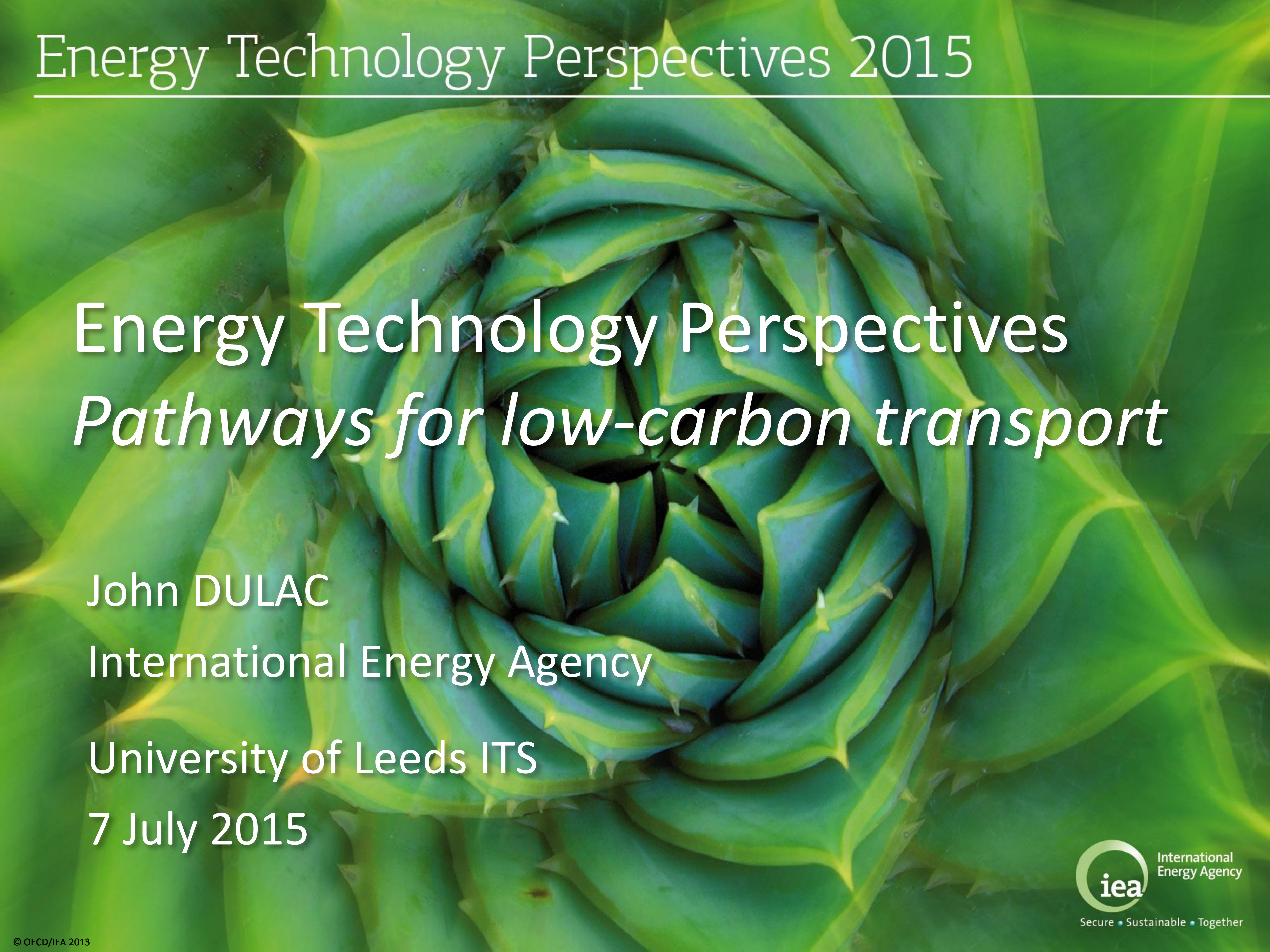
Energy Technology Perspectives 2015



Energy Technology Perspectives
Pathways for low-carbon transport

John DULAC
International Energy Agency

University of Leeds ITS
7 July 2015

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IEA Energy Technology Activities

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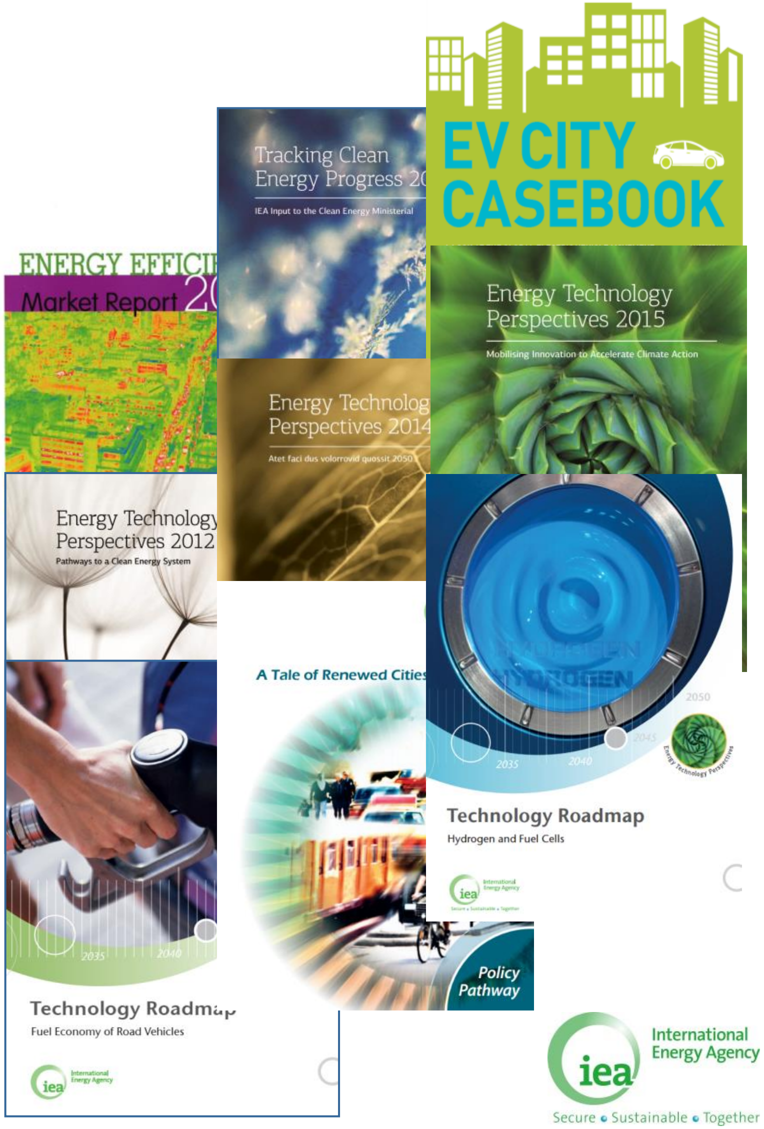
2015

- Where are we today?
- Where do we need to go?
- How do we get there?



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iea INTERNATIONAL LOW-CARBON ENERGY TECHNOLOGY PLATFORM

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Energy Technology Perspectives

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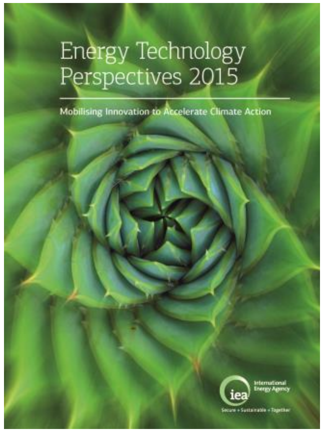

- Comprehensive, long-term analysis of trends and energy technology potential to 2050
- Three main scenarios:
  - 6DS: limited changes
  - 4DS: current strategies for energy efficiency extended to 2050
  - 2DS: CO_2 emission mitigation scenario

Find out more: www.iea.org/etp

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Carbon intensity of supply is stuck

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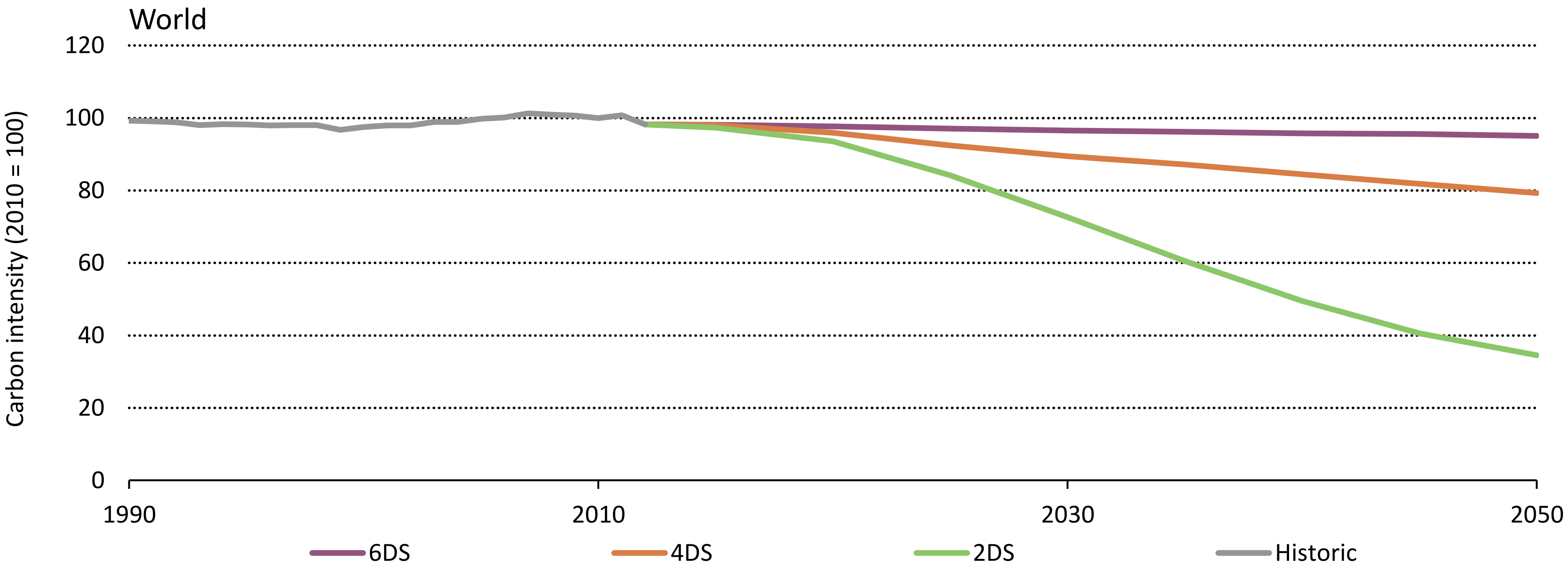
Energy Sector Carbon Intensity Index (ESCII)



Meaningful progress at a global scale has yet to be demonstrated

Source: IEA ETP 2015

A transformation is needed...

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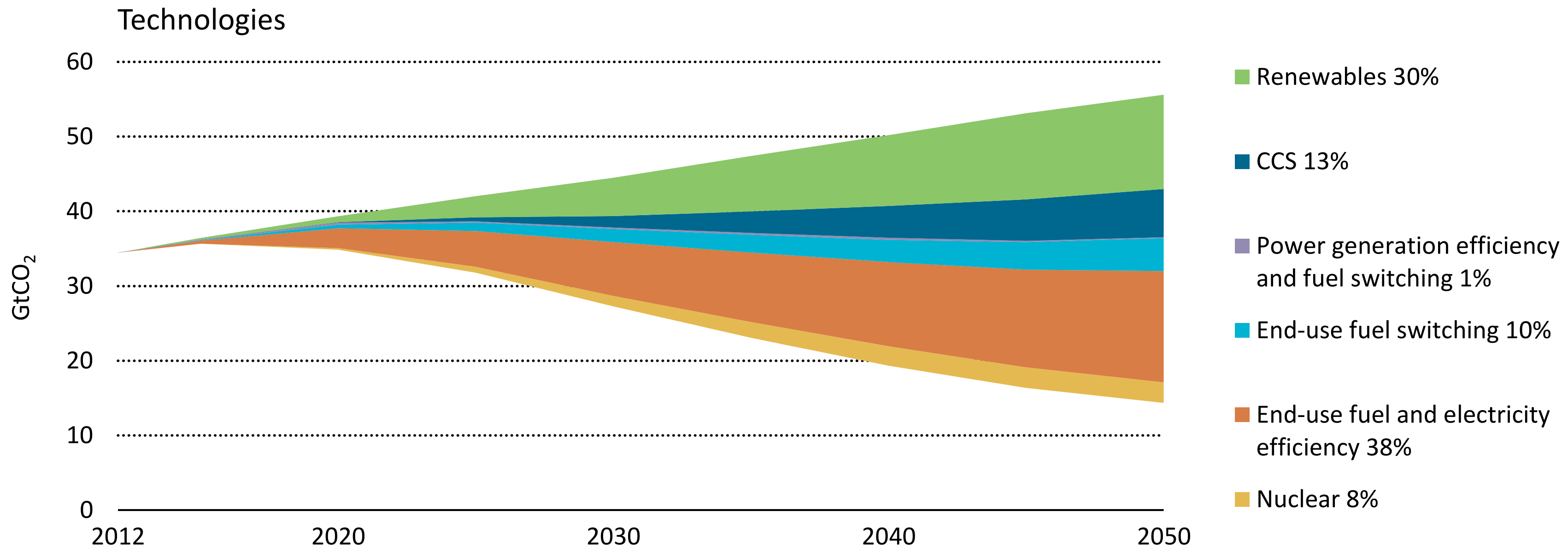
Contribution by technology area to CO_2 reductions (6DS to 2DS)



...and we to have the tools to develop a strategy and be proactive

Source: IEA ETP 2015

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A transformation is needed…

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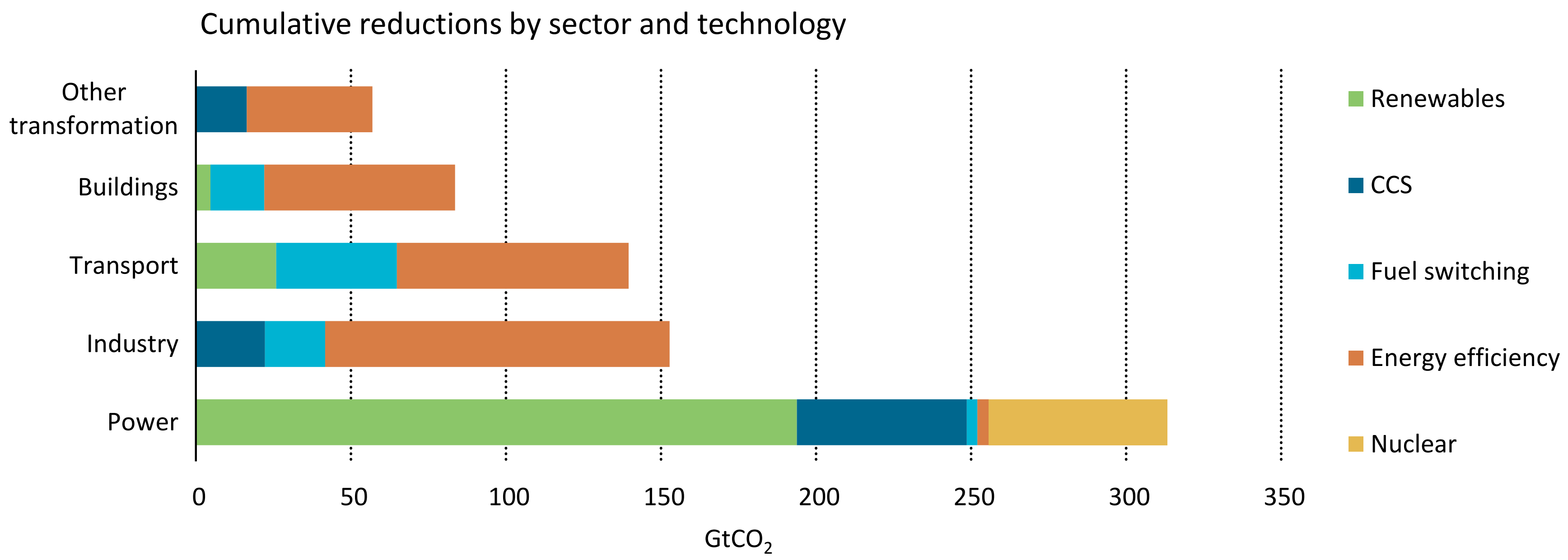
Contribution by sector to CO_2 reductions (6DS to 2DS)



Transport represents 20% of CO_2 savings in the 2DS

Source: IEA ETP 2015

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The IEA Mobility Model

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MoMo: project history

2003	World Business Council for Sustainable Development and the Sustainable Mobility Project (SMP) transport model
2004	**SMP model developed further as IEA MoMo**
2006-2008	Deeper analysis of vehicle technology potential, including plug-in hybrid electric vehicles 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 Vehicle, fuel and infrastructure costs associated to scenario
2013+	Progressive transition to systems dynamics platform Assessment of urban transport activity and potential

The IEA Mobility Model

MoMo: what is it?

- Analytical tool used to elaborate projections of transport activity, energy demand and CO_2 emissions
- Core of transport analysis in ETP
- Essential tool for transport-related 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

The IEA Mobility Model

MoMo: what is it?

- Spreadsheet model of global transport
  - Mainly focus on vehicles and energy – also covers emissions, safety, infrastructure and materials
  - Based on hypotheses on GDP and population growth, vehicle fuel economy, fuel costs, travel demand, and vehicle and fuel market shares
- World divided in 29 regions, including several specific countries
- Contains large amount of data on technology and fuel pathways
  - Full evaluation of life cycle GHG emissions
  - Valuation of transport expenditures: vehicles, fuels and infrastructure
  - Module on material requirements for LDV manufacturing

The IEA Mobility Model

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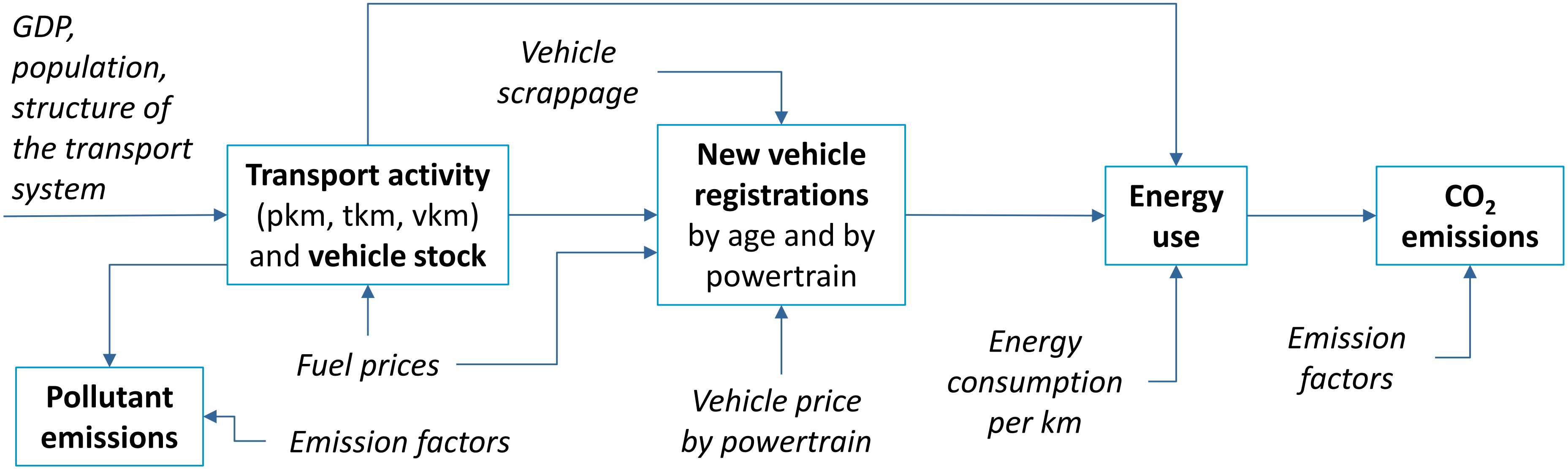
MoMo: key modelling steps



GDP, population, structure of the transport system

Transport activity (pkm, tkm, vkm) and **vehicle stock**

Vehicle scrappage

New vehicle registrations by age and by powertrain

Energy use

CO_2 emissions

Pollutant emissions

Fuel prices

Emission factors

Vehicle price by powertrain

Energy consumption per km

Emission factors

- Generation of transport activity (pkm, tkm, vkm) and vehicle stock
- Evaluation of new vehicle sales by powertrain and characterisation of vehicles by vintage
- Calculation of energy use
- Estimation of CO_2 and pollutant emissions

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MoMo: analytical capability (1/2)

- LDVs and freight trucks
  - Stock/sales model has been developed
  - Activity, intensity and energy use are estimated
  - CO_2 emissions are calculated (well-to-wheel and tank-to-wheel, using ETP modelling framework)
  - Pollutant emissions (CO, VOCs, PM, lead and NO_x) estimated
  - Vehicle and fuel costs are tracked
- Buses and 2/3 wheelers
  - MoMo tracks stock, stock efficiency, travel, energy use and emissions
- Rail and air
  - Total travel activity, energy intensities, energy use and emissions are tracked
- Shipping
  - To date, MoMo tracks sectorial energy use and emissions

The IEA Mobility Model

MoMo: analytical capability (2/2)

- MoMo has a user interface that allows
  - What-if scenario building
  - 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. fuel cells) and how they impact materials requirements (e.g. precious metals)
  - Full life-cycle analysis for GHG emissions from LDVs (including manufacturing)
- Recent MoMo developments include
  - Urban/non-urban travel splits applying data from 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

The IEA Mobility Model

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MoMo: who supports this work?

bp

Statoil

RENAULT NISSAN

HONDA

UITP

TOYOTA

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

International Transport Forum

ExxonMobil

MICHELIN

ITDP
Institute for Transportation & Development Policy

UC DAVIS ITS

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Energy consumption in transport

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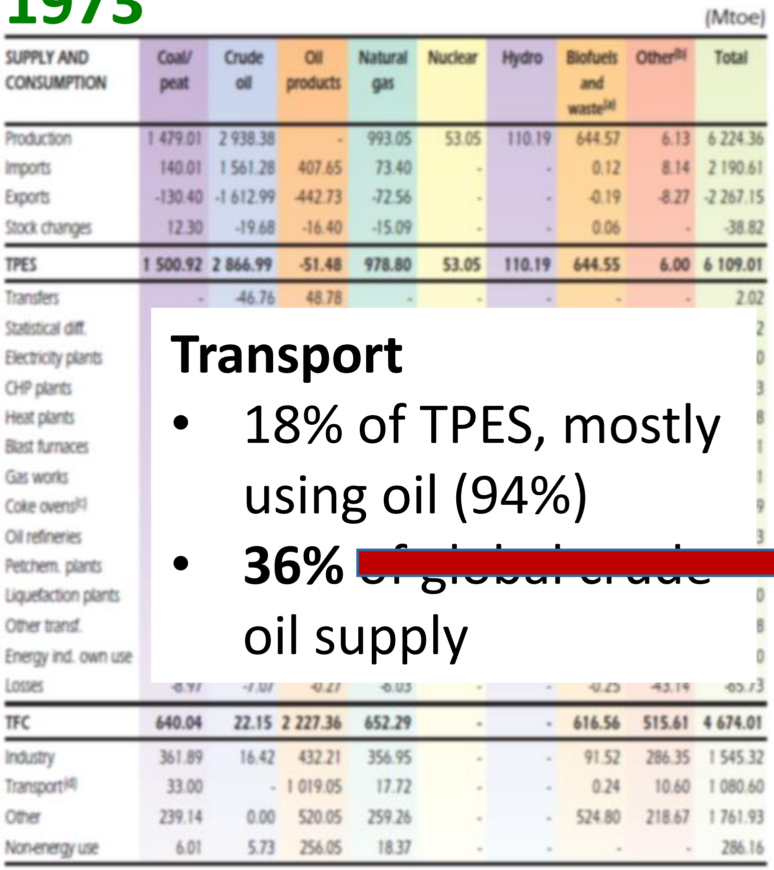
1973



(Mtoe)

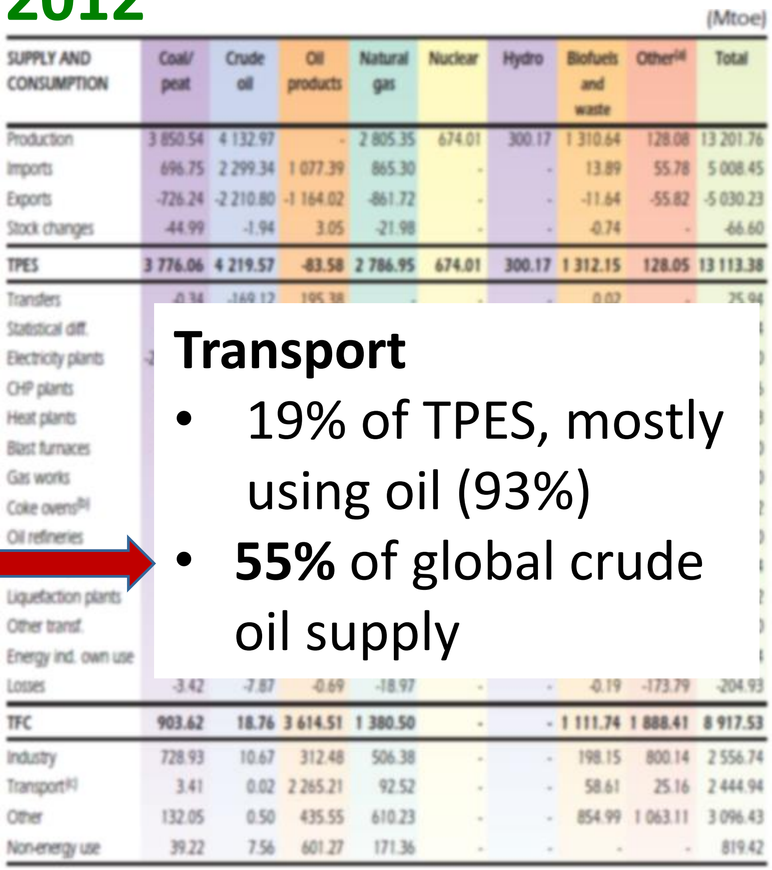
SUPPLY AND CONSUMPTION	Coal/ peat	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Biofuels and waste[a]	Other[b]	Total
Production	1 479.01	2 938.38	-	993.05	53.05	110.19	644.57	6.13	6 224.36
Imports	140.01	1 561.28	407.65	73.40	-	-	0.12	8.14	2 190.61
Exports	-130.40	-1 612.99	-442.73	-72.56	-	-	-0.19	-8.27	-2 267.15
Stock changes	12.30	-19.68	-16.40	-15.09	-	-	0.06	-	-38.82
TPES	**1 500.92**	**2 866.99**	**-51.48**	**978.80**	**53.05**	**110.19**	**644.55**	**6.00**	**6 109.01**
Transfers	-	-46.76	48.78	-	-	-	-	-	2.02
Statistical diff.									
Electricity plants									
CHP plants									
Heat plants									
Blast furnaces									
Gas works									
Coke ovens[c]									
Oil refineries									
Petchem. plants									
Liquefaction plants									
Other transf.									
Energy ind. own use									
Losses	-8.97	-7.07	-0.27	-6.03	-	-	-0.25	-43.14	-65.73
TFC	**640.04**	**22.15**	**2 227.36**	**652.29**	-	-	**616.56**	**515.61**	**4 674.01**
Industry	361.89	16.42	432.21	356.95	-	-	91.52	286.35	1 545.32
Transport[d]	33.00	-	1 019.05	17.72	-	-	0.24	10.60	1 080.60
Other	239.14	0.00	520.05	259.26	-	-	524.80	218.67	1 761.93
Non-energy use	6.01	5.73	256.05	18.37	-	-	-	-	286.16

(a) Biofuels and waste final consumption has been estimated.
(b) Other includes geothermal, solar, wind, electricity and heat, etc.
(c) Also includes patent fuel and BKB plants.
(d) Includes international aviation and international marine bunkers.

Transport

- 18% of TPES, mostly using oil (94%)
- **36%** of global crude oil supply

2012



(Mtoe)

SUPPLY AND CONSUMPTION	Coal/ peat	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Biofuels and waste	Other[a]	Total
Production	3 850.54	4 132.97	-	2 805.35	674.01	300.17	1 310.64	128.08	13 201.76
Imports	696.75	2 299.34	1 077.39	865.30	-	-	13.89	55.78	5 008.45
Exports	-726.24	-2 210.80	-1 164.02	-861.72	-	-	-11.64	-55.82	-5 030.23
Stock changes	-44.99	-1.94	3.05	-21.98	-	-	-0.74	-	-66.60
TPES	**3 776.06**	**4 219.57**	**-83.58**	**2 786.95**	**674.01**	**300.17**	**1 312.15**	**128.05**	**13 113.38**
Transfers	-0.34	-169.12	195.38	-	-	-	0.02	-	25.94
Statistical diff.									
Electricity plants									
CHP plants									
Heat plants									
Blast furnaces									
Gas works									
Coke ovens[b]									
Oil refineries									
Liquefaction plants									
Other transf.									
Energy ind. own use									
Losses	-3.42	-7.87	-0.69	-18.97	-	-	-0.19	-173.79	-204.93
TFC	**903.62**	**18.76**	**3 614.51**	**1 380.50**	-	-	**1 111.74**	**1 888.41**	**8 917.53**
Industry	728.93	10.67	312.48	506.38	-	-	198.15	800.14	2 556.74
Transport[b]	3.41	0.02	2 265.21	92.52	-	-	58.61	25.16	2 444.94
Other	132.05	0.50	435.55	610.23	-	-	854.99	1 063.11	3 096.43
Non-energy use	39.22	7.56	601.27	171.36	-	-	-	-	819.42

Transport

- 19% of TPES, mostly using oil (93%)
- **55%** of global crude oil supply

Source: IEA Key World Energy Statistics 2014

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Energy consumption in transport

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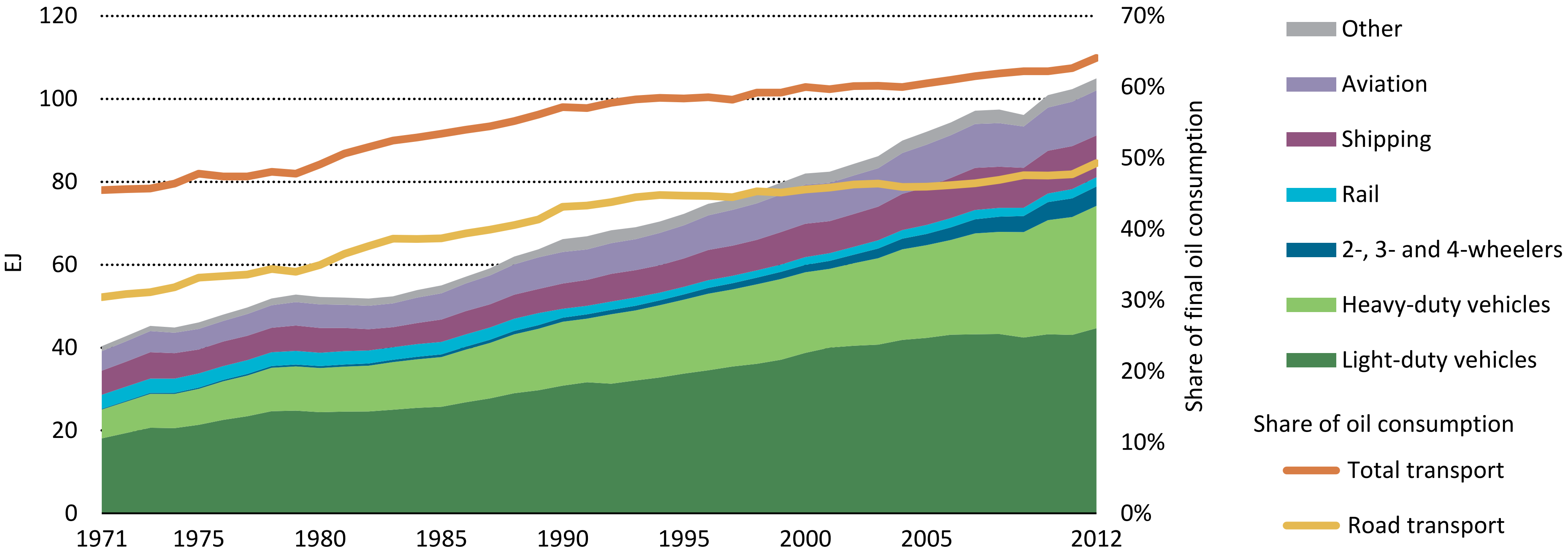
Global transport energy consumption by mode



Road transport accounts for ¾ of transport energy use

Source: IEA Key World Energy Statistics 2014

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Energy consumption in transport

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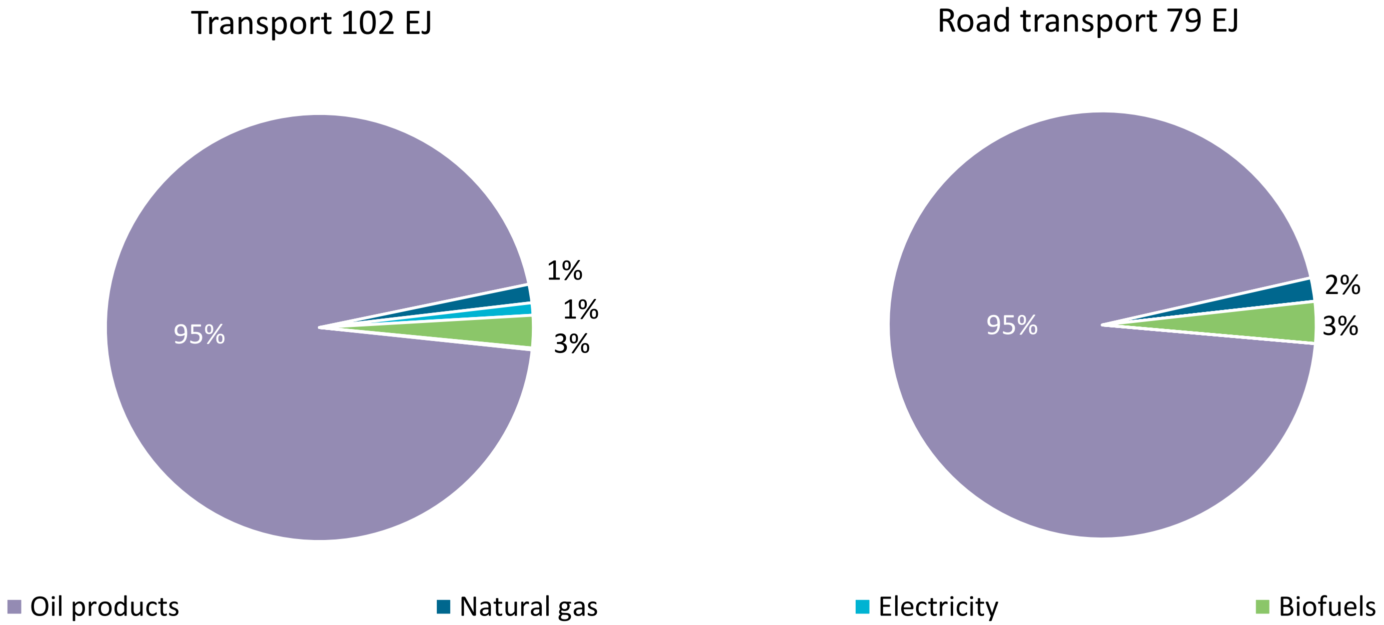
Global transport energy consumption by fuel type in 2012



Despite fuel economy measures and alternative fuels introductions, transport is still highly dependent on oil.

Source: IEA Key World Energy Statistics 2014

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Transport energy outlook to 2050

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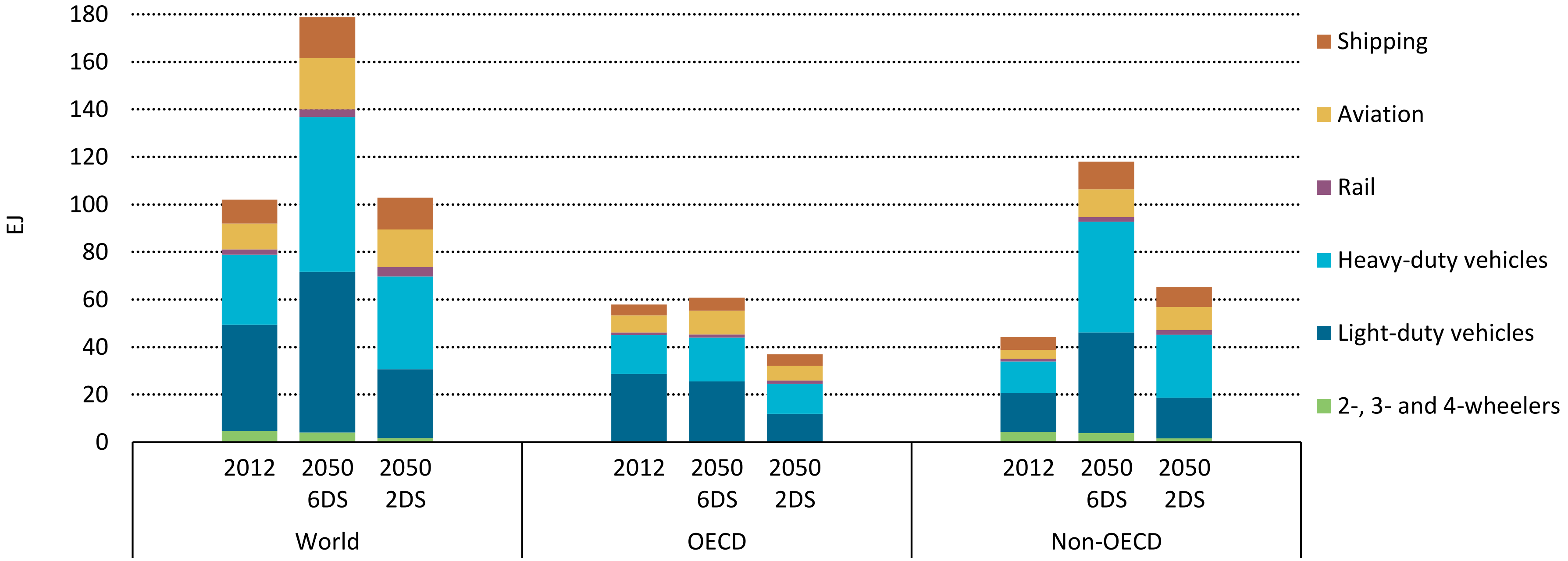
Transport energy forecasts by region



Global transport energy use could increase as much as 75% by 2050 without concerted action.

Source: IEA Mobility Model

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Shifting mobility demand growth

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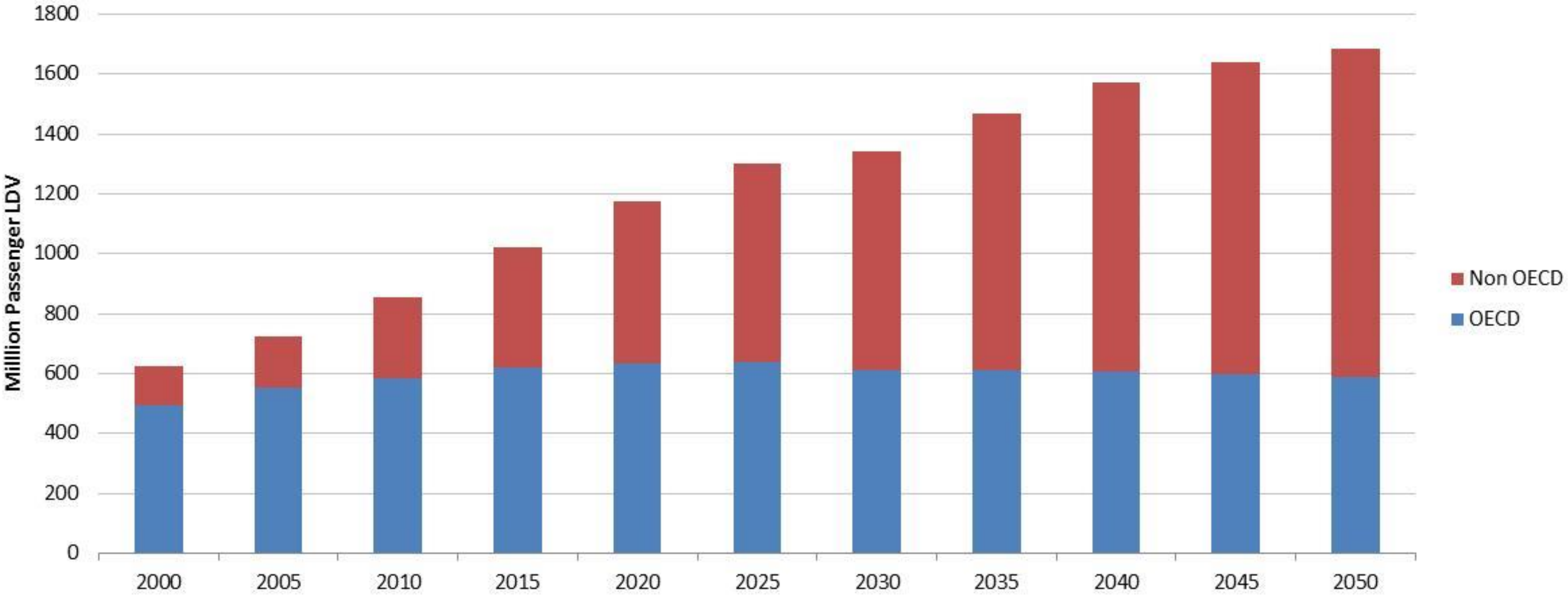
Passenger light-duty vehicle growth to 2050 (6DS)



Passenger vehicle market will continue to drive transport market as non-OECD countries continue to grow.

Source: IEA Mobility Model

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Avoid, Shift and Improve Approach

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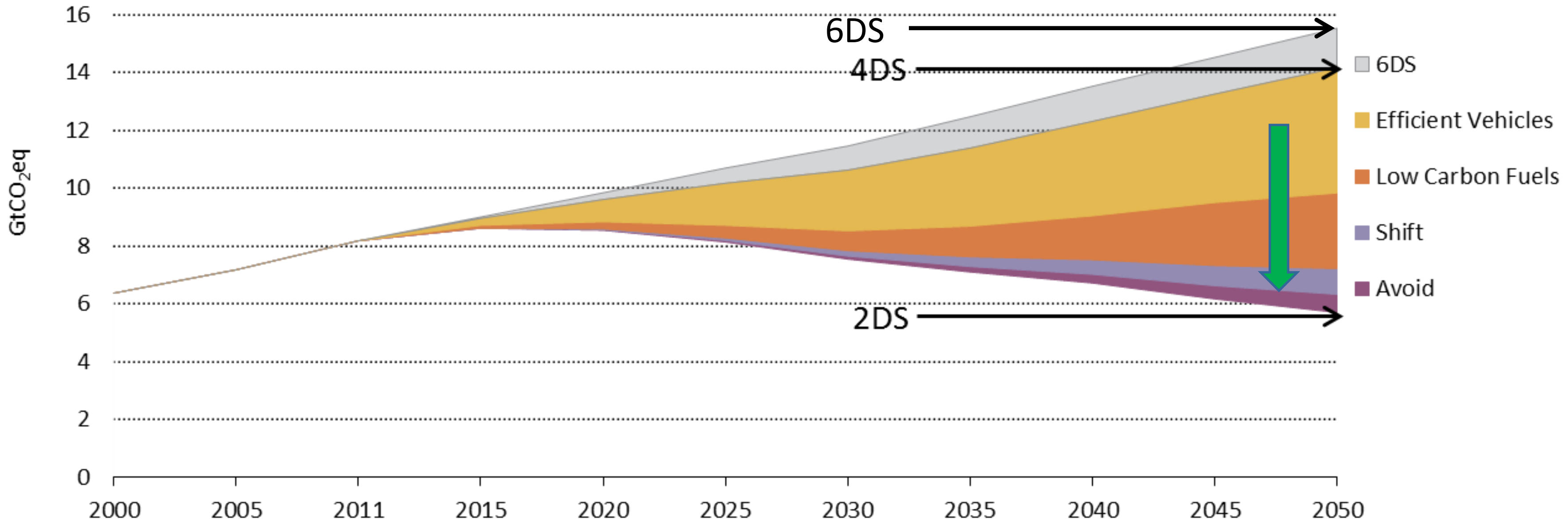
Transport CO_2 reduction potential by contribution



Scenarios to low(er)-carbon transport

- Avoid unnecessary travel
- Shift to more efficient modes
- Improve the energy efficiency of each mode

Source: IEA ETP 2014

Transpor technology paradigm shift

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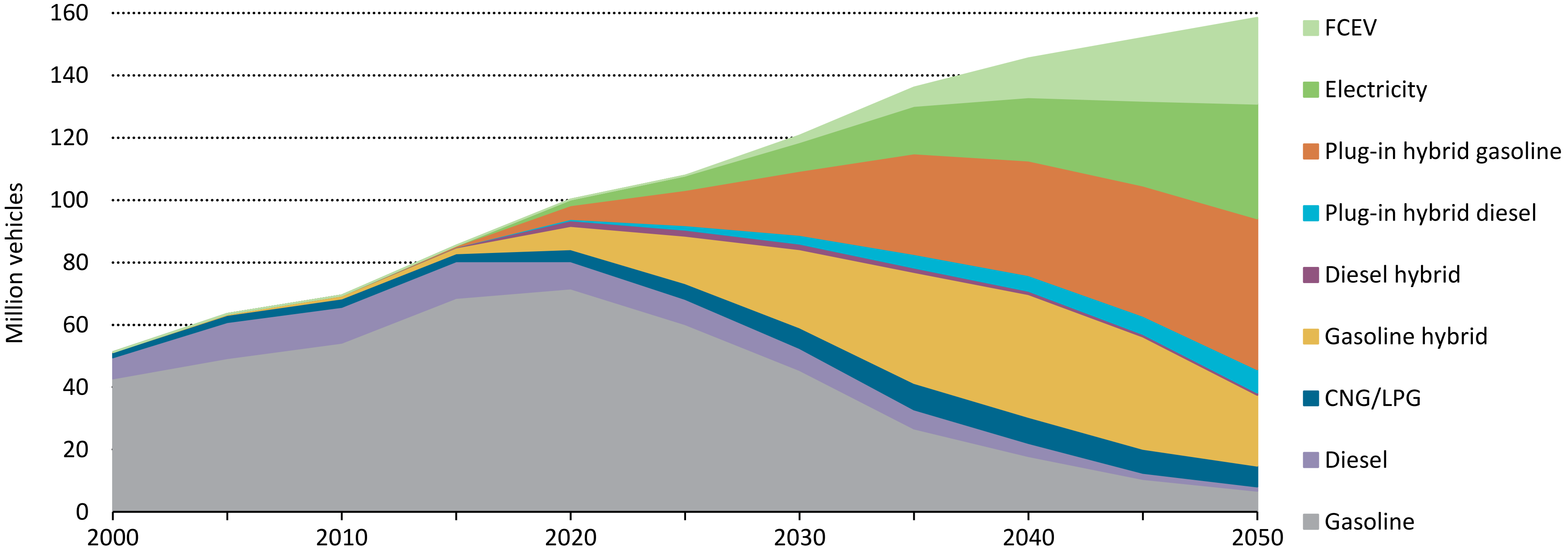
Global portfolio of PLDV technologies (2DS)



EVs, PHEVs and FCEVs account for nearly ¾ of new vehicle sales in 2050 under the 2DS.

Source: IEA Mobility Model

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Global transport expenditures to 2050

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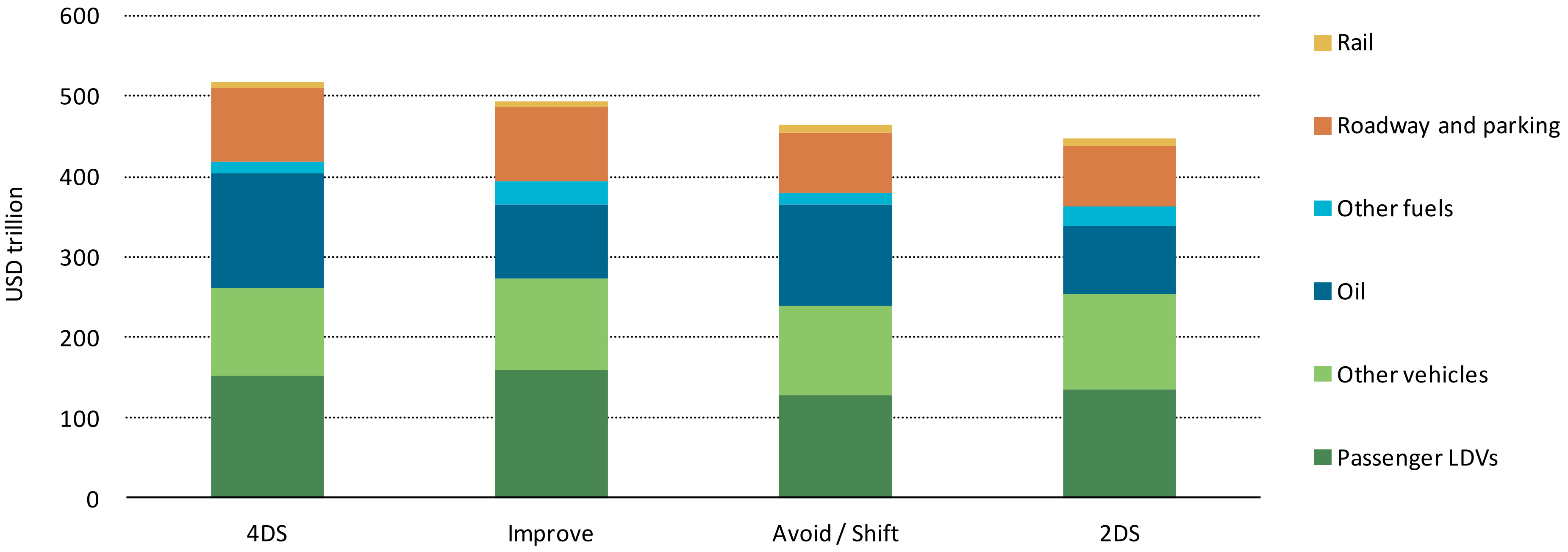
Global transport expenditures to 2050 (vehicles, fuel, infrastructure)



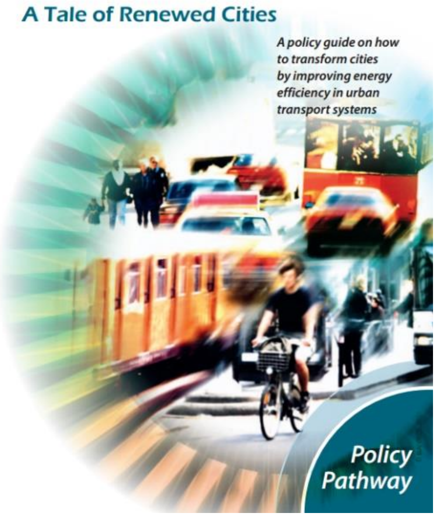
'Avoid, shift and improve' approach could reduce global transport expenditures by USD 70 trillion to 2050.

Source: IEA ETP 2012

Moving forward sustainably

Avoid and Shift

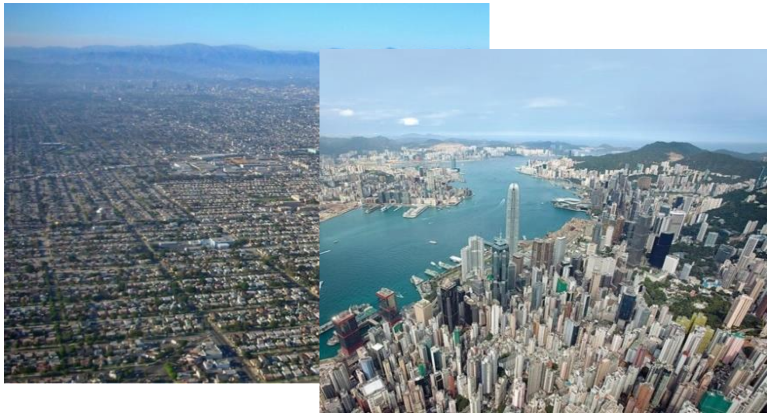
- High-density environments and good transit use less energy
- Time frame to alter urban design is often long
- Structural change = behavioural change



A Tale of Renewed Cities

A policy guide on how to transform cities by improving energy efficiency in urban transport systems

Policy Pathway



Infrastructure and transport growth

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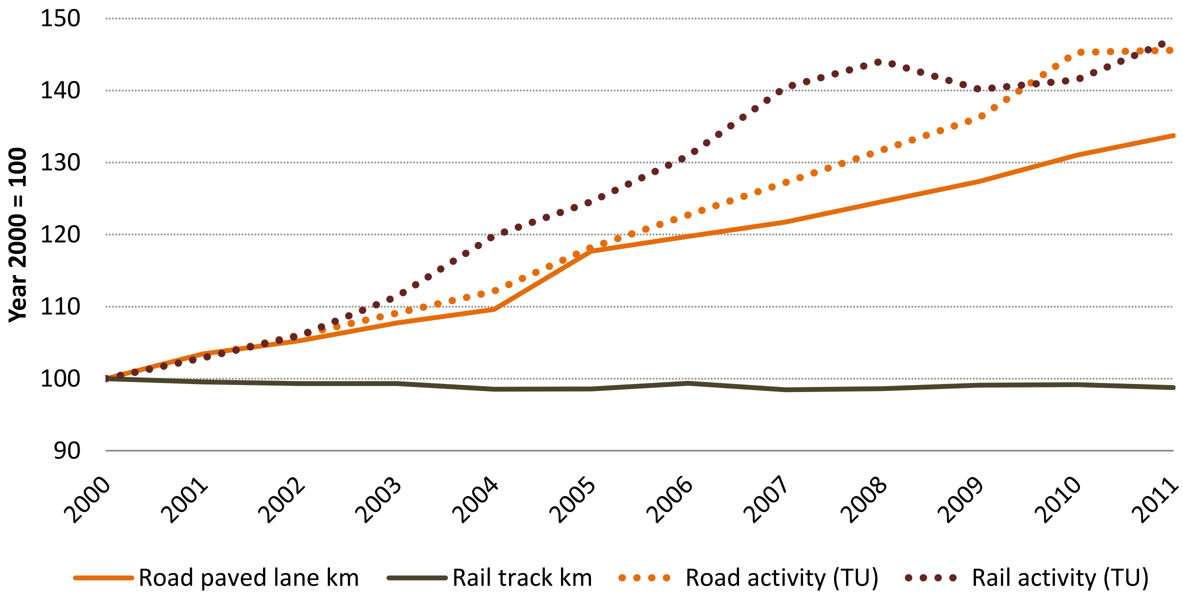
Infrastructure and carrying capacity index (road and rail)



Note: transport units (TU) are passenger and freight-tonne km

*Rail carries more than 20% of global land transport activity using 2% of total infrastructural km.**

**Activity is passenger and freight-tonne km. Infrastructural km include road paved lane-km and track-km.*

Source: IEA Mobility Model, UIC (2013) and IRF (2013)

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Moving forward sustainably

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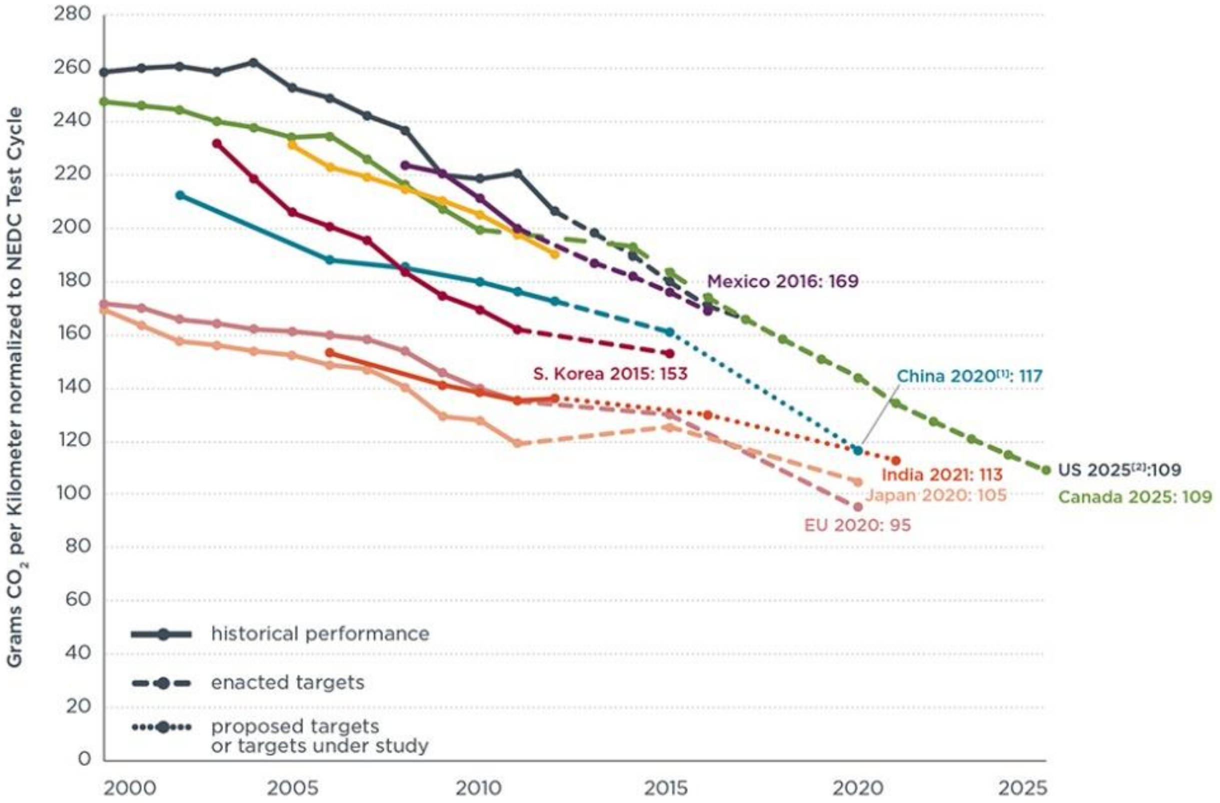
Improve

- Market pull (short-term)
- Technology push (longer term)
- Risk of rebound effect: need for integrated measures



[1] China's target reflects gasoline vehicles only. The target may be higher after new energy vehicles are considered.
[2] US, Canada, and Mexico light-duty vehicles include light-commercial vehicles.
[3] Supporting data can be found at: http://www.theicct.org/info-tools/global-passenger-vehicle-standards

Source: GFEI (2013)

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Transport electrification trends

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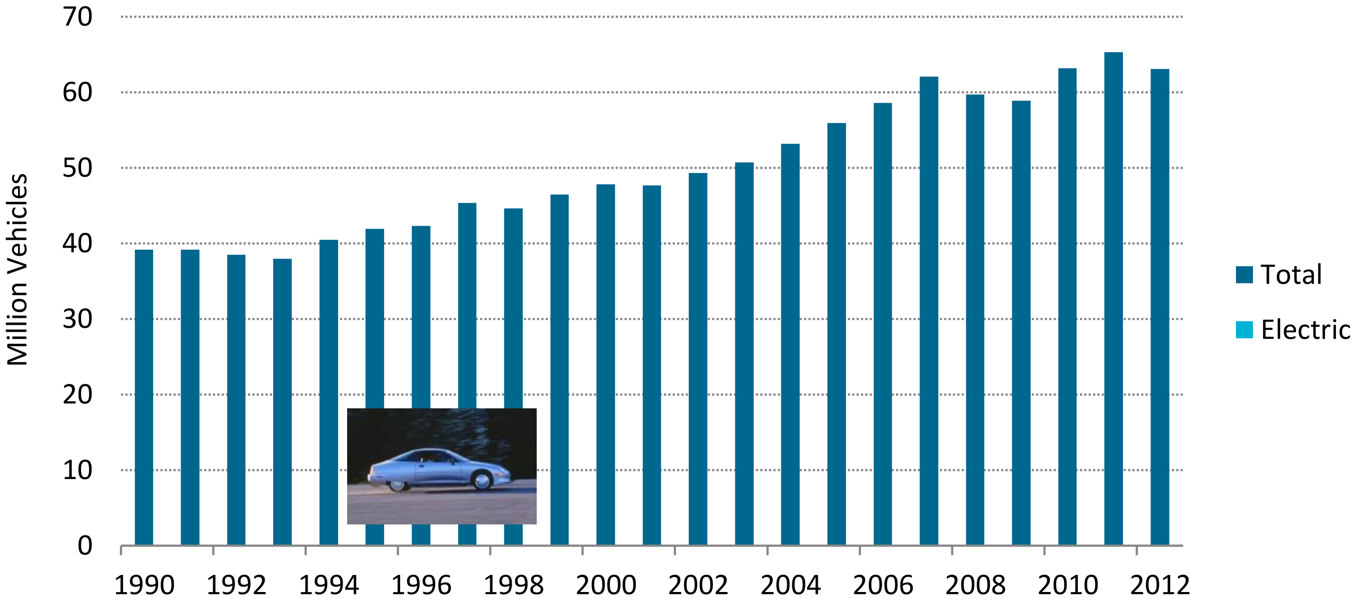
Electric vehicle and global PLDV sales



Global electric vehicle sales topped 125 000 in 2012.

Despite progress, this still represents a tiny fraction of PLDV sales.

Source: IEA Mobility Model

Source: ETP 2014

Low carbon transport + grid

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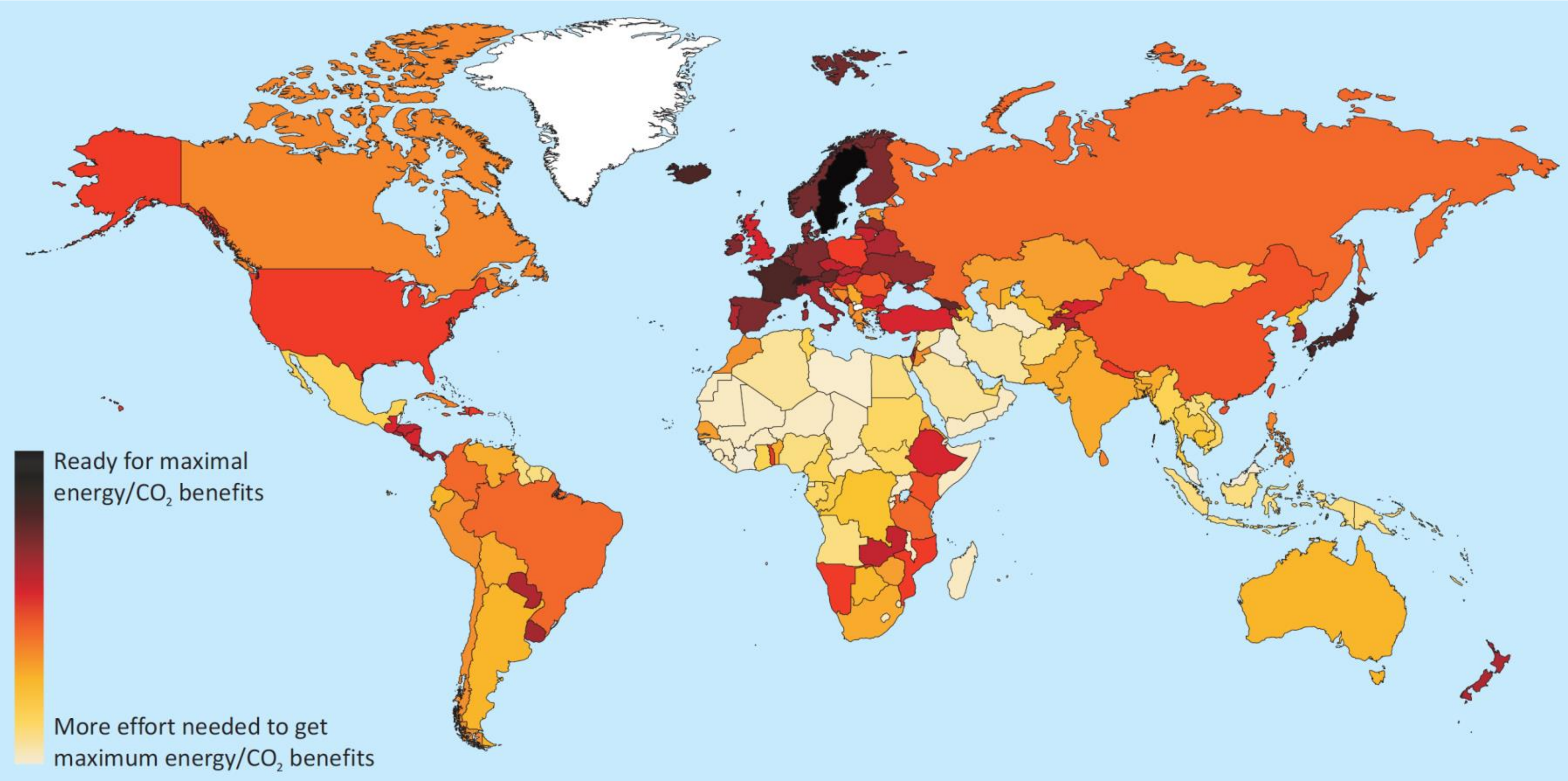
Low-Carbon Electric Transport Maximisation IndeX (“Letmix”)

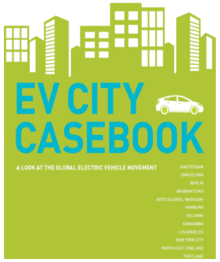


Source: ETP 2014

Electric Vehicles Initiative (EVI)

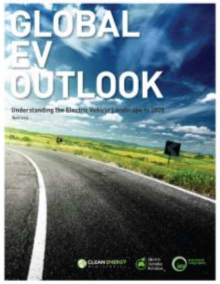
Electric Vehicles Initiative

- **Announced at Clean Energy Ministerial in 2010**
- **8 → 16 countries:** Canada, China, Denmark, France, Germany, India, Italy, Japan, Netherlands, Norway, Portugal, South Africa, Spain, Sweden, United Kingdom, United States
- **Four primary objectives:**
  - **Common data collection/analysis efforts** (Global EV Outlook)
  - **Greater RD&D collaboration** (co-operation with IA-HEV)
  - **City forum linking cities within EVI countries** (EV City Casebook)
  - **Industry engagement**
- **Recent Events:**
  - **EV-Smart Grid public/private roundtable at CEM5 in Seoul, May 2014**
  - **Big Ideas Workshop in Copenhagen, May 2014**
  - **EVI/ISGAN/IA-HEV workshop in Vancouver, October 2014**



EV CITY CASEBOOK

A LOOK AT THE GLOBAL ELECTRIC VEHICLE MOVEMENT



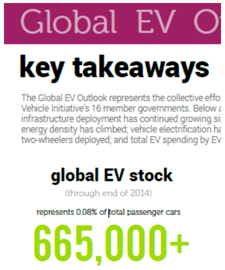
GLOBAL EV OUTLOOK

Understanding the Electric Vehicle Landscape to 2020

EV CITY CASEBOOK

50 BIG IDEAS

SHAPING THE FUTURE OF ELECTRIC MOBILITY



Global EV O

key takeaways

global EV stock

(through end of 2014)

represents 0.08% of total passenger cars

665,000+

GFEI
GLOBAL FUEL ECONOMY INITIATIVE
www.globalfueleconomy.org

Global Fuel Economy Initiative

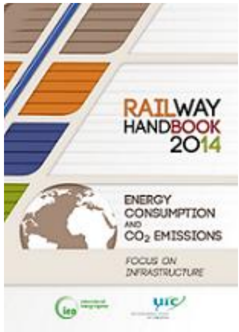
Six core partners: FIA Foundation, UNEP, IEA, ITF, ICCT and UC Davis, financial support from GEF and EU

GFEI recognized as leading initiative in energy and climate reports and discussions

THE GFEI FUEL ECONOMY TARGETS
From 2005 baseline:

- **30%** reduction in L/100km by 2020 in all new cars in OECD countries
- **50%** by 2030 in all new cars globally
- **50%** by 2050 in all cars globally

Joint Railway Handbook on Energy Consumption and CO_2 emissions



RAILWAY HANDBOOK 2014

ENERGY CONSUMPTION AND CO_2 EMISSIONS

FOCUS ON INFRASTRUCTURE

What is it?

Statistical handbook on rail, energy use and CO_2 emissions

Data/figures on:

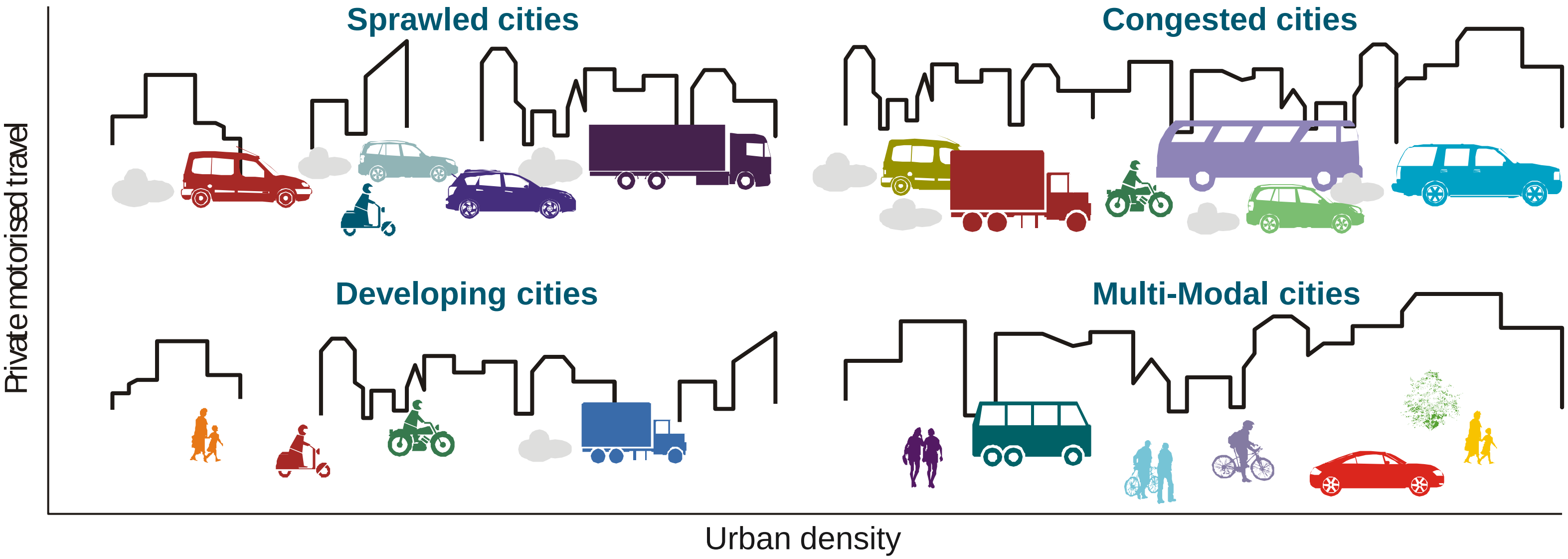
- Rail passenger and freight transport activity, split by traction type
- Comparison with activity on other transport modes
- Rail final energy consumption by fuel
- Information on electricity production mix
- Rail CO_2 emissions (including emissions from electricity generation emissions for rail, tank-to-wheel for other modes)
- Specific energy consumption (final energy per unit activity) and CO_2 emissions for rail

Regional coverage: China, Europe, India, Japan, Russia, USA, World

ETP 2016: urban energy focus

ETP 2015

- Focus on avoid-shift-improve potential through city framework as world continues to urbanise
- Update of 2DS assumptions: assessment of technology deployment potential in urban/non-urban contexts (e.g. electric vehicles)



Source: Tale of Renewed Cities (2013)

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Conclusions

- Transport must be **part of the solution** for decarbonisation
- Transport decarbonisation cannot take place **in isolation**
- Key challenges include:
  - the long time frame needed to **alter urban design**
  - the need to make sure that **promising technologies**, such as battery electric vehicles, can be developed at lower costs
- Need **early action** to move towards increased sustainability

Thank You

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Explore the data behind ETP

www.iea.org/etp

Contact: john.dulac@iea.org