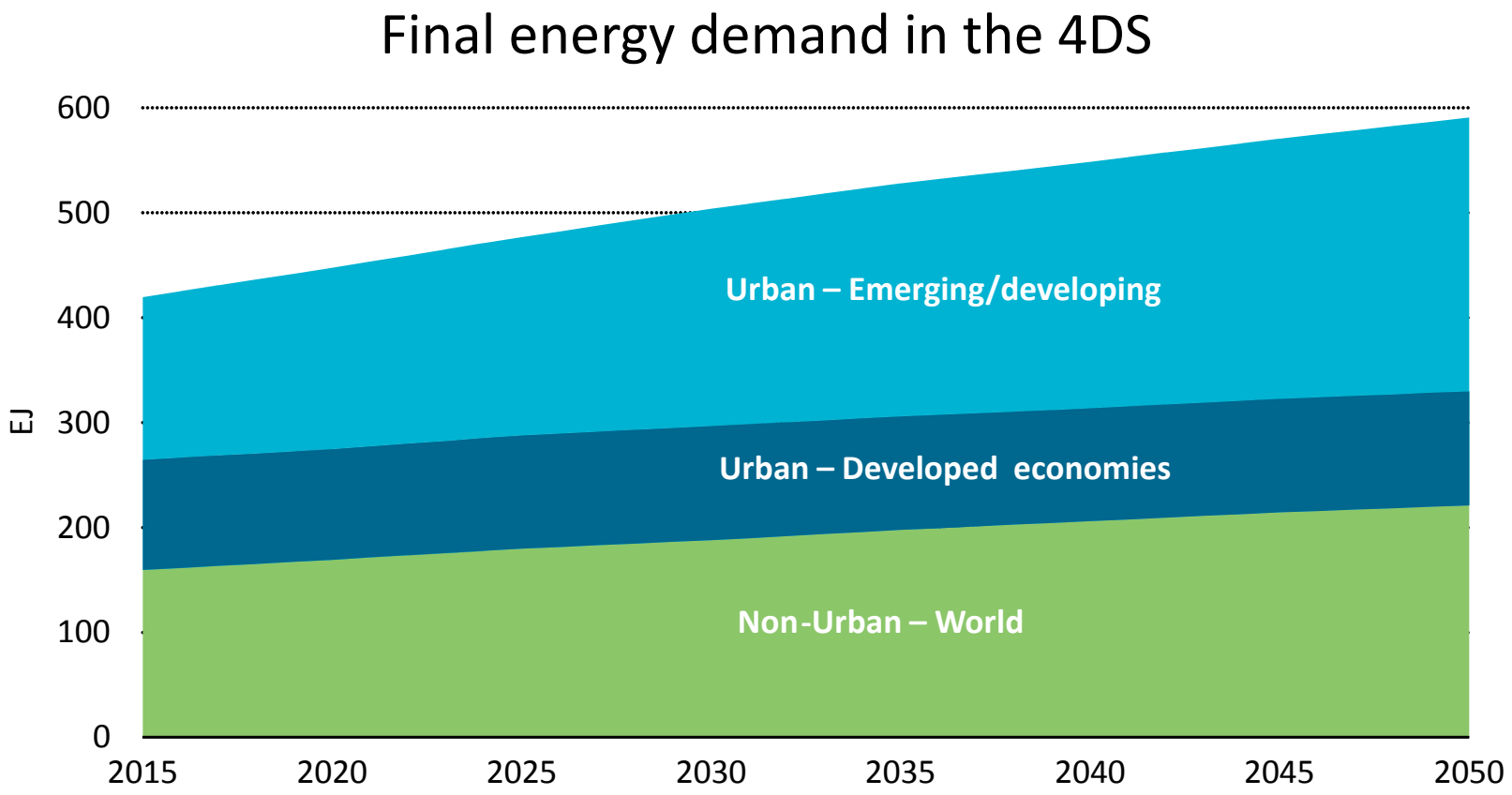

Two-thirds of the growth in global energy demand to 2050 comes from cities in emerging and developing economies

Cities are key to carbon abatement

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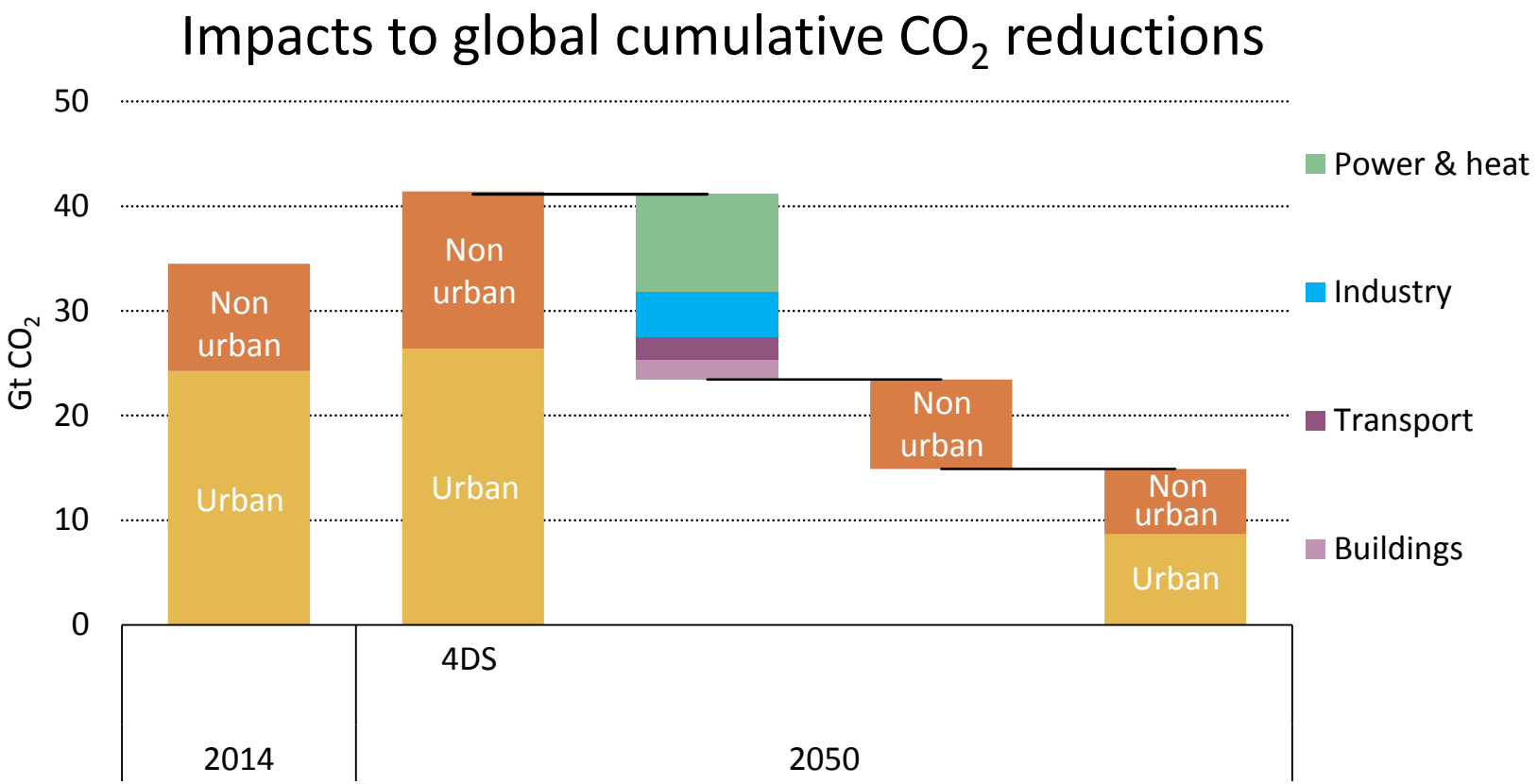

Cities represent 70% of the cost-effective CO_2 abatement potential through 2050

Energy Technology Perspectives 2016 edition

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Focus on sustainable urban energy systems

- ***Policy objectives***: GHG mitigation targets, environmental sustainability, energy security, and economic development
- How ***local and national energy policies*** can be effectively aligned

Transport chapter

- Transportation ***activity***, ***energy demand*** and ***GHG emissions***
- Focus on ***urban*** areas, also with analysis of non-urban parameters
- ***Global***, ***regional*** and ***national*** estimates
- Projections under the different ETP model ***scenarios***
- Analysis of the sustainable energy ***technology options***
- Identification of ***policy solutions***

Passenger energy demand
Mode matters

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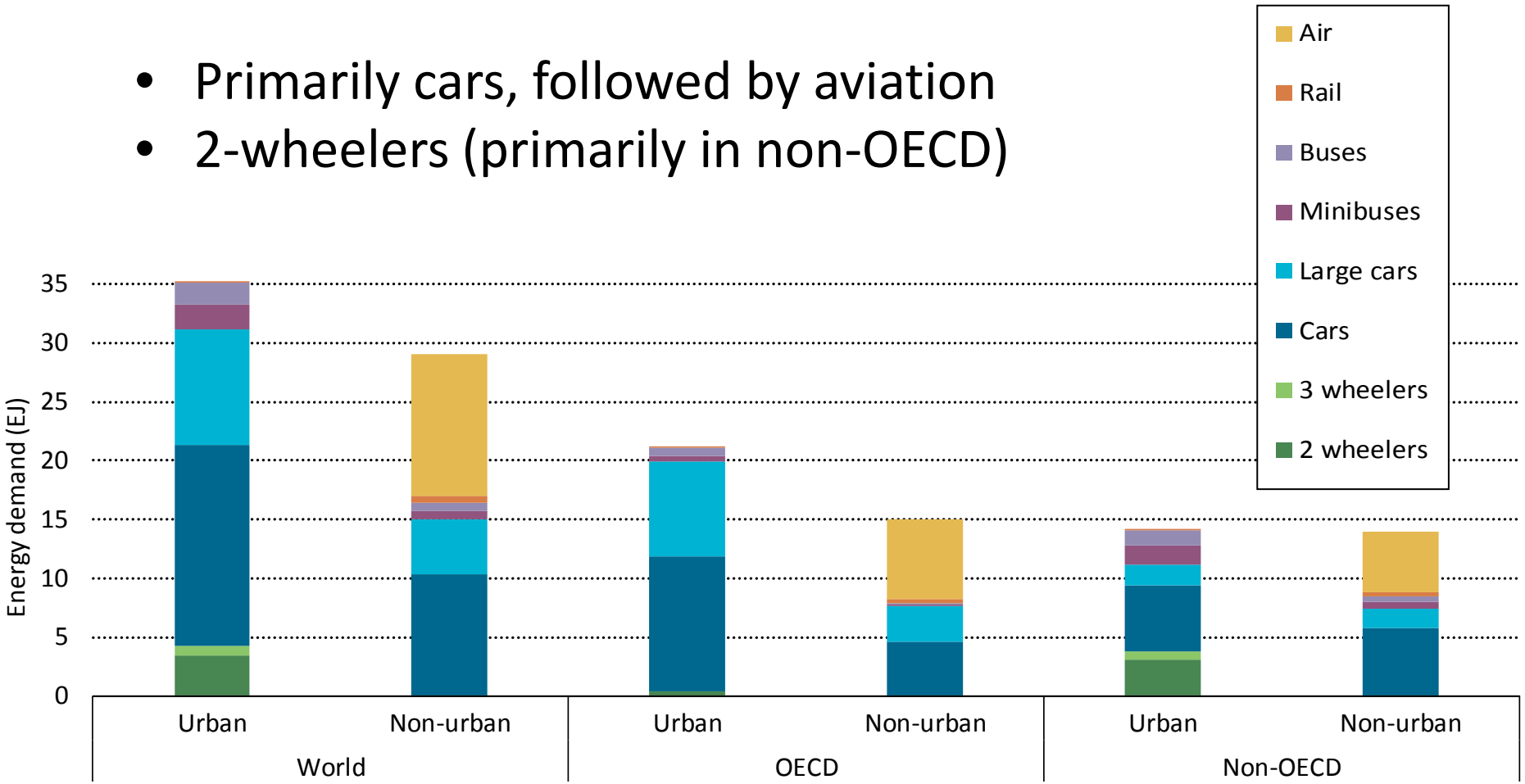
Global passenger transport energy demand in 2015, by mode

- Primarily cars, followed by aviation
- 2-wheelers (primarily in non-OECD)



Freight energy demand
Mode matters

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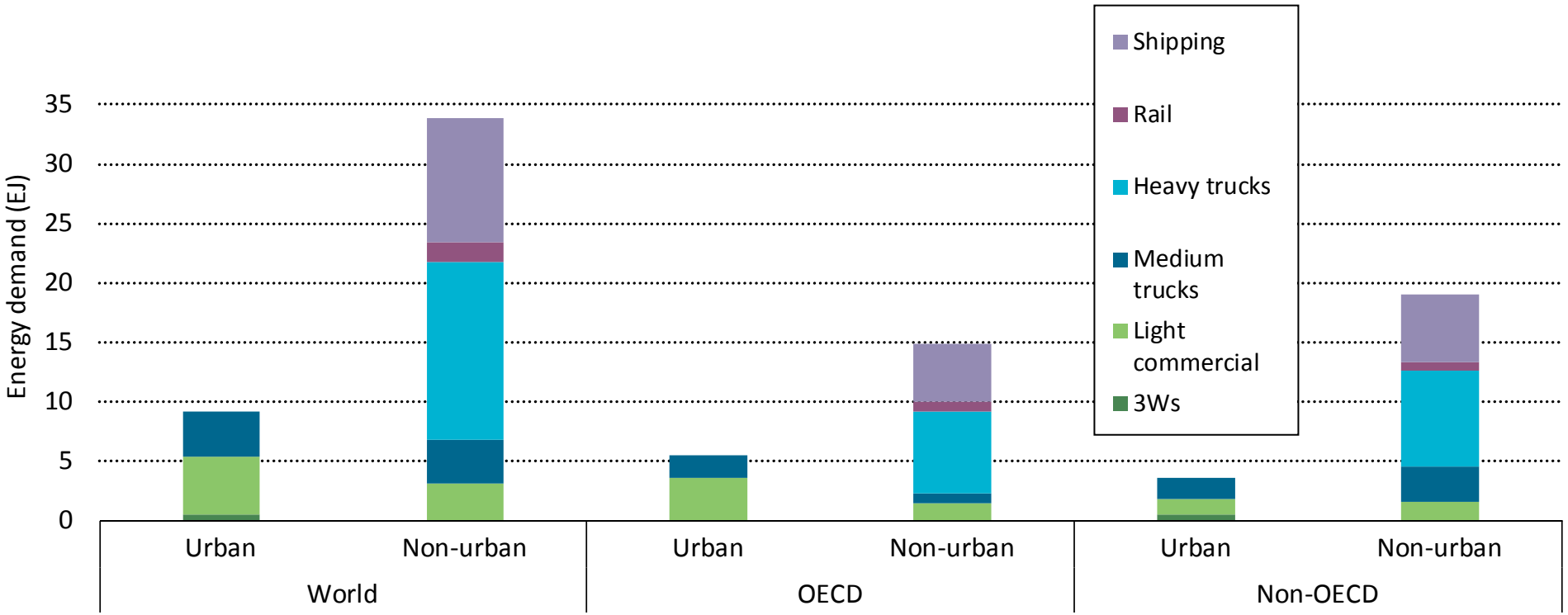
Global freight transport energy demand in 2015, by mode



- Shipping accounts for 81% of all tkm
- But trucks account for the majority of energy use

Passenger transport activity in 2015

Mode matters

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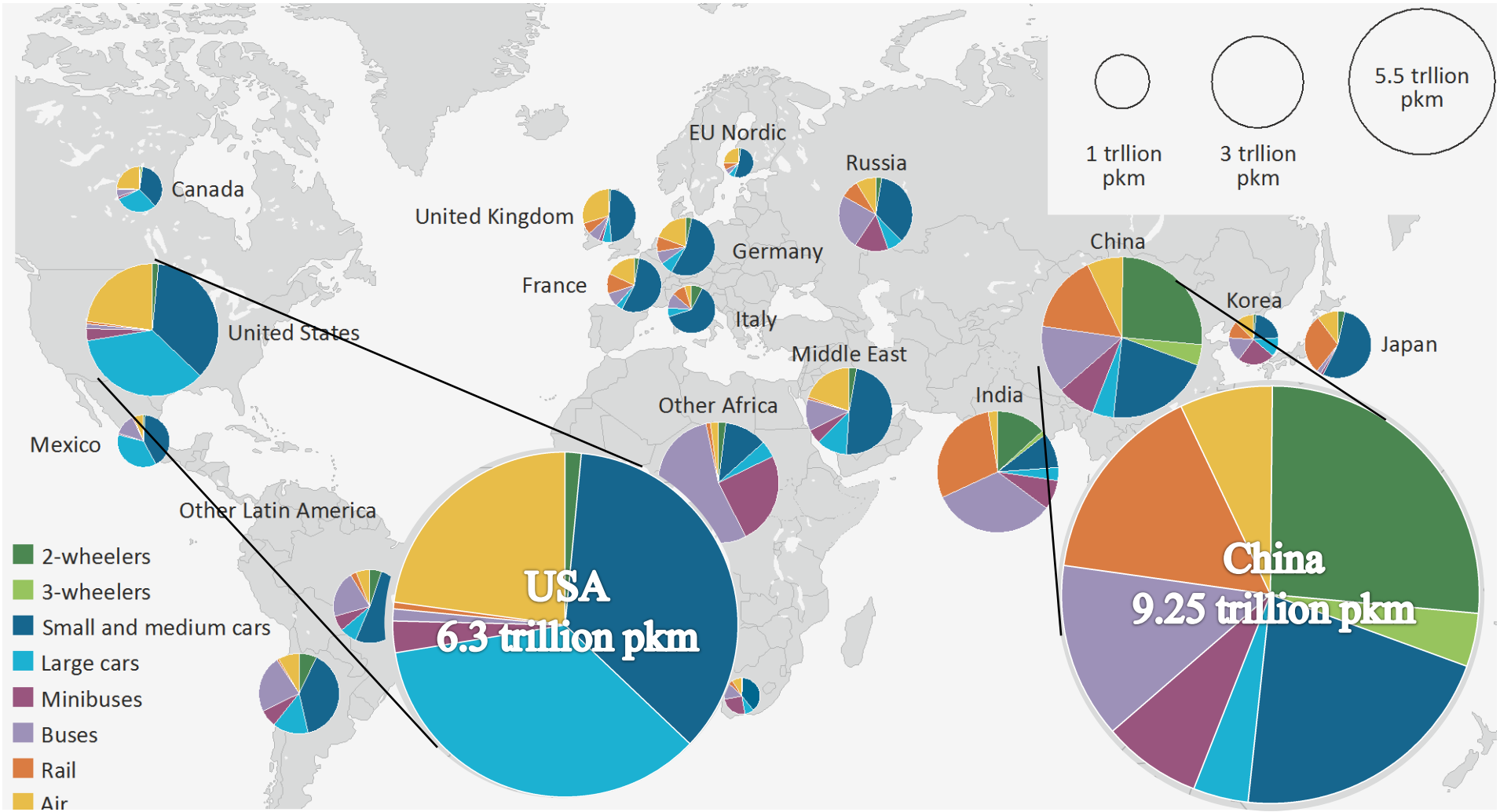
National Passenger transport activity (pkm) in 2015, by mode



Passenger transport energy use in 2015
Mode matters

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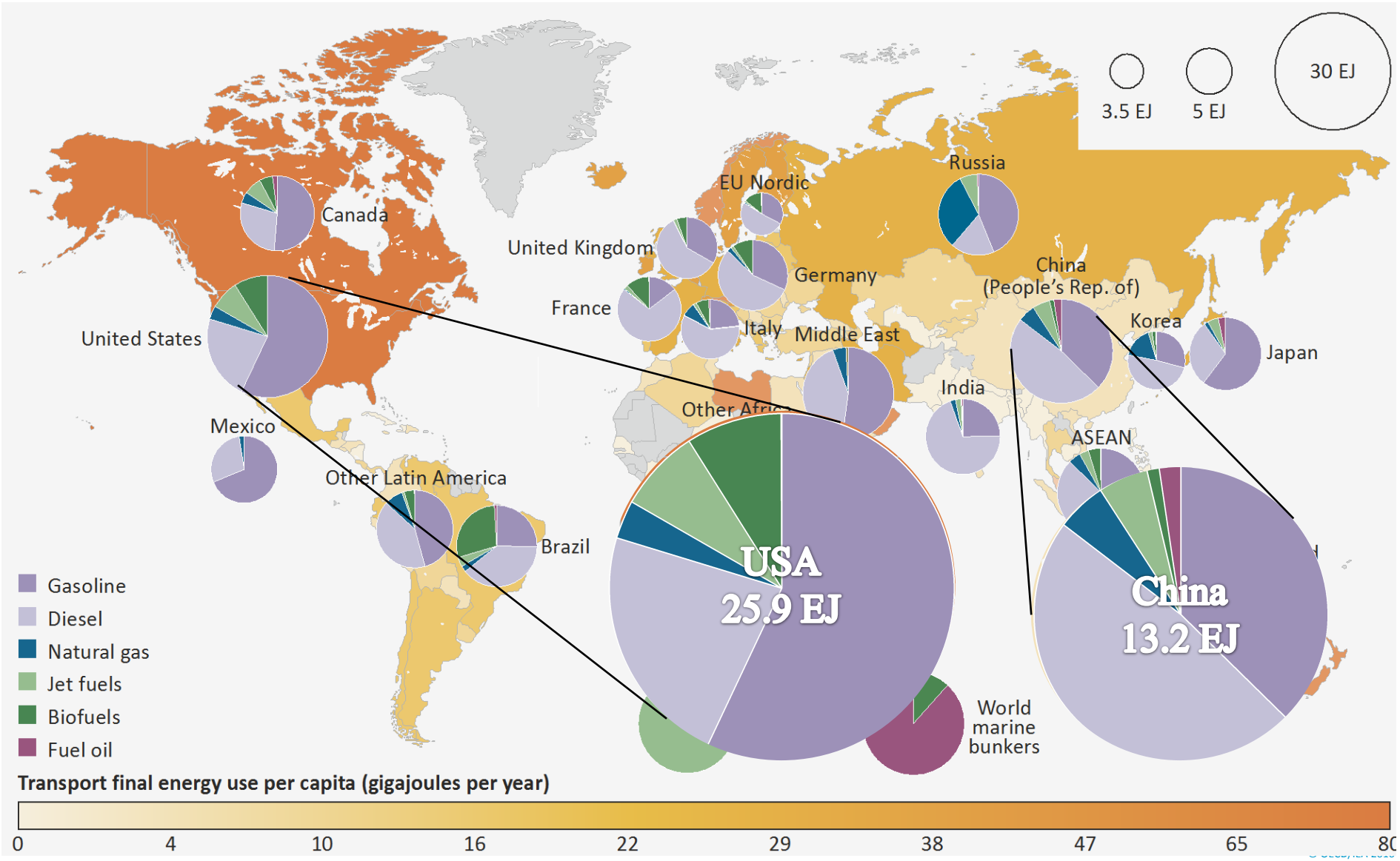

Drivers of modal choices in cities

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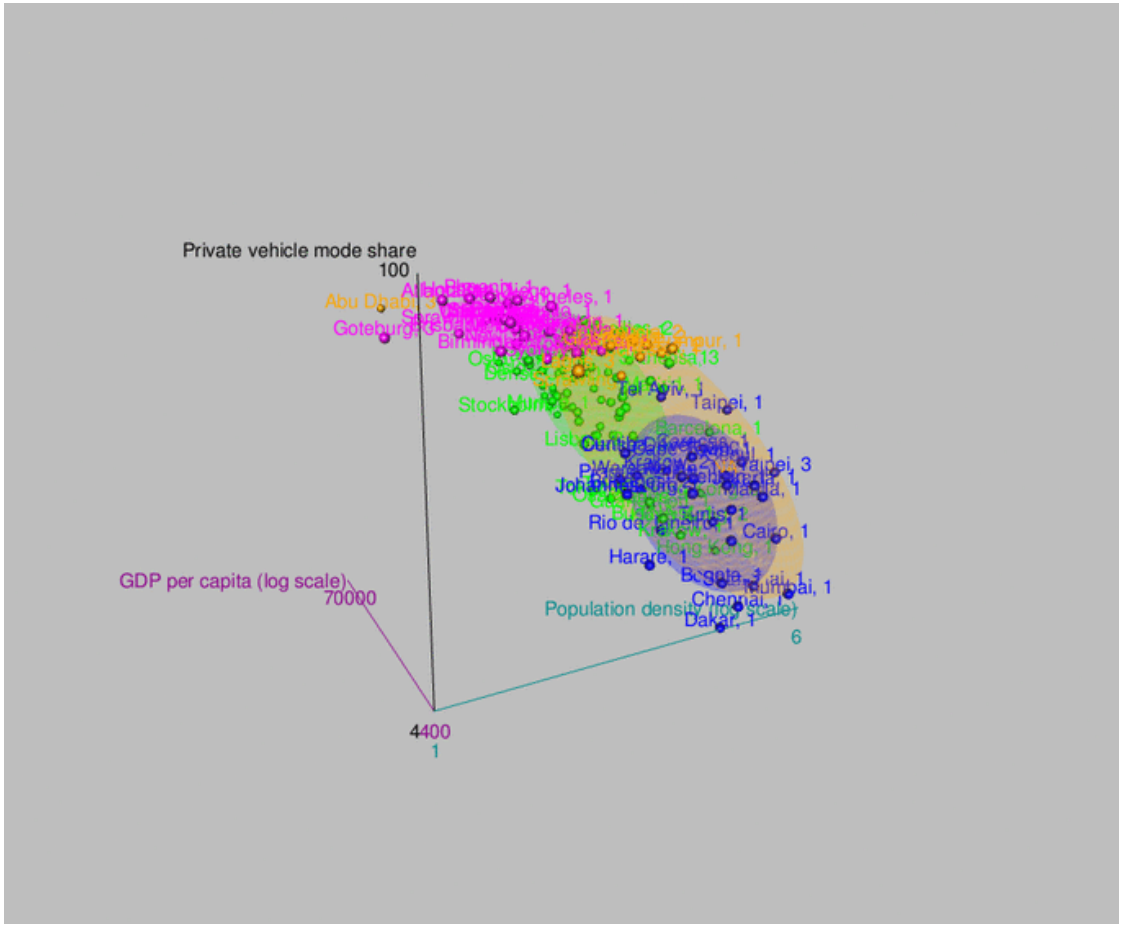
Developing; Emerging; OECD dense; OECD sprawling

Population density & Urban form



Policies:

- Price signals (fiscal policies)
- Travel demand management
- Regulatory policies
- Public transit provision
  - Infrastructure
  - Operation subsidies
- Information & Communication Technologies
  - Mobility as a Service (*MaaS*)

Source: IEA analysis using data from the ***Millennium City Databases*** Union internationale des transports publics (UITP) (2015), Millennium City Databases for Sustainable Transport, database, UITP, Brussels.

GHG emissions in 2015

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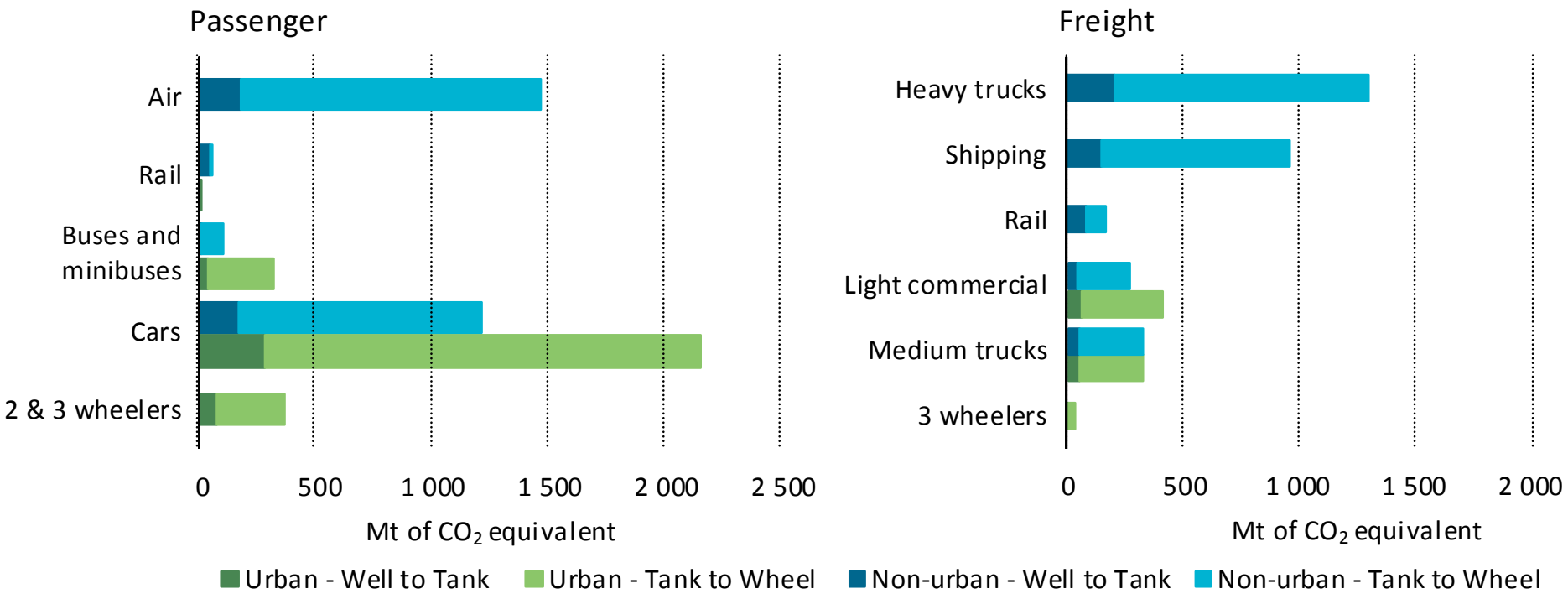
Well-to-wheels GHG emissions in 2015, by mode



- Transport is the least diversified energy demand sector
- Fuel production well-to-tank emissions are primarily due to refining
- GHG emission distribution mirrors closely energy demand

Technologies

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Many technologies can contribute to realizing the 2DS

- Information and communication technologies (ICT)
  - To manage travel demand (i.e. enable "*avoid/shift*")
  - To enable more efficient vehicle operations (i.e. enable "*improve*")
- "Hardware" technologies to improve the energy efficiency of vehicles
  - Both incremental and transformational
  - ***Electrification*** of road transport – cars and trucks
- Fuel supply pathways with low carbon intensity
  - Advanced and sustainably sourced biofuels

Transport energy demand projections

Policy and technology have great potential

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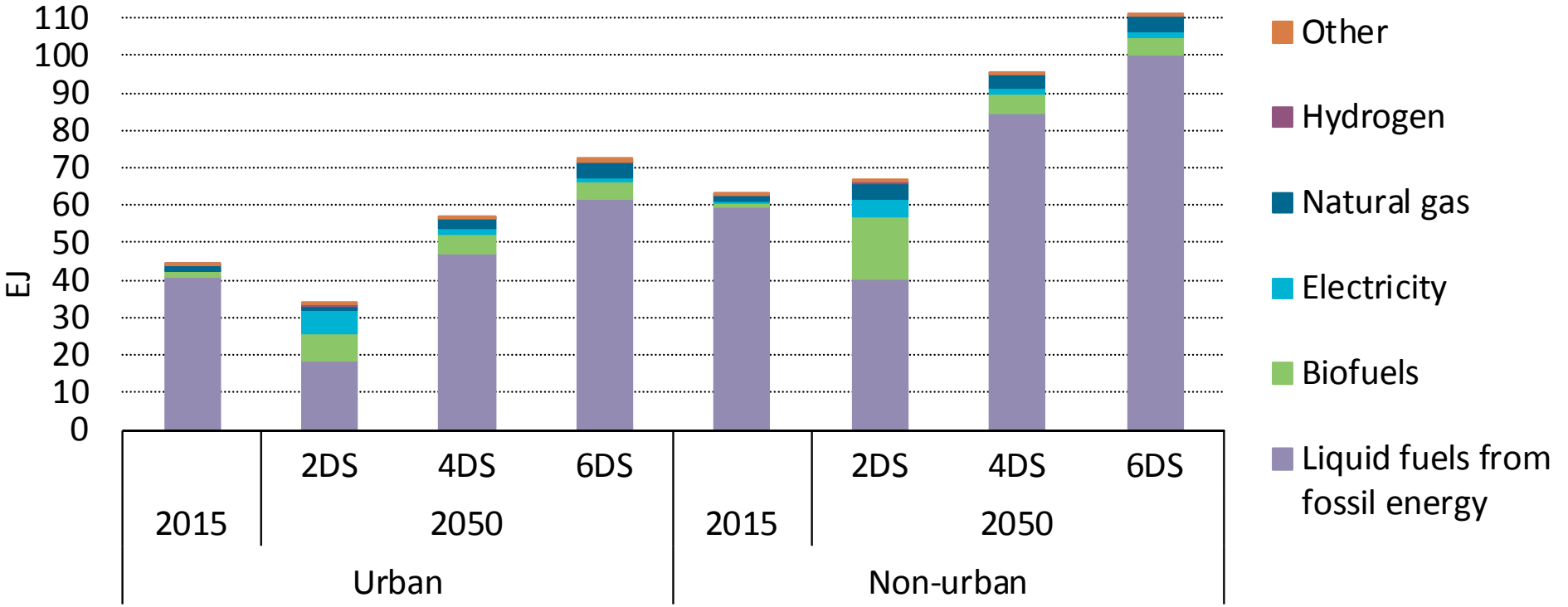
Global Energy for Transport in 2015 & in 2050 in the ETP Scenarios



Transport energy demand: **2015** **107 EJ**

2050 **100 (2DS) - 184 EJ (6DS)**

Need to decouple activity & emissions

Avoid/shift, vehicle efficiency, low carbon fuels

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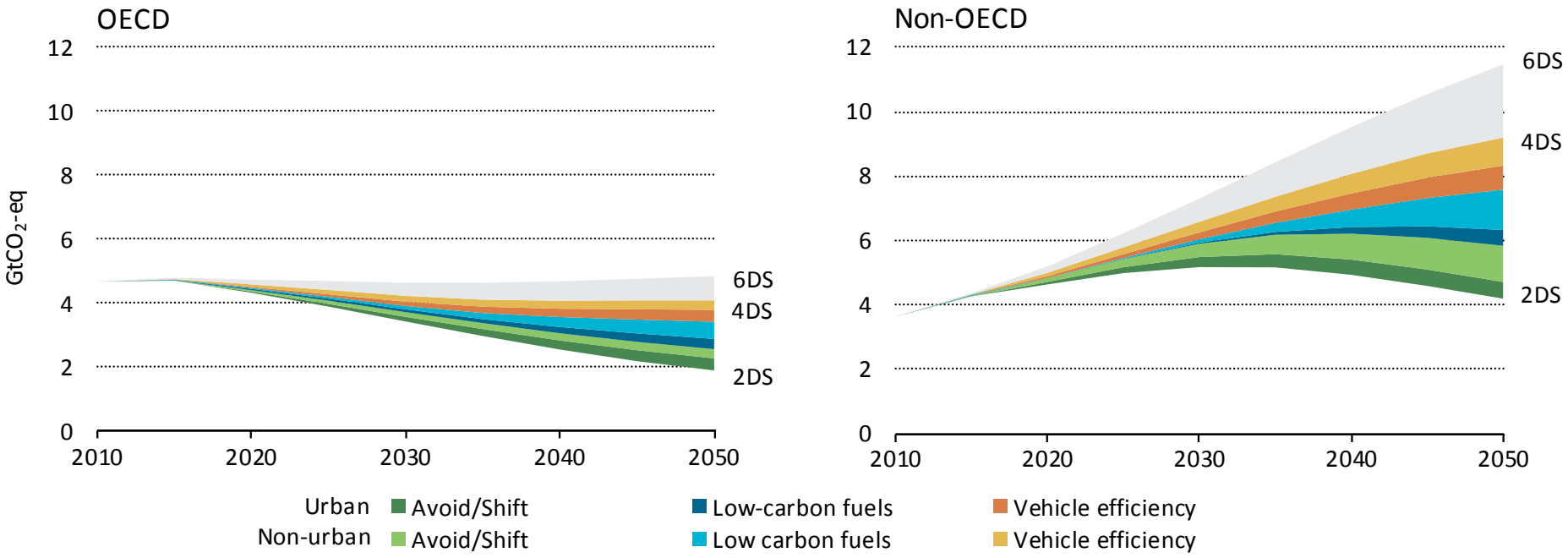
GHG Emissions in the 2DS, 4DS, and 6DS – 2010 to 2050



OECD transport emissions have peaked

Non-OECD transport emissions can be brought back to current levels in 2050

Focus on vehicle technologies

Cars and light trucks

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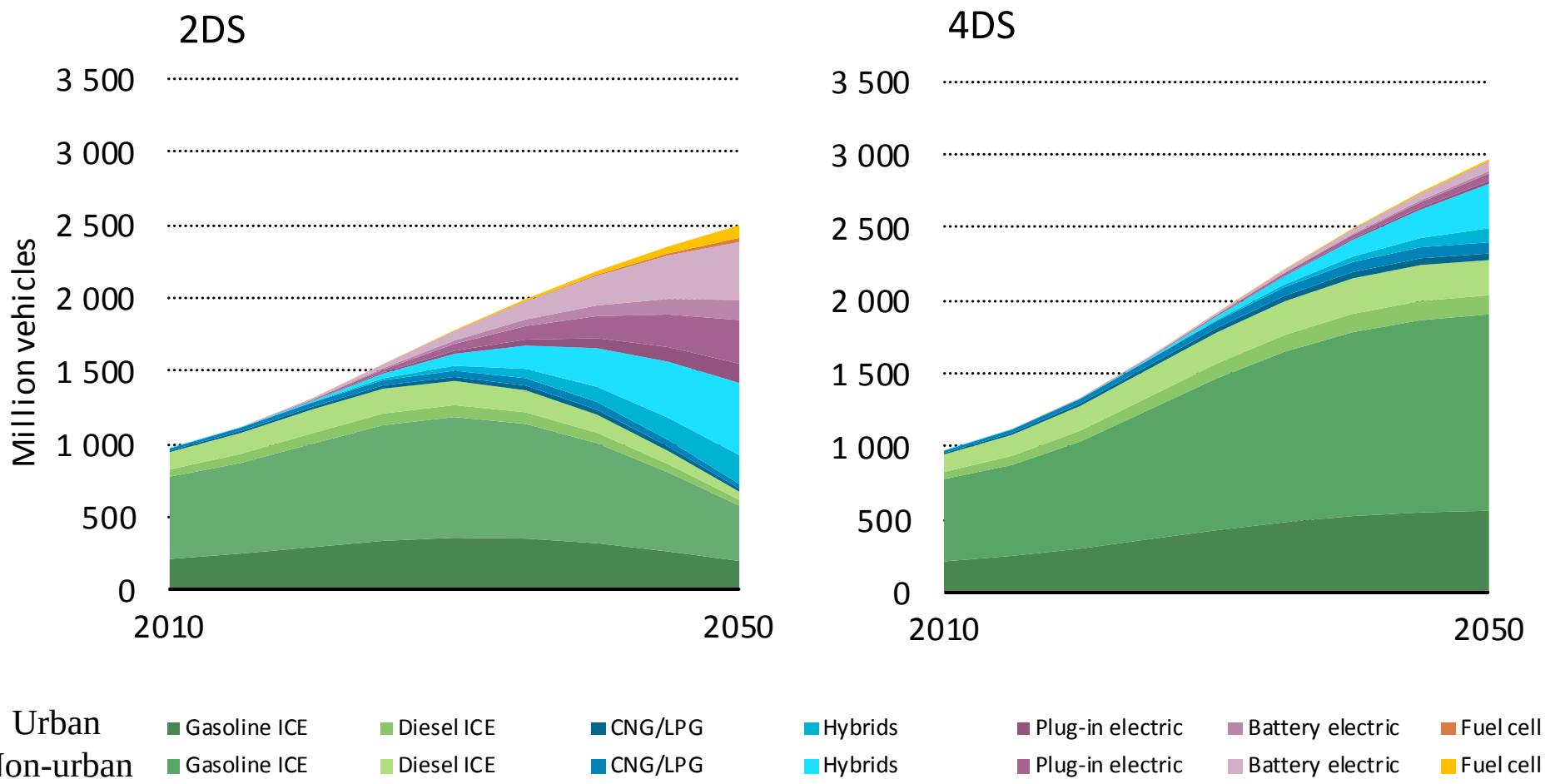

Policy recommendations

Use a coherent portfolio of instruments

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National/Supra-national policies

- Removal of fuel subsidies
- Vehicle taxes
- Introduction of well-to-wheel CO_2 taxation on fuels
- Fuel economy standards
- RD&D support

Local measures

- Compact cities
- Pricing policies
- Regulatory measures
- Public transport investments

Policy portfolio

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Scope	Policy category	Impact		
		Avoid/Shift	Vehicle efficiency	Low carbon fuels
Local	Pricing (congestion charges, tolls parking fees)		Possible	
	Regulatory (access & parking restrictions, low emission zones)		Possible	Minor
	Public transport investments		Possible	
	Compact city			
National	Fuel taxation			Possible
	Fuel economy regulations			Possible
	Vehicle taxation, feebates	Possible		Possible
	Low carbon fuel standards			
	Alternative fuel mandates			
	RD&D support			

Final energy demand in transport
2 Degree Scenario

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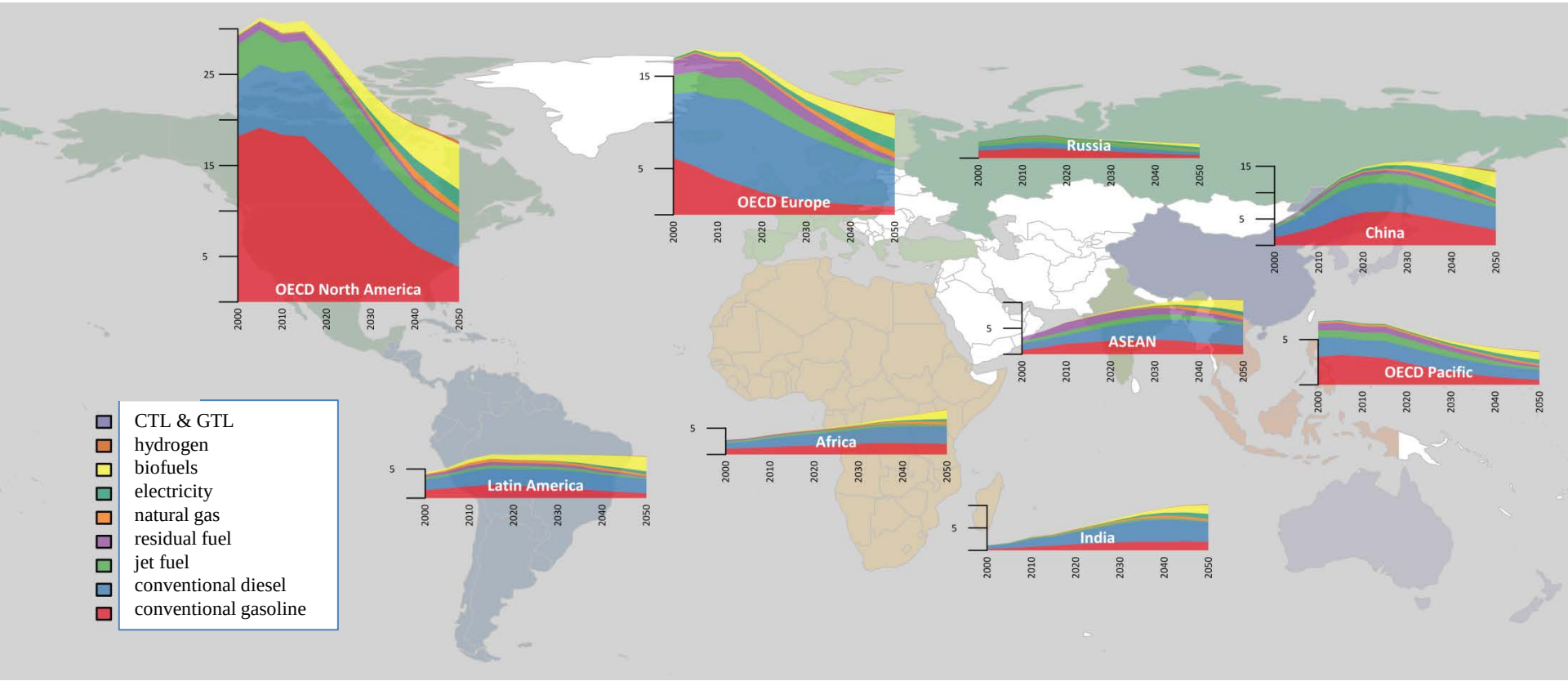

- Transport energy use declines by 40% across the OECD, and increases by 35% across the non-OECD
- Substantial diversification of energy supply

Final energy demand in transport
4 Degree Scenario

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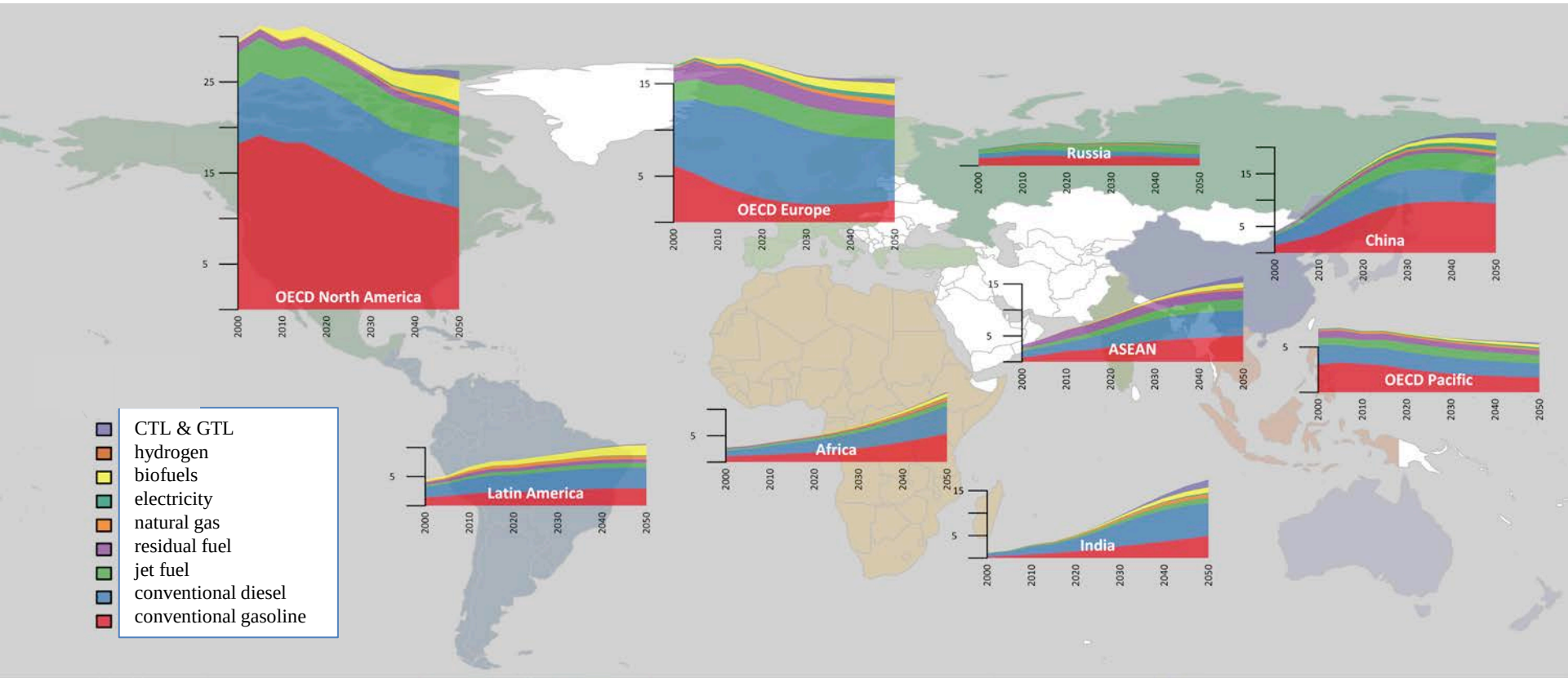

- Transport energy use declines by 14% across the OECD, and more than doubles across the non-OECD
- Some diversification of energy supply

Final energy demand in transport
6 Degree Scenario

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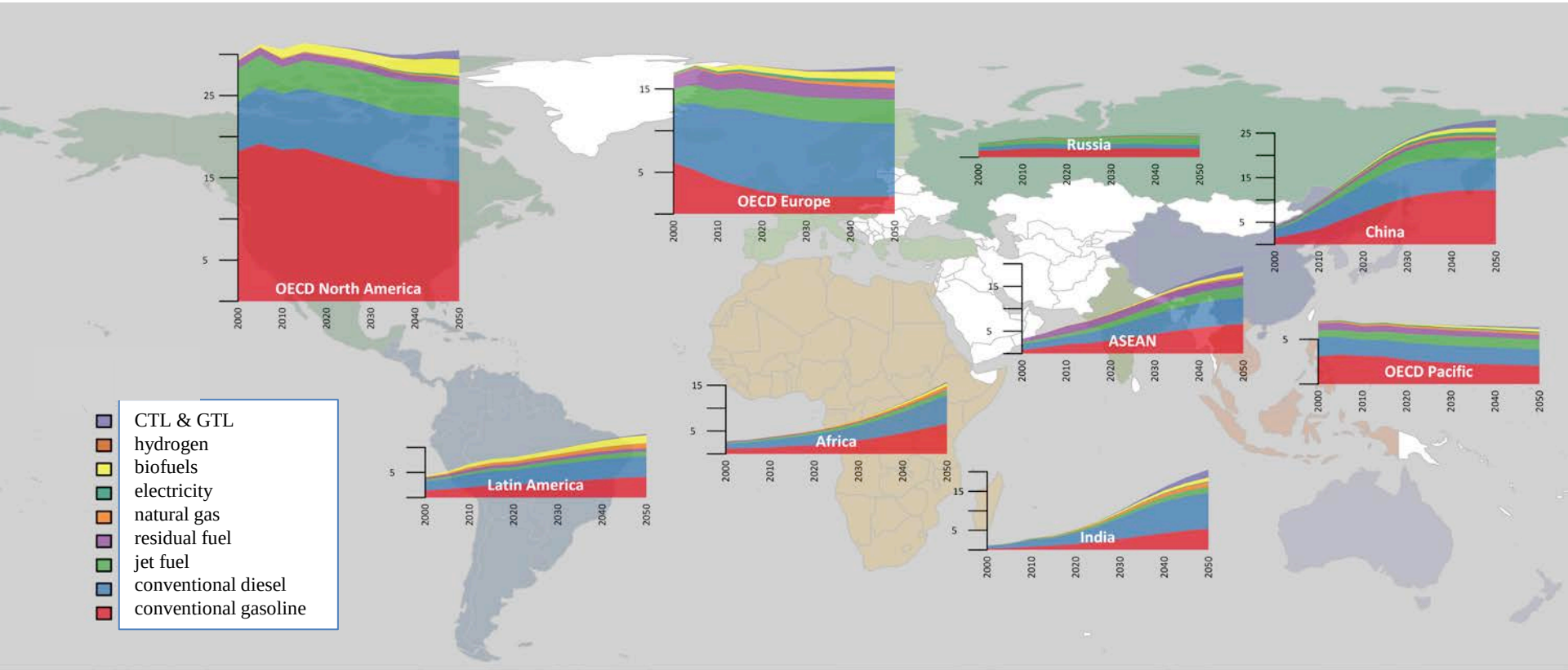

- Transport energy use essentially stagnates in the OECD, and increases by more than 250% across the non-OECD
- Marginal diversification of energy supply

Sustainable transport systems: a cheaper way to provide service

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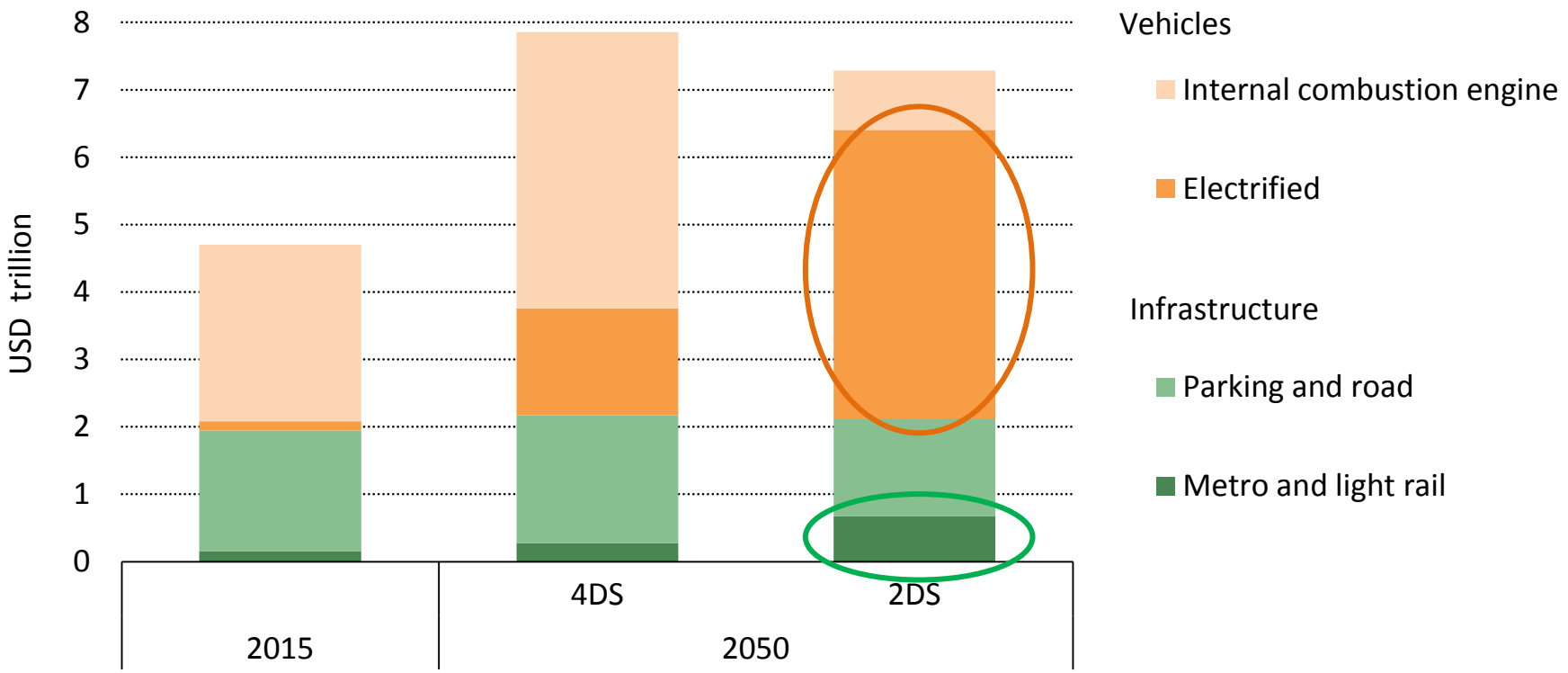
Urban transport investments



In the 2DS, by 2050 one billion cars are electric vehicles and public transport travel activity more than doubles

Sustainable transport systems: Vehicle and fuel expenditure savings

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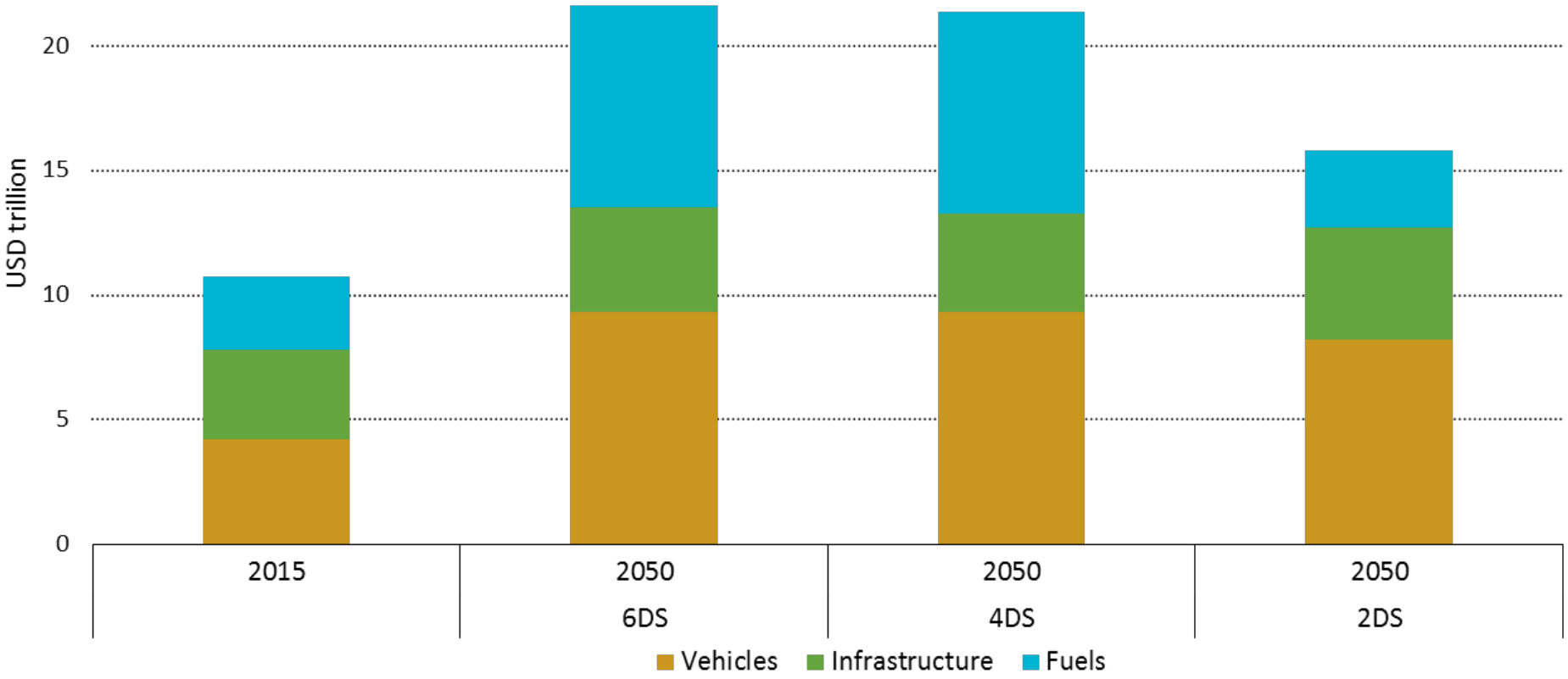
Global total (urban & non-urban) transport expenditures



- Annual expenditures are greater only for infrastructure in the 2DS
- The bulk of these costs would be for high-speed rail

Local and national actions can make the low-carbon transition possible

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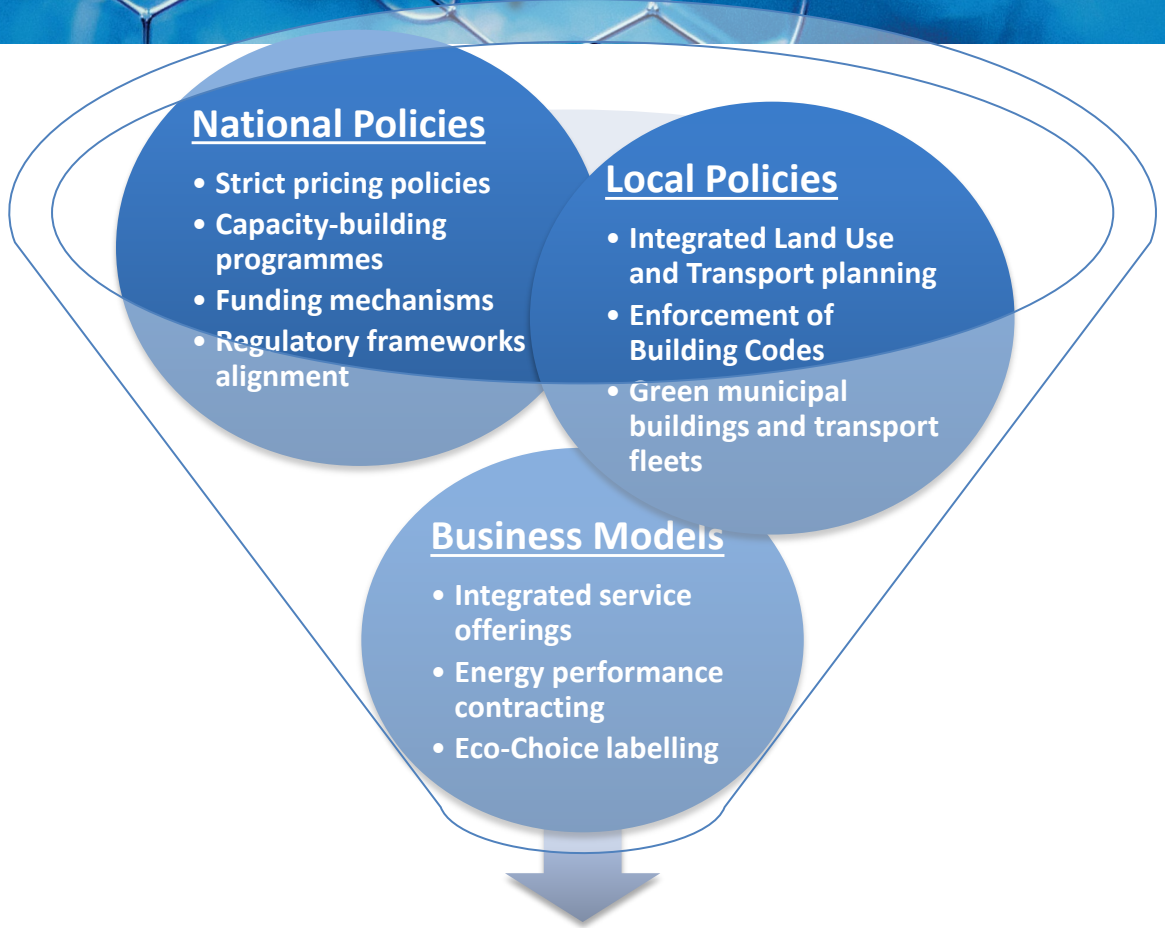

Leveraging all solutions to urban energy sustainability requires strong private and public action both at local and national levels

IEA Energy Technology Network: Technology Collaboration Programmes

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- 6,000 experts
- 1,600 topics to date
- 310 public and private organisations
- 51 countries
- 39 initiatives currently active
- 4 international organisations

This map is without prejudice to the status of sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area. Experts from countries shown above participate in activities of the Technology Collaboration Programmes.

Thank you

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Explore the data behind *ETP*

www.iea.org/etp

Supplemental Slides
and further discussion

ETP 2016

- The Mobility Model (MoMo)
- ETP 2016 methods
- More detailed results from ETP 2016
- Highlights of other recent publications
  - Global Electric Vehicle Outlook
  - Energy and Air Quality, WEO Special Report
  - Global Fuel Economy Initiative
- Upcoming projects
  - Trucks
  - WB2DS

The *Mo*bility *Mo*del (MoMo)

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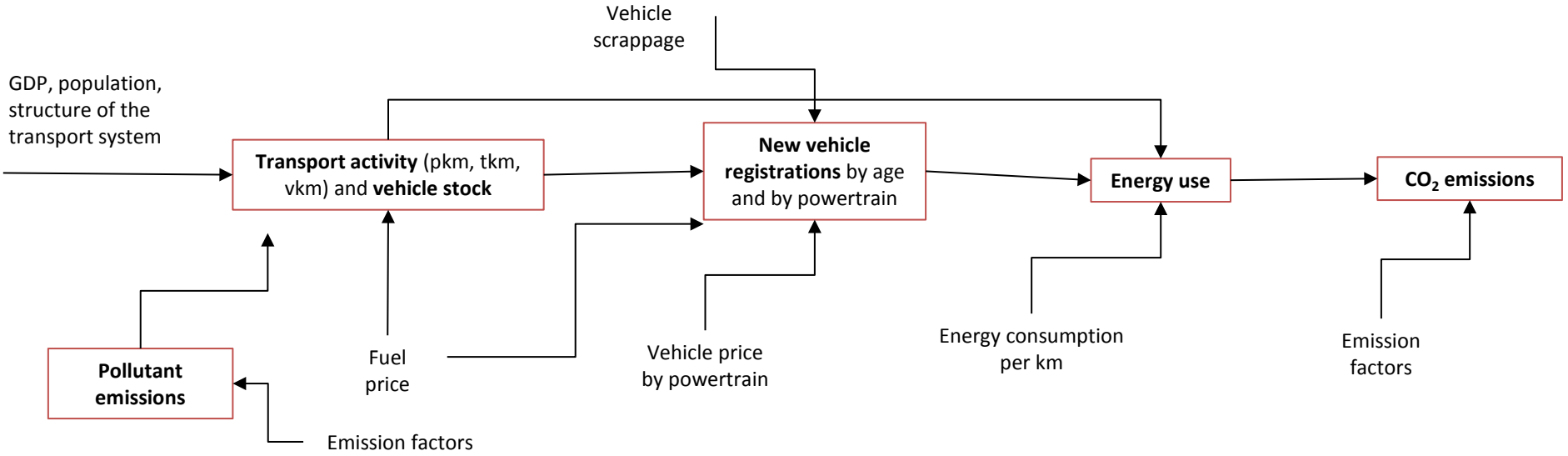

- Estimation of transport activity (pkm, tkm, vkm) and vehicle stock
- Evaluation of new vehicle registrations by powertrain and characterization of the vehicles by age
- Calculation of the energy use
- Estimation of CO_2 and pollutant emissions

The basic ASIF structure: $$F = \sum_i F_i = A \sum_i \left(\frac{A_i}{A}\right)\left(\frac{F_i}{A_i}\right) = \boxed{A \sum_i S_i I_i = F}$$

where, F = total fuel use [MJ/year]
A = vehicle activity [vkm/year]
I = energy intensity [MJ/vkm]
S = structure (shares of vehicle activity) [%]
and *i* is an index of vehicle modes and classes – *MoMo* models vehicles belonging to several modes. Vehicle activity can also be expressed as the product of vehicle stock [vehicles] and mileage [km/year].

The *Mo*bility *Mo*del (MoMo)

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Project history

2003 **World Business Council for Sustainable Development and the Sustainable Mobility Project transport model**
Scenarios exploring transport energy use, CO_2 and pollutant emissions, safety and materials use

2004 **SMP model developed further as IEA Mobility Model (MoMo)**
MoMo data used for the IEA ETP analysis and ETP 2006

2006-2008
Deeper analysis of vehicle technology potential, including plug-in hybrid electric vehicles (PHEVs)
Elasticities of travel and ownership with respect to GDP and oil prices
Integration of significant historical data in MoMo
Development of scenarios for the IEA Energy Technology Perspectives (ETP) project in 2008

2008-2012
Improved user friendliness and detailed modular approach
Expanded coverage of countries and regions
Development of modal shift scenarios
Scenario-specific vehicle, fuel and infrastructure costs

2013+
Assessment of urban transport activity, passenger demand generation, and policy responses
Refined assessment of aviation, maritime shipping, and rail modes
Partial integration with TIMES systems optimization model (in cooperation with China's *Energy Resource Institute* (research division of the NDRC)
Refined generation of activity projections, demand generation of road and rail freight (underway)
Assessment of public costs and revenues (underway)

The *Mo*bility *Mo*del (MoMo)

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An essential tool for transport-related research and policy activities on:

- Fuel efficiency: Global Fuel Economy Initiative (GFEI)
- Vehicle technology: Electric Vehicle Initiative (EVI)
- Cooperative efforts: Railway Handbook on Energy Consumption and CO2 emissions with *International Union of Railways (UIC)*

MoMo is shared with:

- other directorates in the IEA (e.g. Global Energy Economics – WEO; the Energy Efficiency Directorate – EEfD)
- the EIA and the International Transport Forum, who uses it for the formulation of its Transport Outlook
- "MoMo partners", i.e. sponsors and collaborators – mainly from the private sector – providing Voluntary Contributions and/or in-kind help

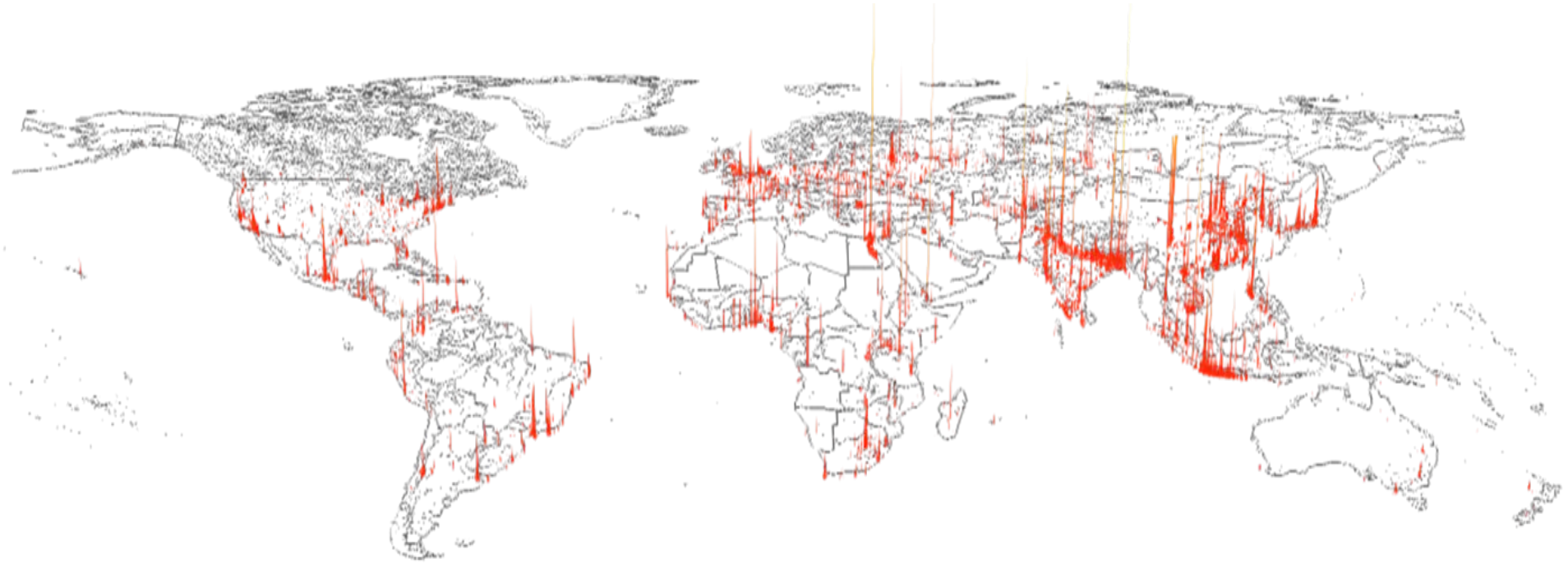
- Currently 20 MoMo partners
- leaders across industry, government, independent research institutes, and academia

RENAULT NISSAN
bp
icct THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION
HONDA
UITP
TOYOTA
Statoil
International Transport Forum
ExxonMobil
ITDP Institute for Transportation & Development Policy
MICHELIN
ITS UCDAVIS
VOLVO
BR PETROBRAS

ETP 2016 Methods

ETP 2016

What is *urban*?



- UN: "The traditional distinction…based on the assumption that urban areas… provide a different way of life and usually a higher standard of living than…rural areas."

"this distinction has 'blurred' in many industrialized countries, and *population density* has replaced socio-economic status as the main feature distinguishing urban from non-urban regions."

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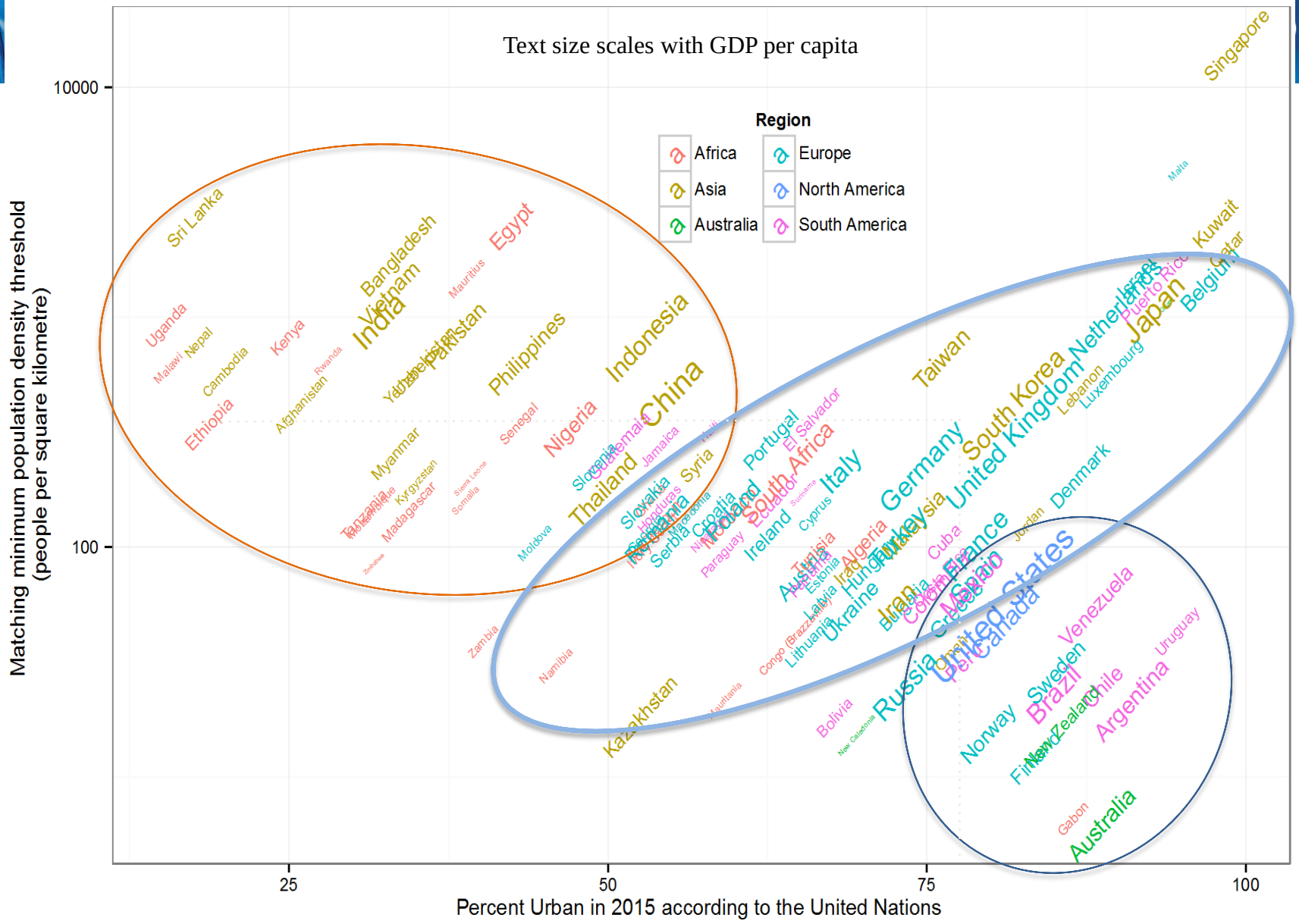
Urban ≠ Population Density



ETP 2016 – GIS analysis, urban vs. non-urban
Example using Germany's Urban regions

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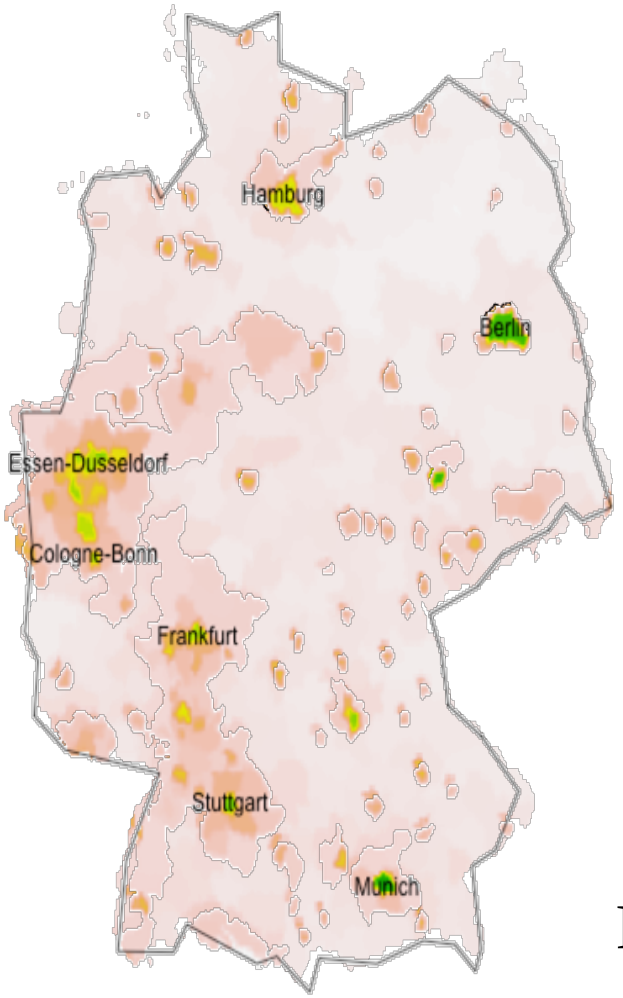

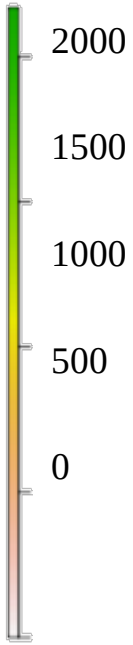

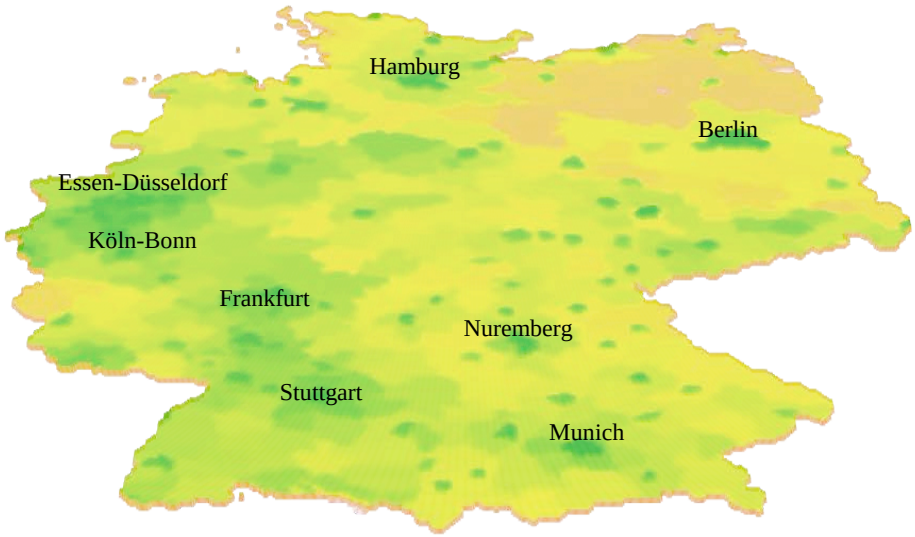

People per km^2

Passenger energy demand in 2015

Urban and non-urban shares

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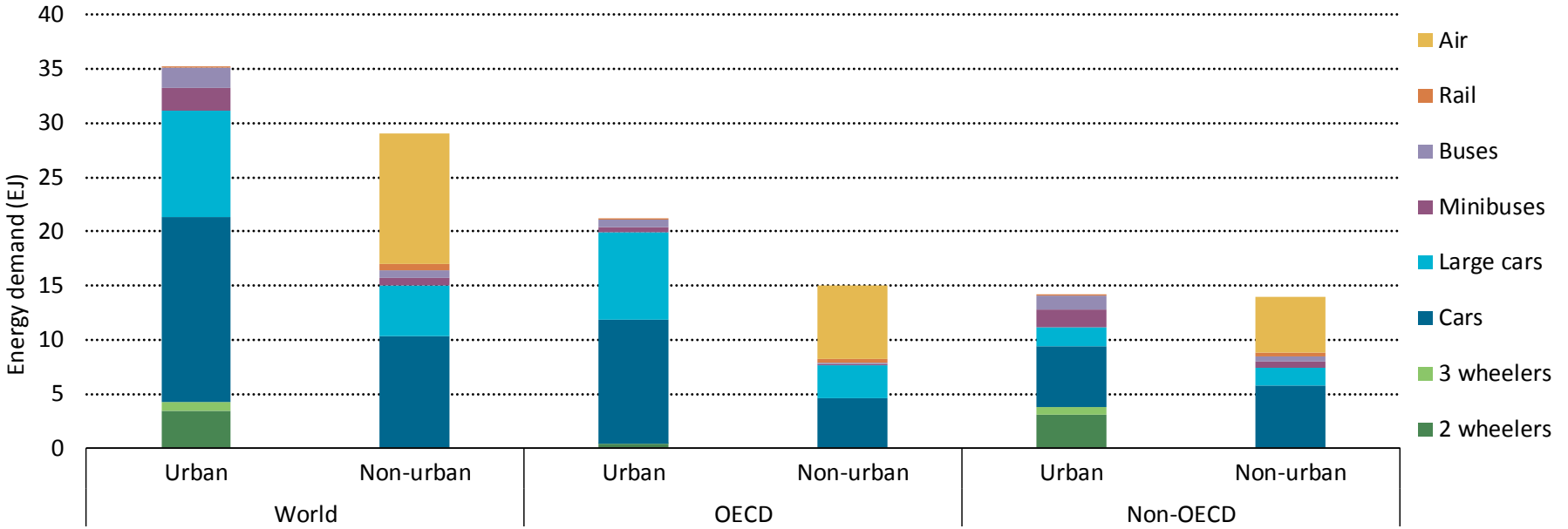

- Cars, followed by aviation, are the main energy consumers in passenger transport in all global regions
- In cities, cars account for 76% of the total (90% in the OECD)
- In the non-OECD, the energy used by two wheelers exceeds that of urban LCVs and medium trucks

Freight transport activity in 2015

Cities account for 1% of the total activity…

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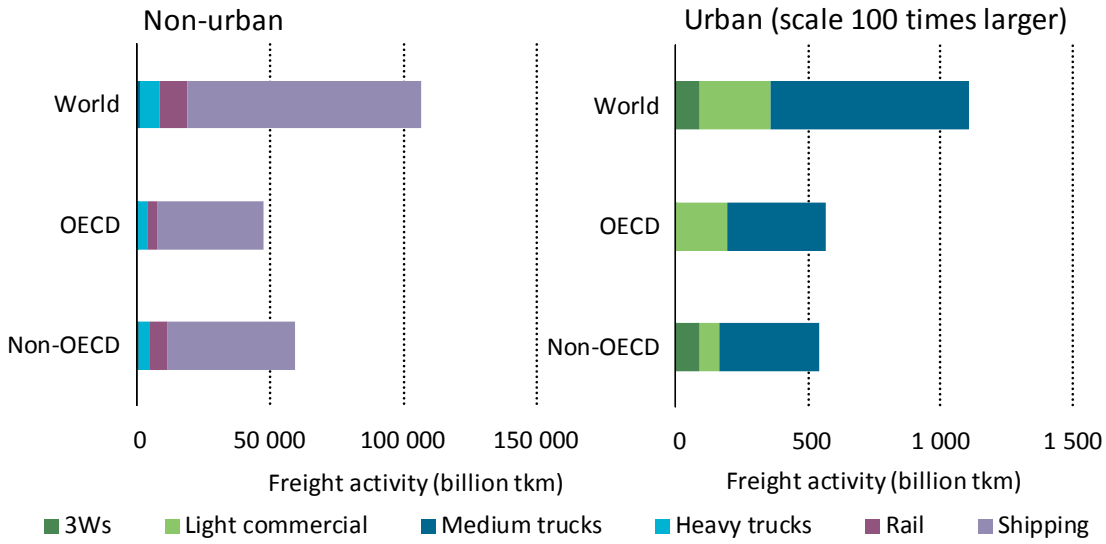
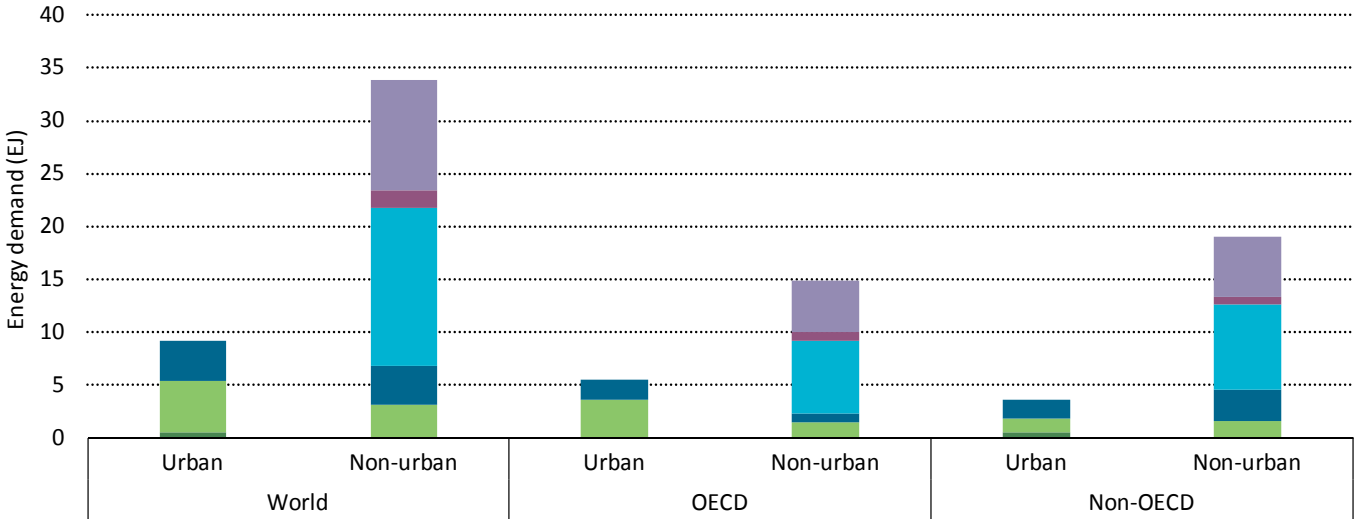
- Activity



- Energy demand



Focus on low carbon fuels

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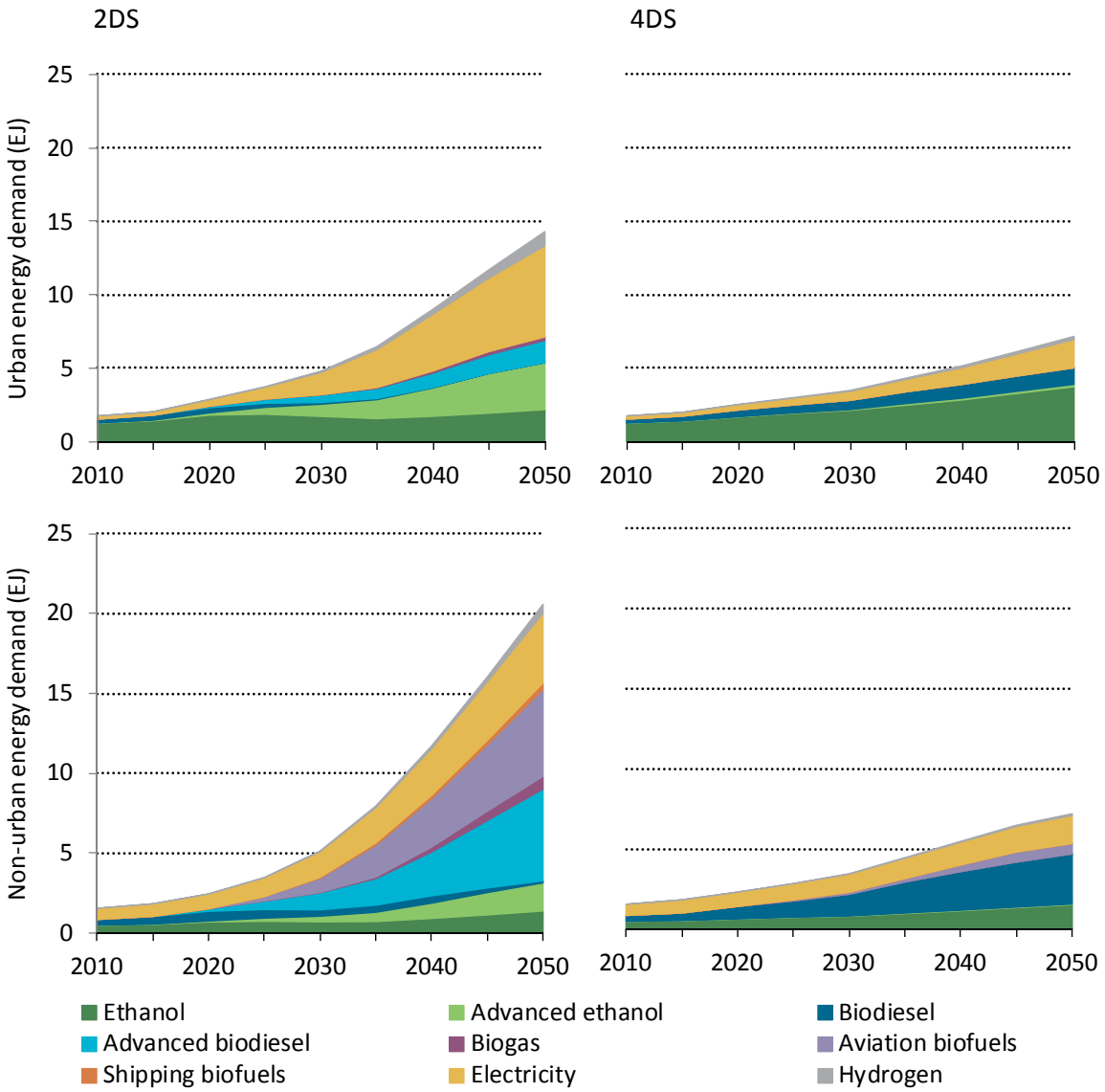
- In 2DS, 2050 demand for alternative energy carriers attains nearly 15 EJ in cities and exceeds 20 EJ for non-urban transport
- This is more than twice the urban demand of 4DS, and three times larger for non-urban
- 2DS-4DS differences in 2030 are smaller: the uptake of alternative fuel vehicles and low-carbon fuels is stronger in the long term



Local policies
Examples of measures already in use

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Pricing	Regulatory instruments	Public transport and walking and cycling support
Congestion charging, cordon pricing, tolls (e.g. London, Milan, Singapore, Stockholm).	Access restrictions (e.g. "yellow label" restrictions in Chinese cities).	Shared bicycle systems and bicycle parking (e.g. *Vélib'* in Paris, Citi Bike in New York).
Parking pricing (widespread in North American, European and Japanese cities, most prevalent in the central business districts of densely populated cities).	Low-emission zones (e.g. time-of-day restricted access for freight trucks, as in many European cities).	Investments in cycling and walking paths, and sidewalks.
	Registration caps (e.g. in Singapore, Shanghai and other Chinese cities).	Transit infrastructure projects/ extensions (e.g. the Paris *Métro*; Bogotá's *Transmilenio*).
	Parking restrictions/reductions in parking supply (e.g. progressive elimination of off-street parking in Copenhagen, Paris and other European cities).	Transit fare subsidies (e.g. local, regional and federal subsidies pay for roughly half of fares on systems in many European and Chinese cities).

- Front runners exist amongst cities
- Effects observed in these cities were instrumental to assess the impact of these policies and generalize it in our projections

May-June publications
Global EV Outlook 2016 (1/2)

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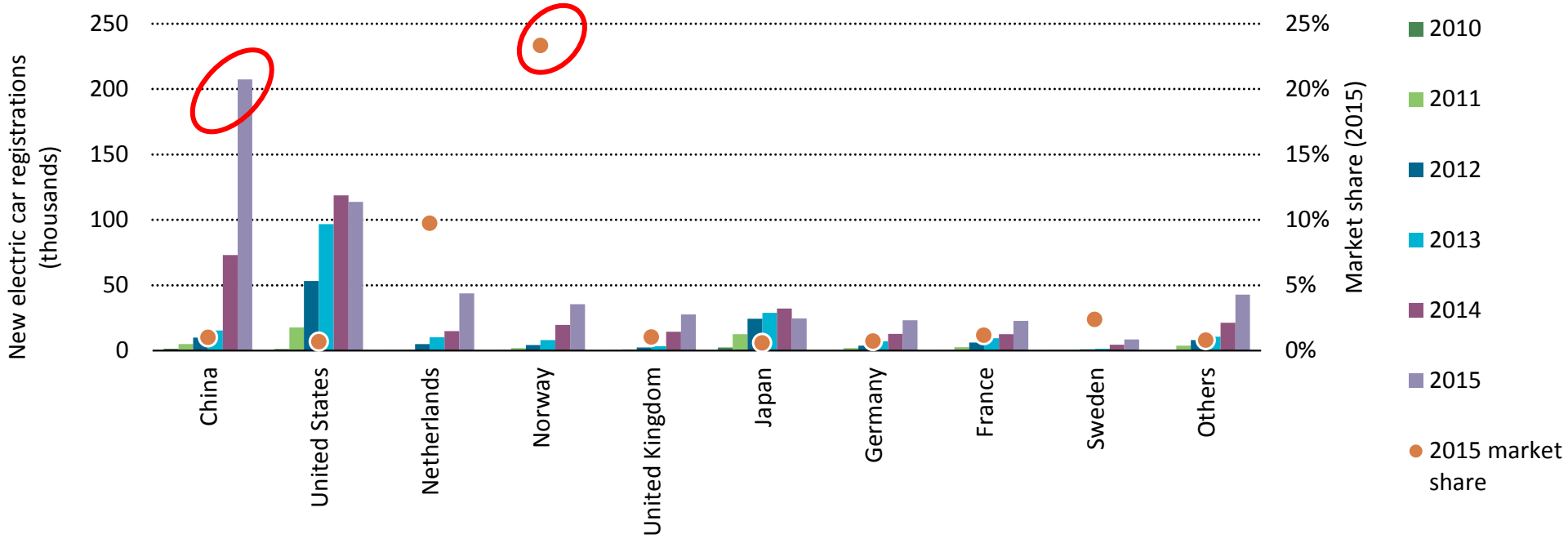

- 1.3 million EVs (BEVs + PHEVs) on the roads in 2015
- 550,000 EVs sold in 2015 (+ 70%)
- China became the first EV market in 2015
- 7 countries >1% market share (Norway, Netherlands, Sweden, Denmark, France, China, UK)

➢ GEVO 2016 also contains: EVSE assessment, policy review, EV purchase subsidies review, aspirational goals to 2020 and 2030

Technology and fuel penetration the 4DS and 2DS

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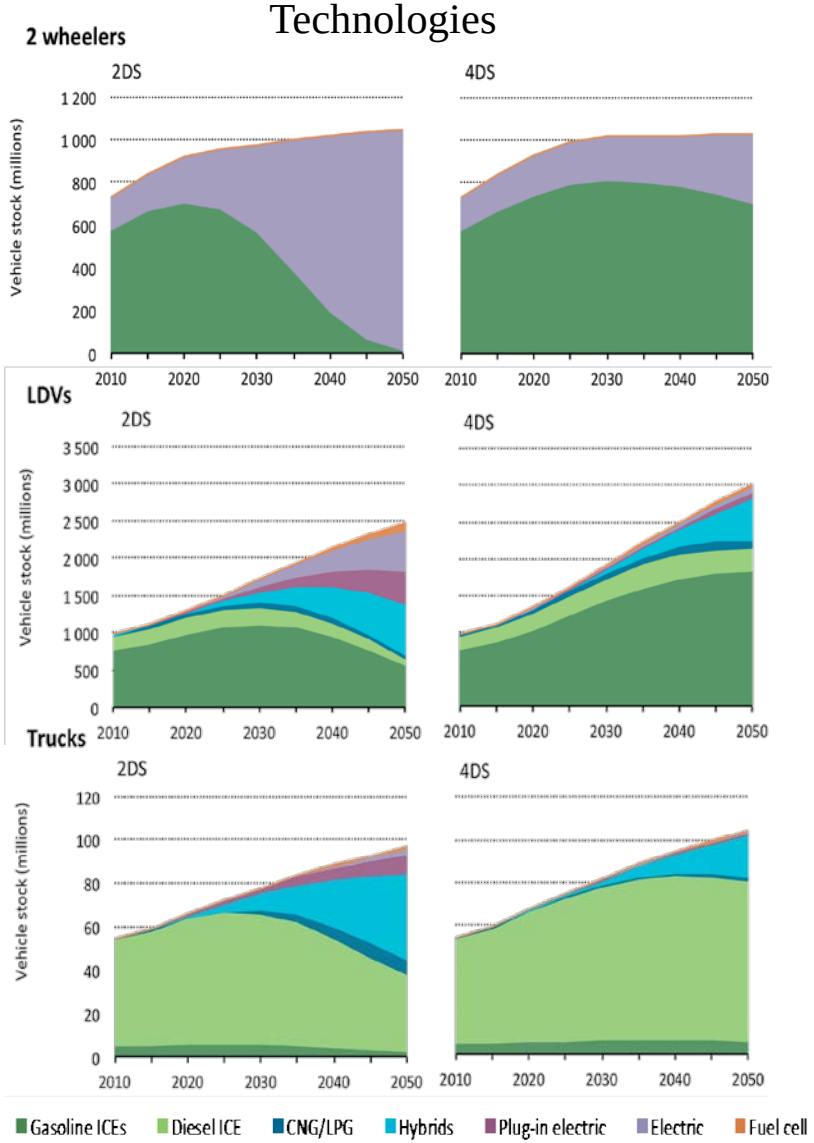
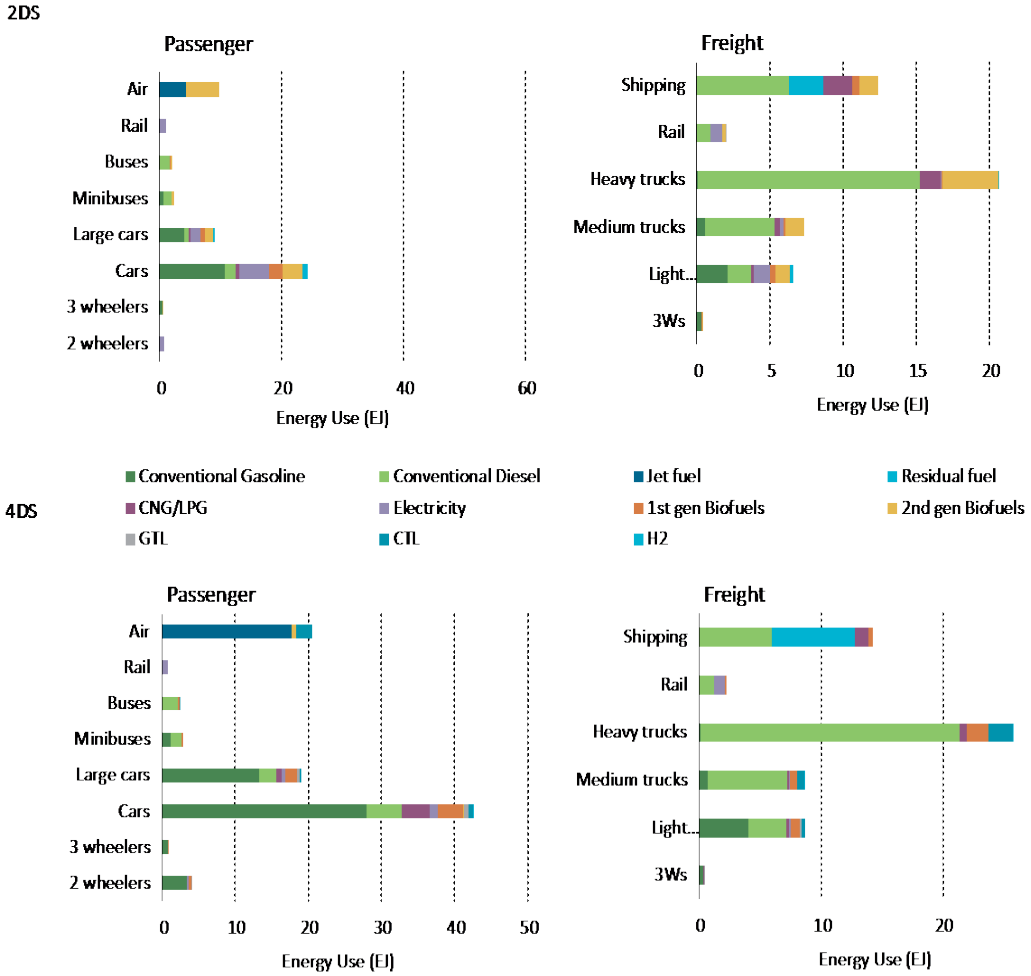
Technologies



Energy carriers



May-June publications

Global EV Outlook 2016 (2/2)

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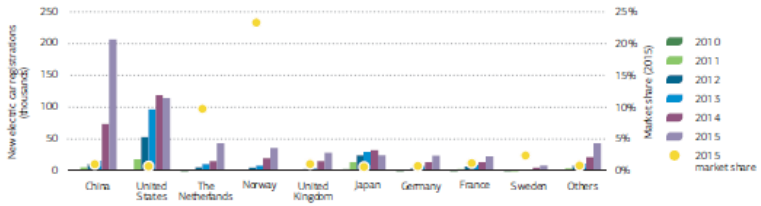
Global EV Outlook 2016

Electric vehicles

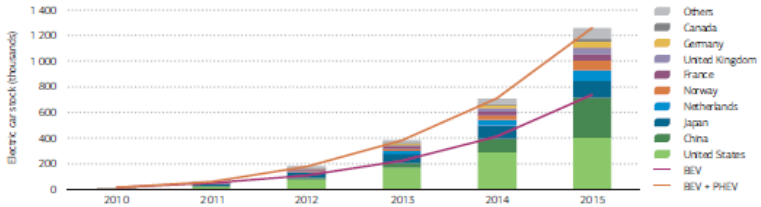
The year 2015 saw the global threshold of 1 million electric cars[1] on the road exceeded, closing at 1.26 million. In 2014, only about half of today's electric car stock existed. In 2005, electric cars were still measured in hundreds. 2015 also saw more than 200 million electric two wheelers on the road, and 170 000 buses, primarily in China.

EV sales and market share in a selection of countries and regions, 2015



Key point: The two main electric car markets are China and the United States. Seven countries have reached over 1% EV market share in 2015 (Norway, the Netherlands, Sweden, Denmark, France, China and the United Kingdom).

Evolution of the global electric car stock, 2010–15

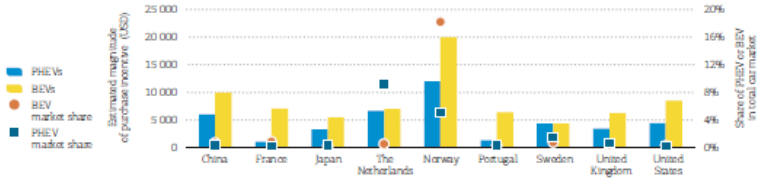


Key point: The uptake of electric cars has been growing since 2010, with a BEV uptake slightly ahead of PHEV uptake. 80% of the electric cars on road worldwide are located in the United States, China, Japan, the Netherlands and Norway.

Policy support

Purchase incentives are among the most relevant and the most effective instruments promoting electric car sales.

Estimates of purchase incentives and market shares for electric cars (BEVs and PHEVs), 2015



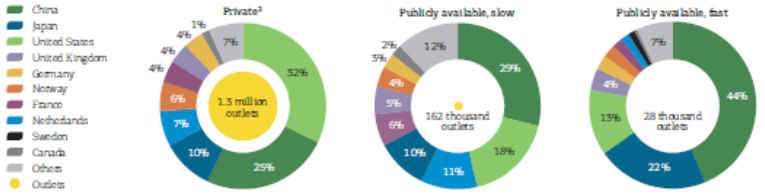
Key point: Policies deployed in different countries result in different purchase incentives and BEV over PHEV adoption patterns, with Norway's purchase incentives level standing out for both BEVs and PHEVs.

1. Electric cars refers here to battery electric (BEVs) and plug-in hybrid electric vehicles (PHEVs).

Charging infrastructure

There are an estimated total of 1.45 million electric car charging points worldwide in 2015. Publicly accessible charging facilities have been following the growth trend of the electric car stock in the past year.

Geographical distribution of the 2015 stock of EVSE outlets by charger type

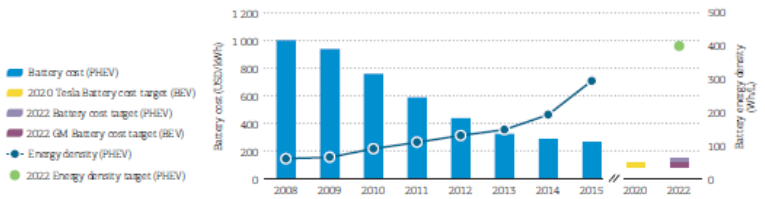


Key point: Country profiles differ with respect to the development of EVSE infrastructure. China and Japan account for more than 65% of fast-charging outlets. The geographical distribution of publicly accessible slow chargers is closer to the distribution of electric cars and private charging outlets.

Battery technology improvements

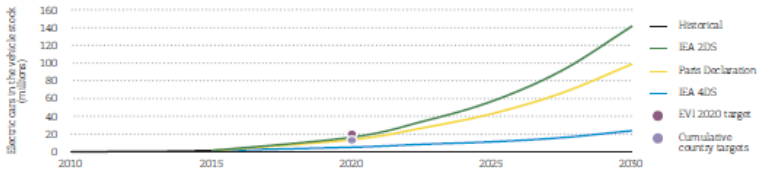
Since 2008, battery costs were cut by a factor four and battery energy density had a fivefold increase. Technological developments hold the promise to continue to deliver improvements in the forthcoming years.

Evolution of battery energy density and cost



Key point: The trends of battery energy density and cost over the past decade give encouraging signs on the possibility of meeting targets defined by carmakers and the United States Department of Energy (US DOE) for 2020 and 2022.

Deployment scenarios for the stock of electric cars to 2030



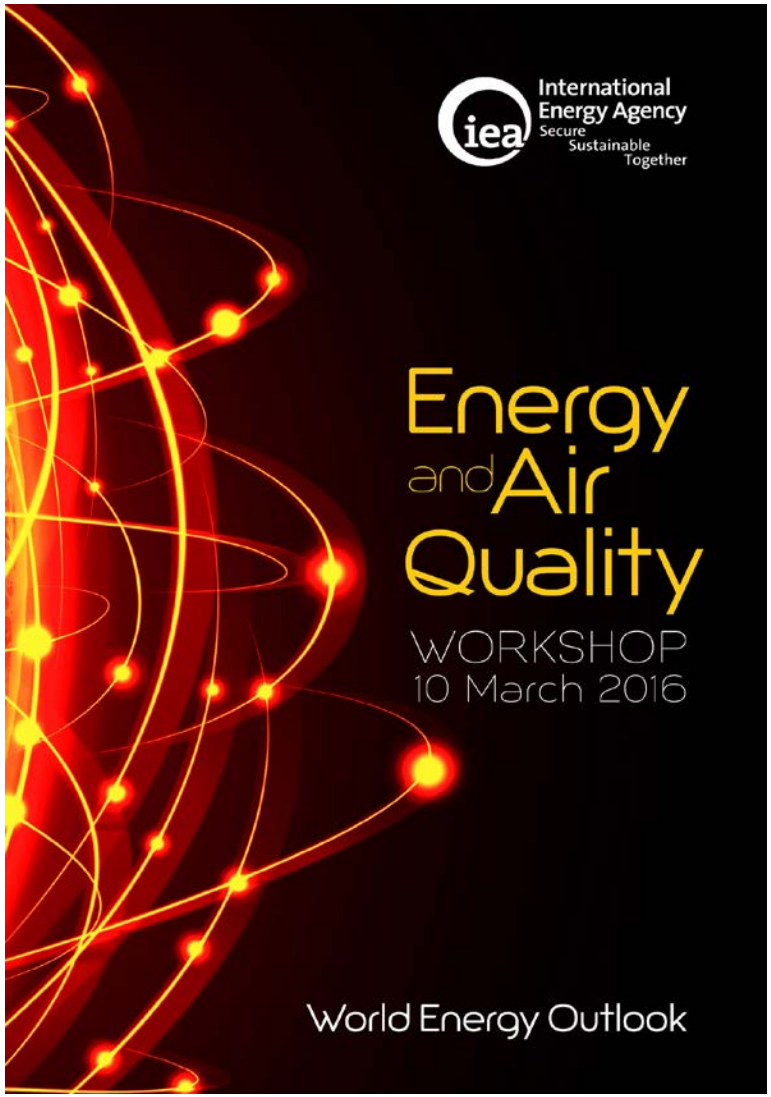
Key point: Individual country commitments would bring 13 million electric cars on the road by 2020. The EVI aims at a deployment of 20 million electric cars by 2020. In both cases, reaching 2020 deployment targets for BEVs and PHEVs requires a sizeable growth of the electric car stock. Meeting 2030 decarbonisation and sustainability goals requires a major deployment of electric cars in the 2020s.

2. Private chargers are estimated assuming that each electric vehicles is coupled with a private charger.

May-June publications
Energy and Air Quality (2/2)

ETP 2016

- Energy producing and consuming sectors are responsible for more than 99% of anthropogenic emissions of sulfur dioxide and nitrogen oxides to the atmosphere, and almost 85% of the emissions of particulate matter.
- Power generation and industry are the leading sources of sulfur dioxide (mainly from coal use).
- Oil-fuelled vehicles & power generation are leading sources of nitrogen oxides, and the residential sector (bioenergy, kerosene & coal) & industry are the leading emitters of particulate matter.
- As the largest source of air pollution, the energy sector must be lead actions to improve air quality around the world.
- There is a range of proven policies and technologies with which to do so. In the United States, European Union and Japan, regulations have helped achieve a major drop in emissions in some sectors, but no jurisdiction can claim that the task is complete.
- Policies having an impact on air quality include regulations that specify emissions limits for power plants or specific industrial facilities, as well as fuel quality or vehicle emissions standards.
- Market-based instruments include levies on polluting fuels, subsidies to encourage fuel-switching & emissions trading schemes.



ETP 2017 model developments
Update of freight transport drivers (1/5)

ETP 2016

Project scope

- Long term projection of demand for
  - Medium Freight Trucks (MFTs) – 3.5 tonne to 15.5 tonne Gross Vehicle Weight
  - Heavy Freight Trucks (HFT) – greater than 15.5 tonne Gross Vehicle Weight

- Projecting:
  - Tonne Kilometres
  - Vehicle Kilometres
  - Stock

ETP 2017 model developments

Update of freight transport drivers (3/5)

ETP 2016

Explanatory Variable	Source
Gross Domestic Product – Purchasing Power Parity	IEA
Industry Value Added	IEA
Services Value Added	IEA
Agriculture Value Added	IEA
Population	OECD Stats
Population Density	OECD Stats
Fuel Price	IEA
Normalised Fuel Price	-
Country Area	OECD Stats
Vkm - Medium, Large, and Total	Eurostat, NATS
Tkm - Medium, Large, and Total	Worldbank, OECD Stats, Eurostat Development Banks, National Statistics Offices
No. of Vehicles - Medium, Large, and Total	National Statistics Offices
Rail Tkm	UIC
Road Infrastructure	IEA
Rail Infrastructure	IEA
Road – Rail tkm Ratio	-
Road – Rail Infrastructure Ratio	-

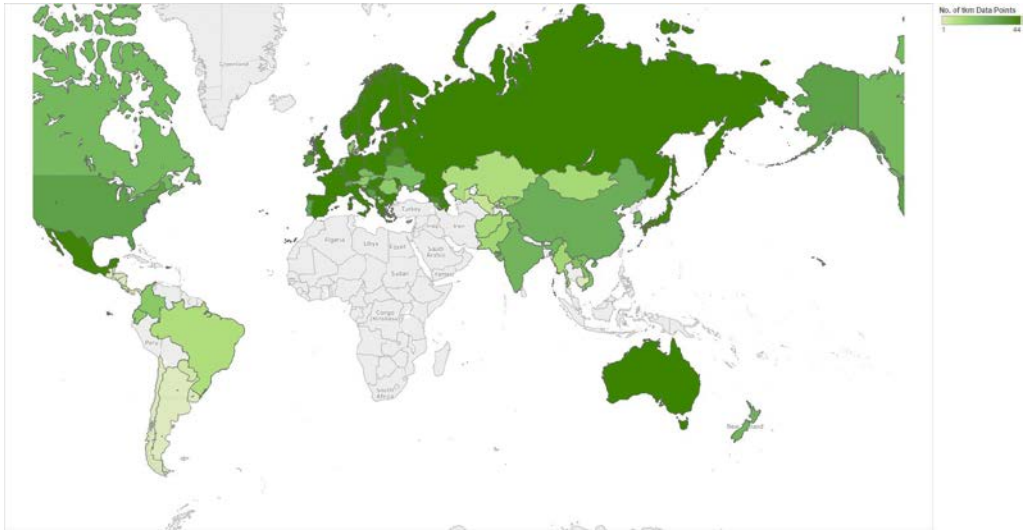
ETP 2017 model developments

Update of freight transport drivers (4/5)

ETP 2016

Data availability

- Tkm



- Vkm