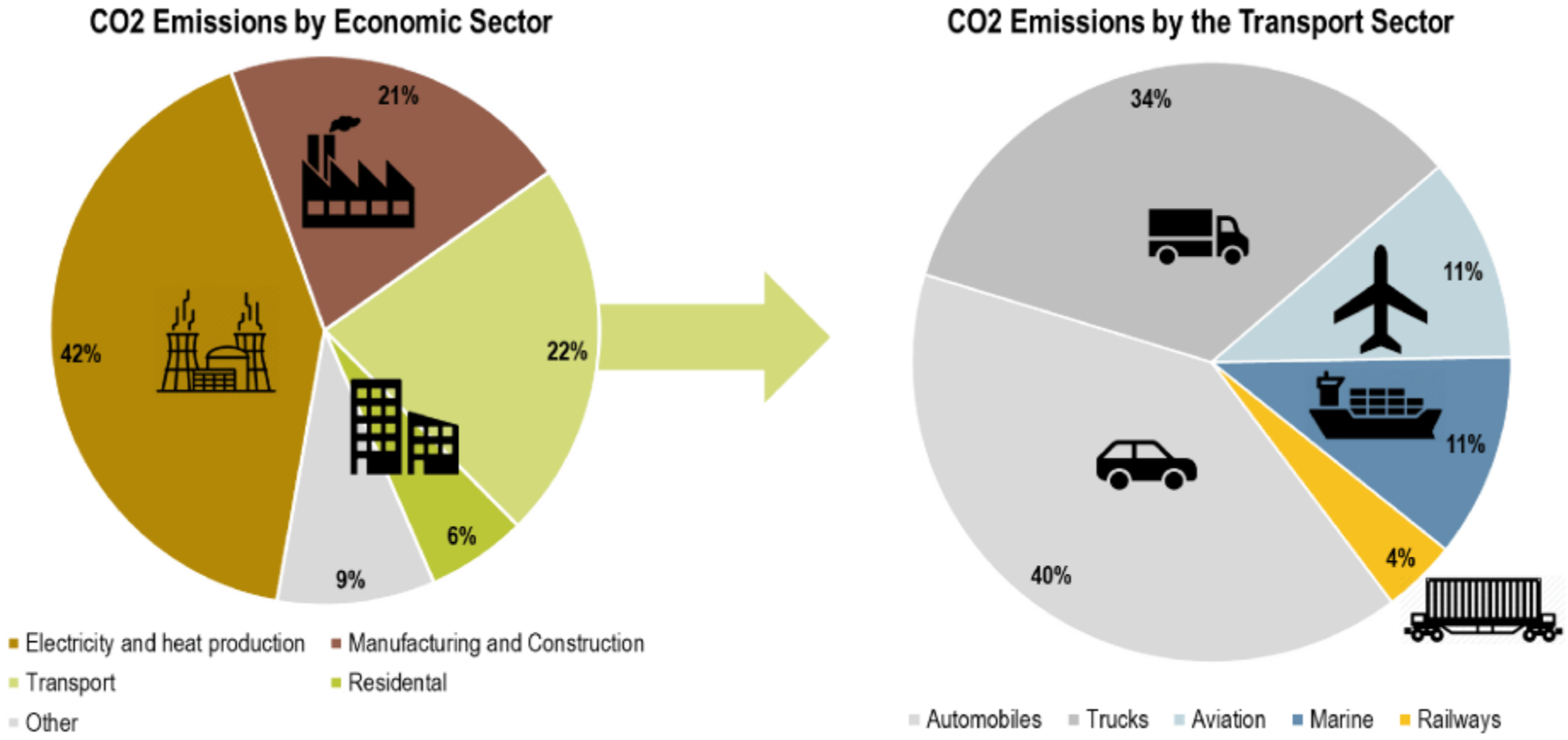
Low carbon transportation

Filip Černoch
cernoch@mail.muni.cz

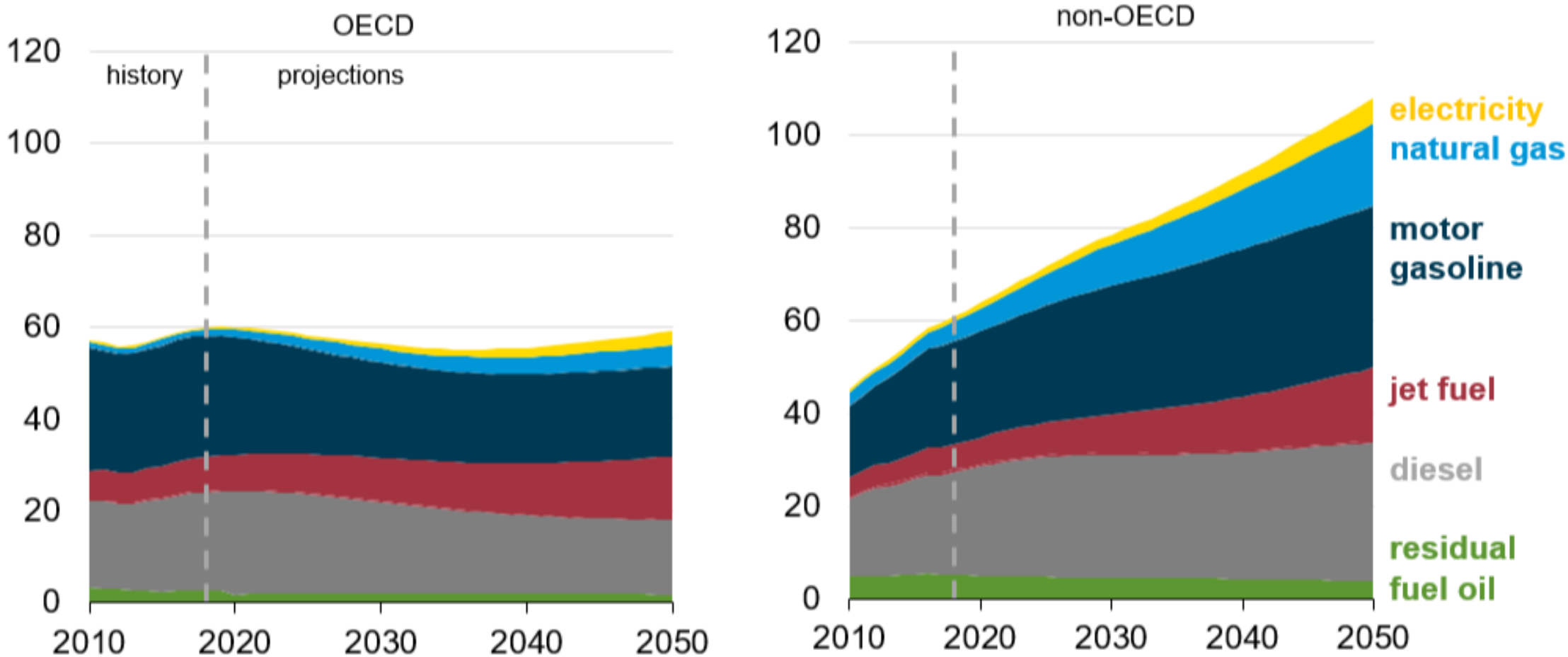
Transport and decarbonization



Data for 2014

Transportation energy consumption

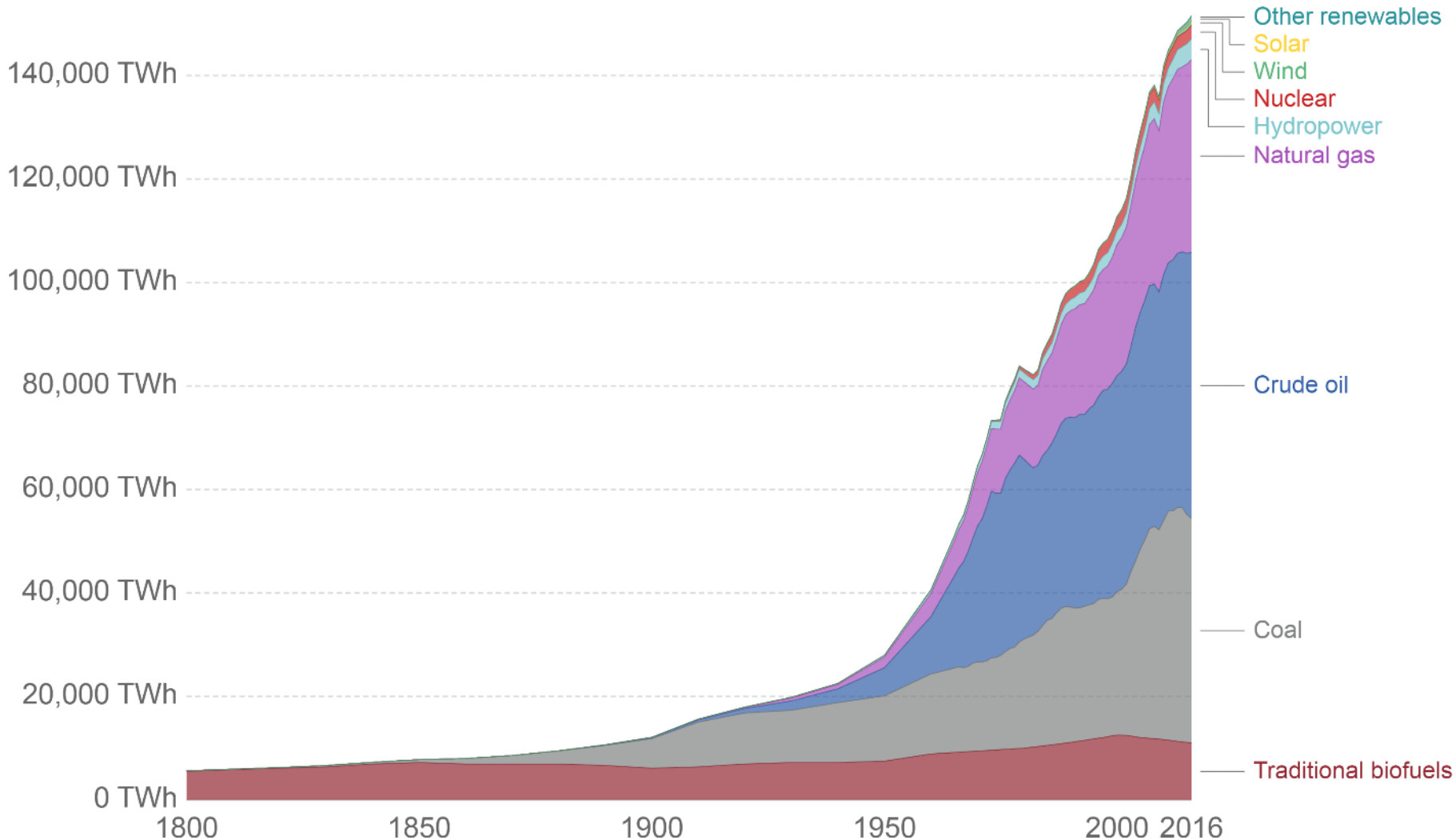
quadrillion British thermal units



Global Primary Energy Consumption, World

Global primary energy consumption, measured in terawatt-hours (TWh) per year. Here 'other renewables' are renewable technologies not including solar, wind, hydropower and traditional biofuels.

Our World in Data



Source: Vaclav Smil (2017) and BP Statistical Review of World Energy

Available (climate related) improvements

- Reduction of travel distances (urban planning).
- Increase of share of public transportation.
- Shift of road freight activity to rail and shipping.
- Development of energy efficiency of vehicles.
- Change in public preferences.
- Promoting the use of low-carbon fuels.

EV deployment in 2018

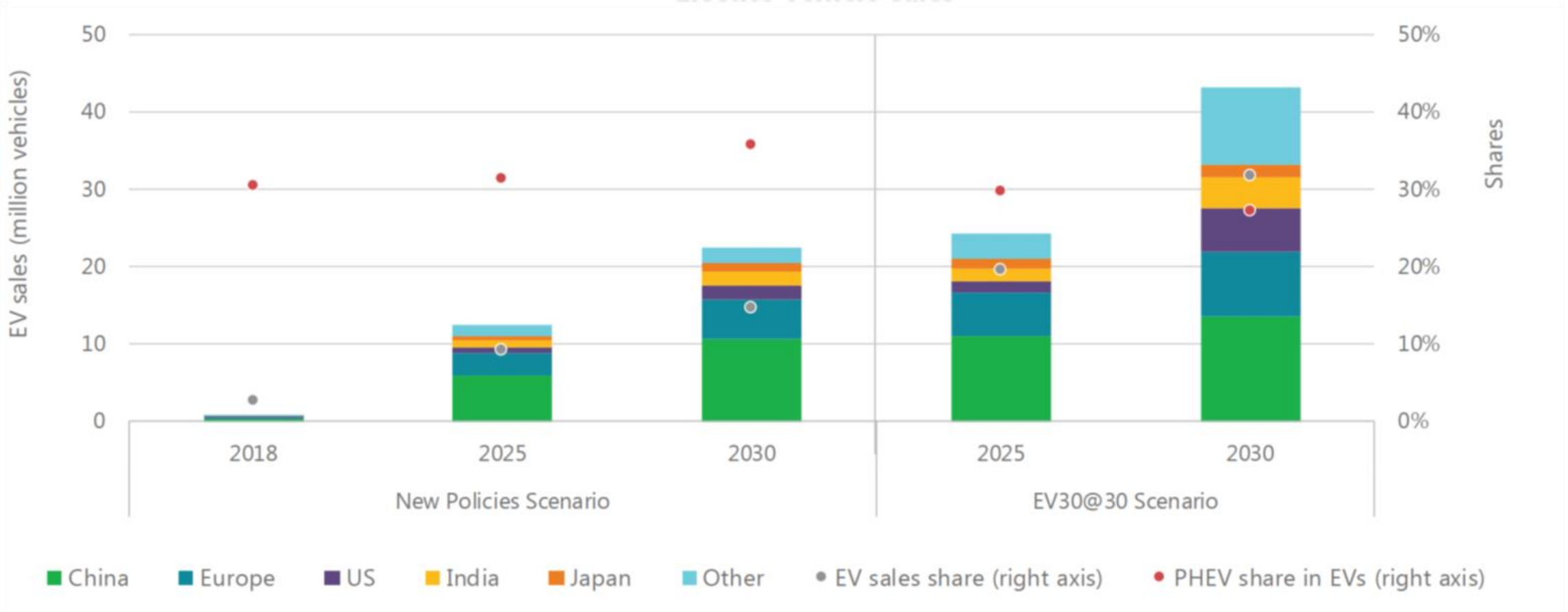
- Continues to growth rapidly – in 2018 5.1 million cars, up 2 million from 2017.
- China the largest market (almost half of the global EV stock), followed by Europe and the U.S. Norway leader in terms of EV market share (46%).
- More than 3 million two-wheelers on roads in 2018, 460 000 buses, 250 000 light commercial vehicles. Lows-speed EV (LSEVs) about 5 million units. Medium trucks sales in thousands.
- 5.2 million EV chargers – most are domestic slow chargers + about 540 000 publicly accesible chargers.
- EV consumed about 58 TWh of electricity (mostly two-wheelers in China), saving 36 Mt CO_2e.
- Global spending on EV purchases grew to $82bn in 2018, up 70% on the previous year, and government support makes up 18% of that spend.

Global EV sales and market share, 2013 - 2018

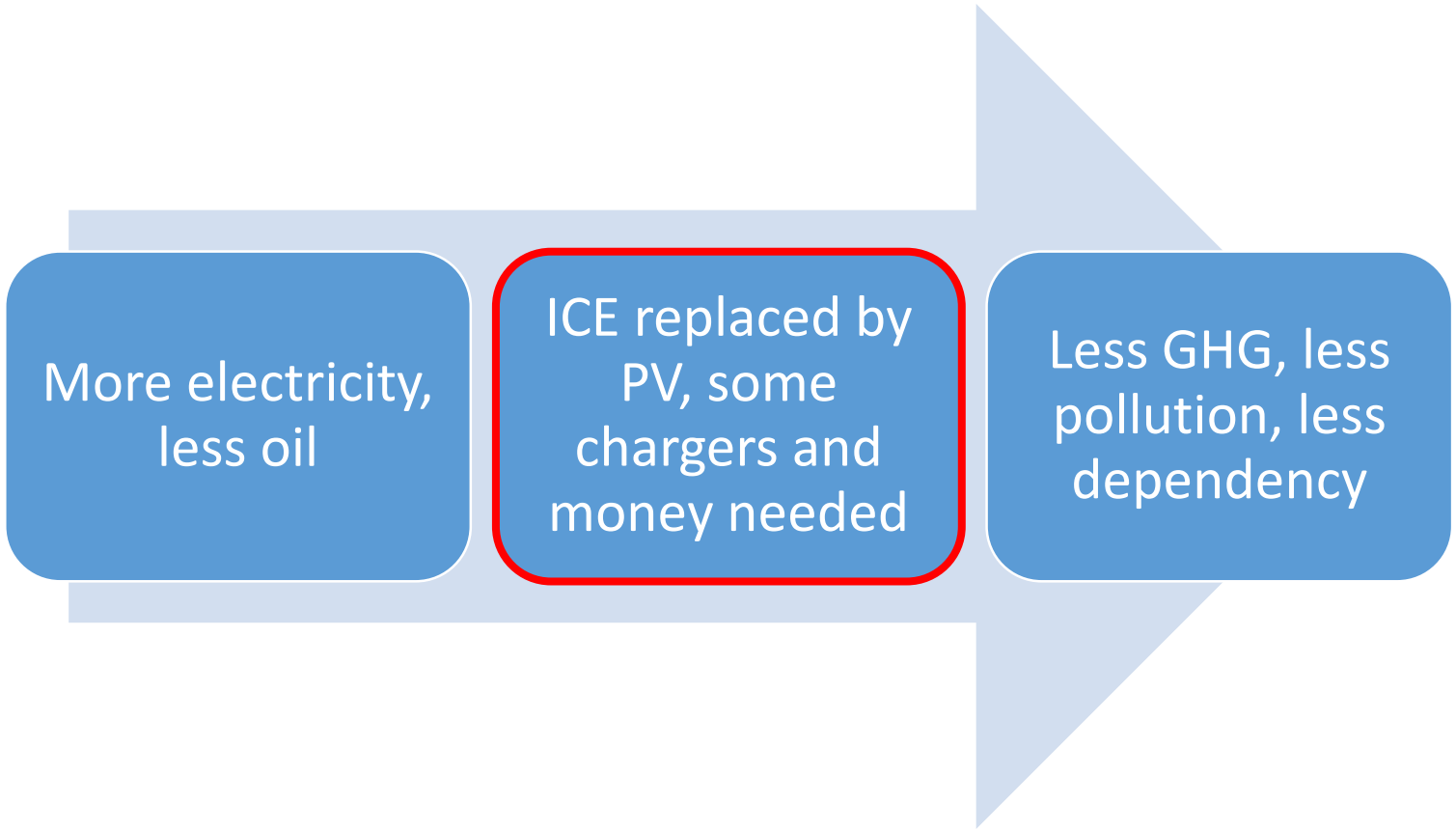
Outook for the 2018 – 2030 period

- New policies scenario (NPS) – works with policies and measures already put in place, plus policies that are in official targets and plans, plus announcements of OEMs producers.
  - EV stock (but two-wheelers) over 55 million EV in 2025 (9% of vehicle sales), 135 in 2030 (15% of sales).
- EV30@30 scenario – in line with Electric Vehicle Iniciative aims at 30% market share for EVs (but two-wheelers) in 2030.
  - EV stock (but two-wheelers) over 250 million in 2030.

Outook for the 2018 – 2030 period – EV sales



Complexity of the transition



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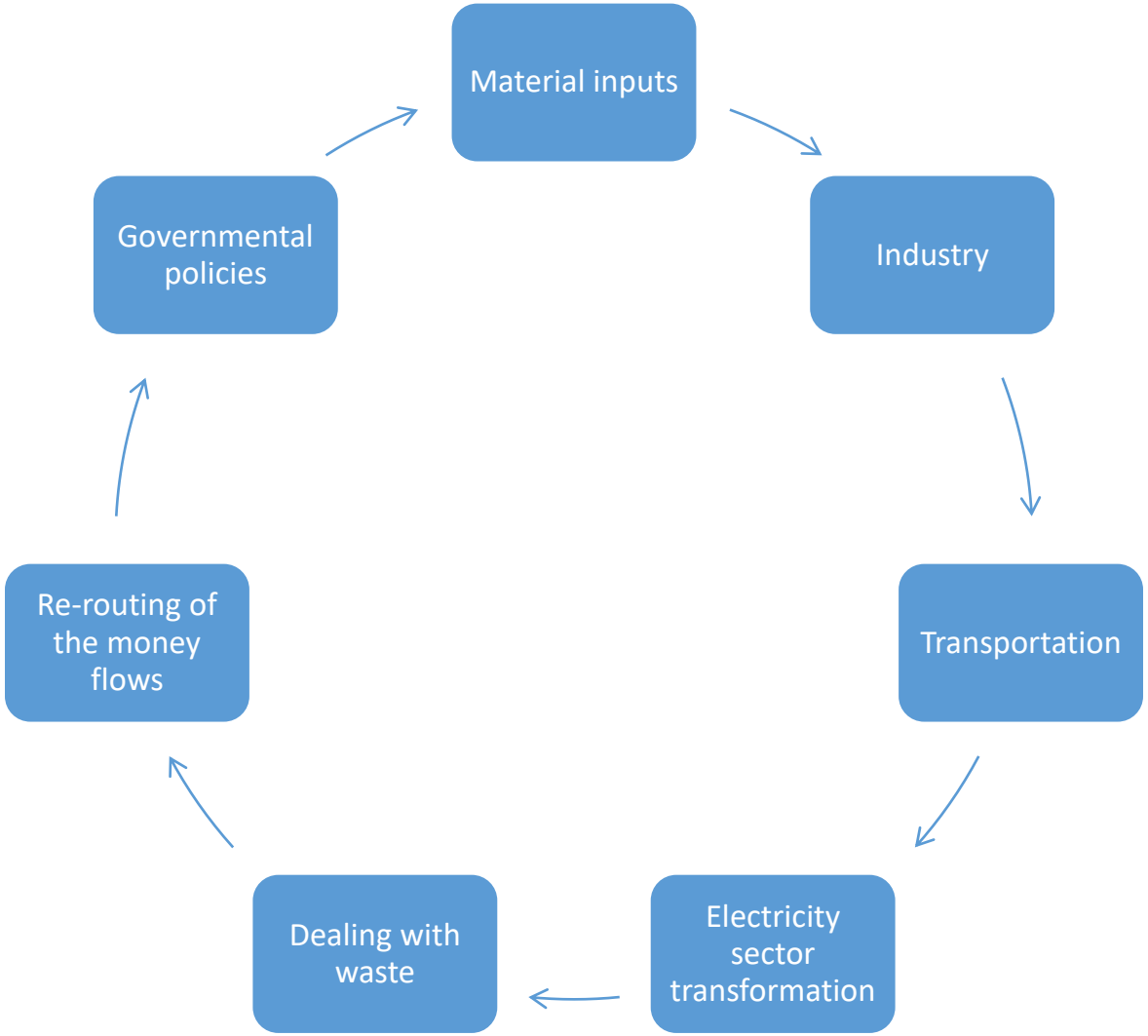
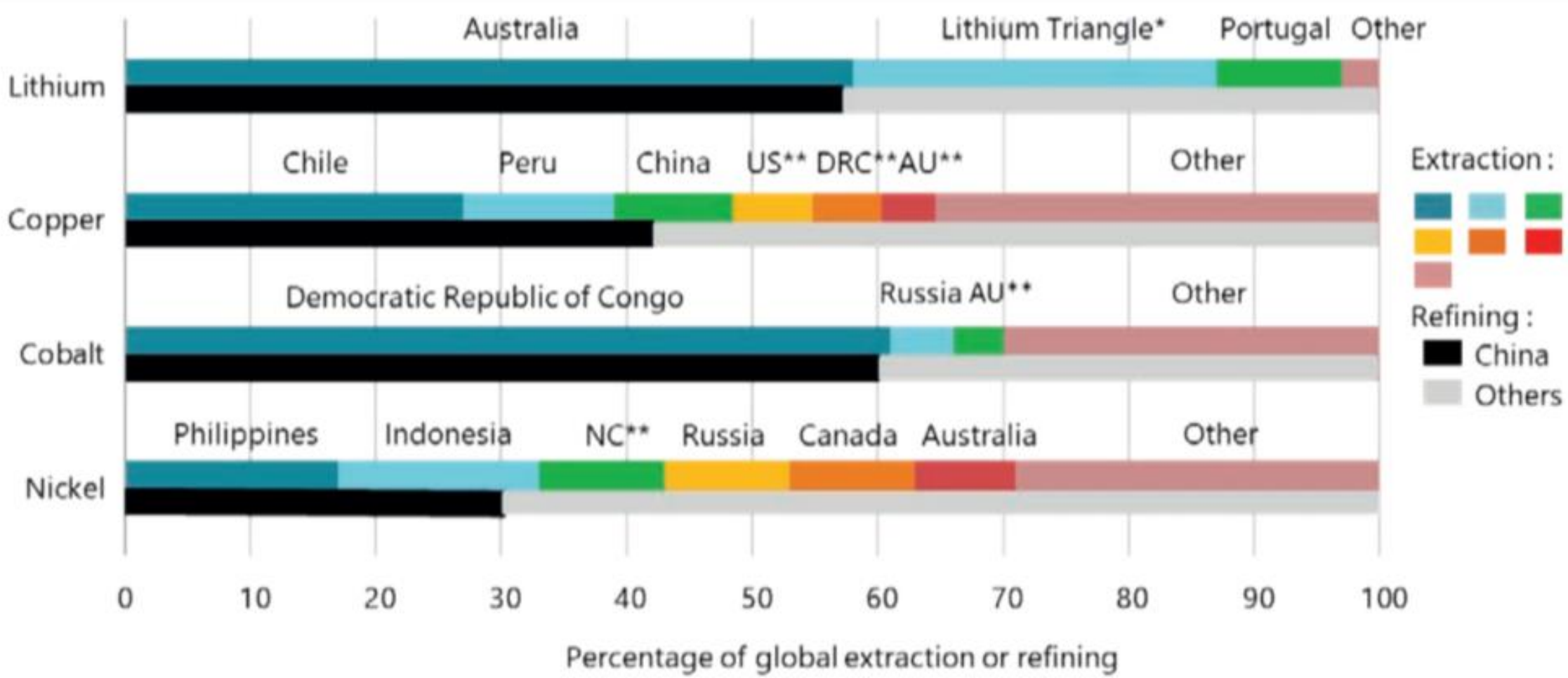


Material inputs

- Oil replaced by a) electricity, b) scarce materials for bateries, c) materials for grid development.
- Underdeveloped and volatile production capacities – demand and supply fluctuations, sudden disruptions, stockpiling.
- Geopolitical considerations.
- Social issues.
- Environmental concerns (mined in countries with low/non-existing standards).



* Lithium Triangle = Argentina, Bolivia and Chile.

** US= United States; AU= Australia; DRC= Democratic Republic of Congo; NC= New Caledonia.

	Lithium	Cobalt	Nickel	Copper
Supply and capacity ramp-up challenges	Large geological availability. Current overcapacity. Up to 10 years lead time to production.	Current production surplus. Up to 10 years lead time to production. Market highly dependent on by-product extraction	Geologically abundant, but variety of end-product grades. Challenges in ramping up capacity for the production of EV battery-suitable grade	Large resources, with long time needed to convert resources into reserves (17 years on average).
Social challenges	In lithium Triangle: water-related conflicts, local (indigenous) community's under-benefitting from the activity, corruption.	20% of mining in DRC is artisanal, which is associated with health and safety concerns for miners, plus child labor. Cases of corruption in both artisanal and largescale mining.	Conflicts with local (indigenous) communities due to environmental issues.	Same social problems as for cobalt in the DRC and some local communities oppose new mining activities (water shortage concerns) (Peru, Chile).

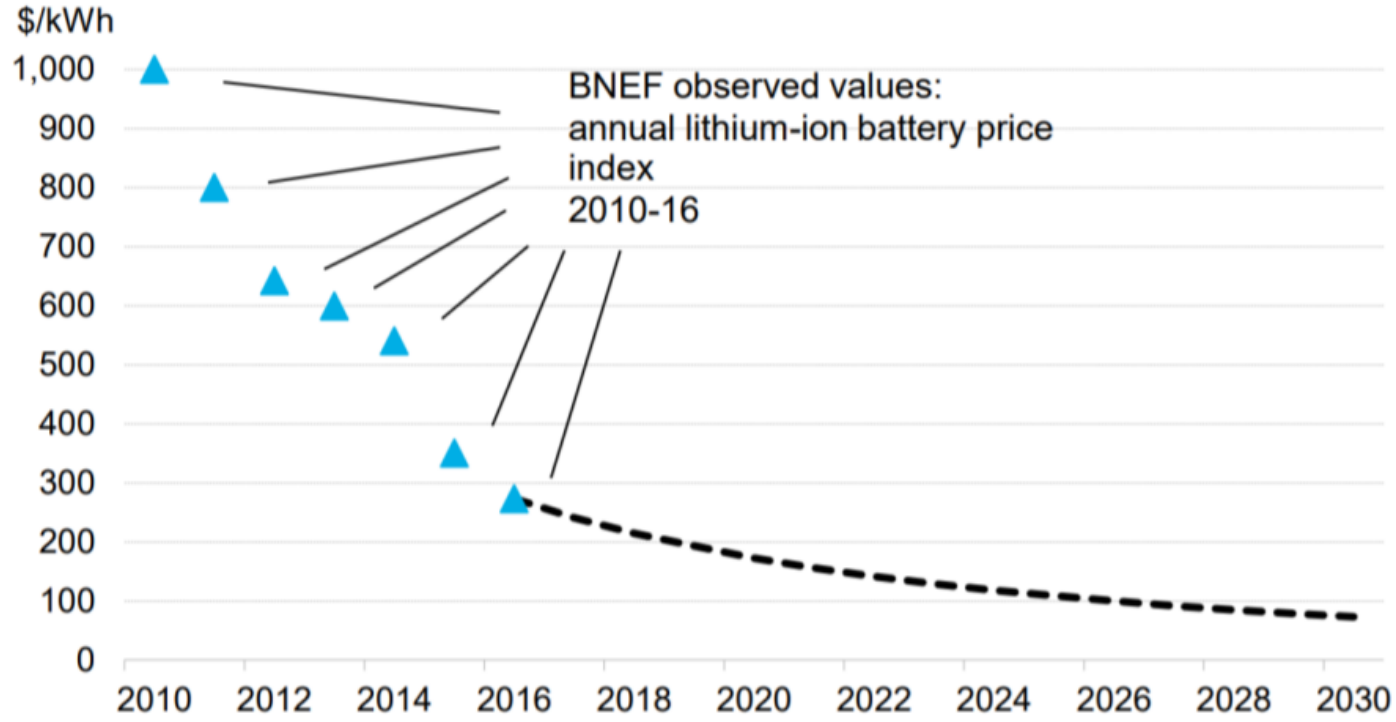
The role of industry

- Driving the development, resulting in lower prices, higher quality of PV vs. scepticism and reluctance to change.
- Standard medium size EV app. 40% more expensive than similar ICE car. Might be competitive in the mid 2020s?

Original equipment manufacturer	Announcement
BMW	15-25% of the BMW Group's sales in 2025 and 25 new EV models by 2025.
BJEV-BAIC	0.5 million electric car sales in 2020 and ***1.3 million electric car sales in 2025***.
BYD	0.6 million electric car sales in 2020.
Chonquing Changan	***21 new BEV models and 12 new PHEV models by 2025, 1.7 million sales by 2025 (100% of group's sales)***.
Dongfeng Motor CO	6 new EV models by 2020 and 30% electric sales share in 2022.
FCA	***28 new EV models by 2022.***
Ford	40 new EV models by 2022.
Geely	1 million sales and 90% of sales in 2020.
GM	20 new EV models by 2023.
Honda	15% electric vehicle sale share in 2030 (part of two-thirds of electrified vehicles by 2030, globally and by 2025 in Europe).
Hyundai-Kia	12 new EV models by 2020.
Mahindra & Mahindra	0.036 million electric car sales in 2020.
Mazda	One new EV model in 2020 and 5% of Mazda sales to be fully electric by 2030.
Mercedes-Benz	0.1 million sales in 2020, ***10 new EV models by 2022 and 25% of the group's sales in 2025.***
Other Chinese OEMs	7 million sales in 2020.
PSA	0.9 million sales in 2022.
Renault-Nissan-Mitsubishi	12 new EV models by 2022. Renault plans 20% of the group's sales in 2022 to be fully electric. Infiniti plans to have all models electric by 2021.
Maruti Suzuki	A new EV models in 2020, ***35 000 electric car sales in 2021*** up to ***1.5 million in 2030.***
Tesla	Around 0.5 million sales in 2019 and a new EV model in 2030.
Toyota	**More than** ten new models **by the early 2020s** and 1 million BEV and FCEV sales **around** 2030.
Volkswagen	0.4 million electric car sales in 2020, up to ***3 million electric car sales in 2025***, 25% of the group's sales in 2025, 80 new EV models by 2025 and ***22 million cumulative sales by 2030.***
Volvo	50% of group's sales to be fully electric by 2025.

Lithium-ion battery price index

- Prices dropped by 79% between 2010 – 2016.

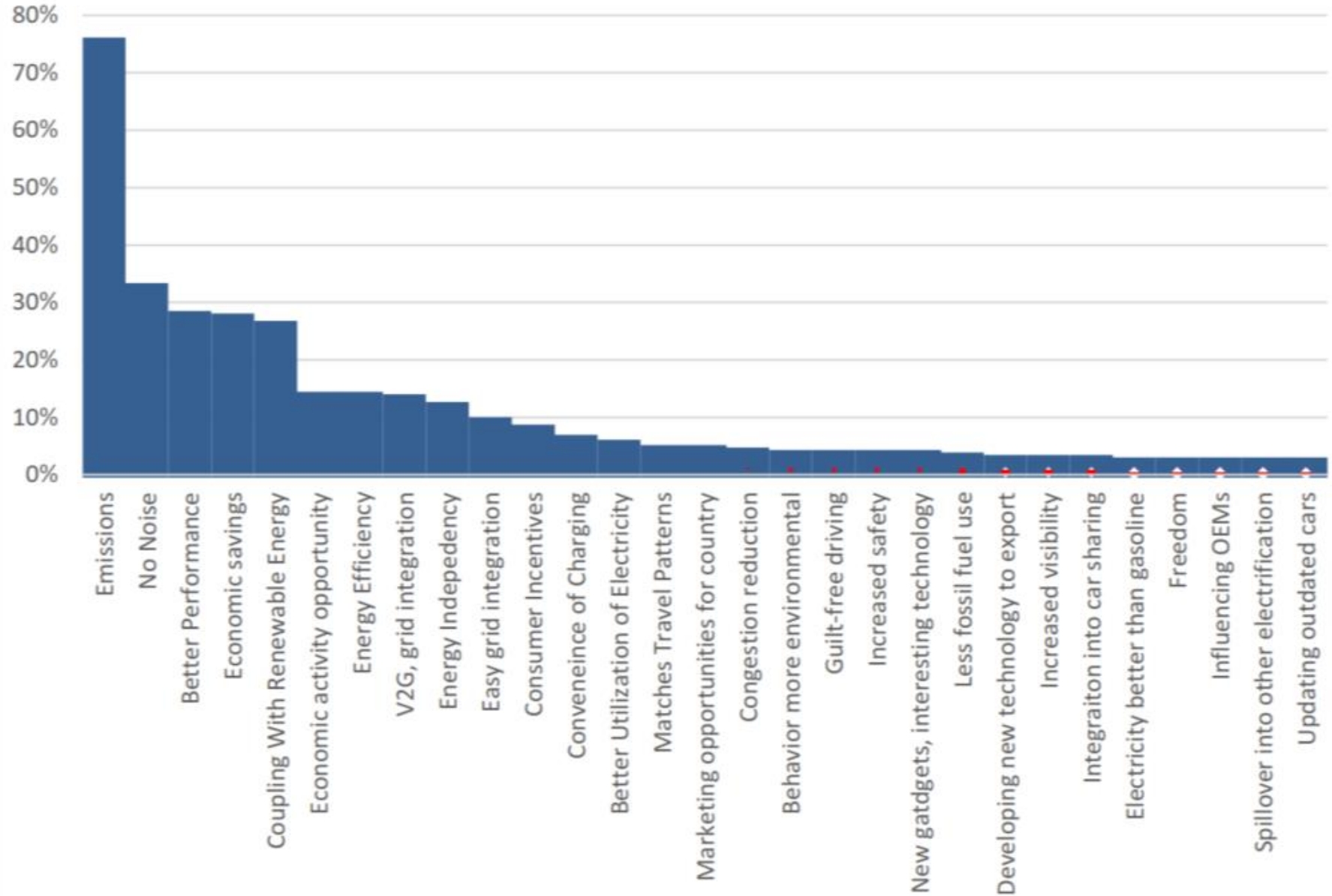


Societal lock-in

- Customers are not fully rational, cost and time-driven actors.
- (Unrealistic) expectation that automobile culture will be replaced by any means to get somewhere at an affordable costs.
- However, cars are also means of indentification, conspicuous consumption, abodes of privacy and solitude (cocooning and fortressing) and ritual, instruments of aggression and skil, ceremonial initiations into adulthood, potential hobbies.
- Cars provide status and emotional affect through their speed, security, safety, link to sexuality, career achievement, facilitation of freedom.

= Not only what you need, but what you yearn for.

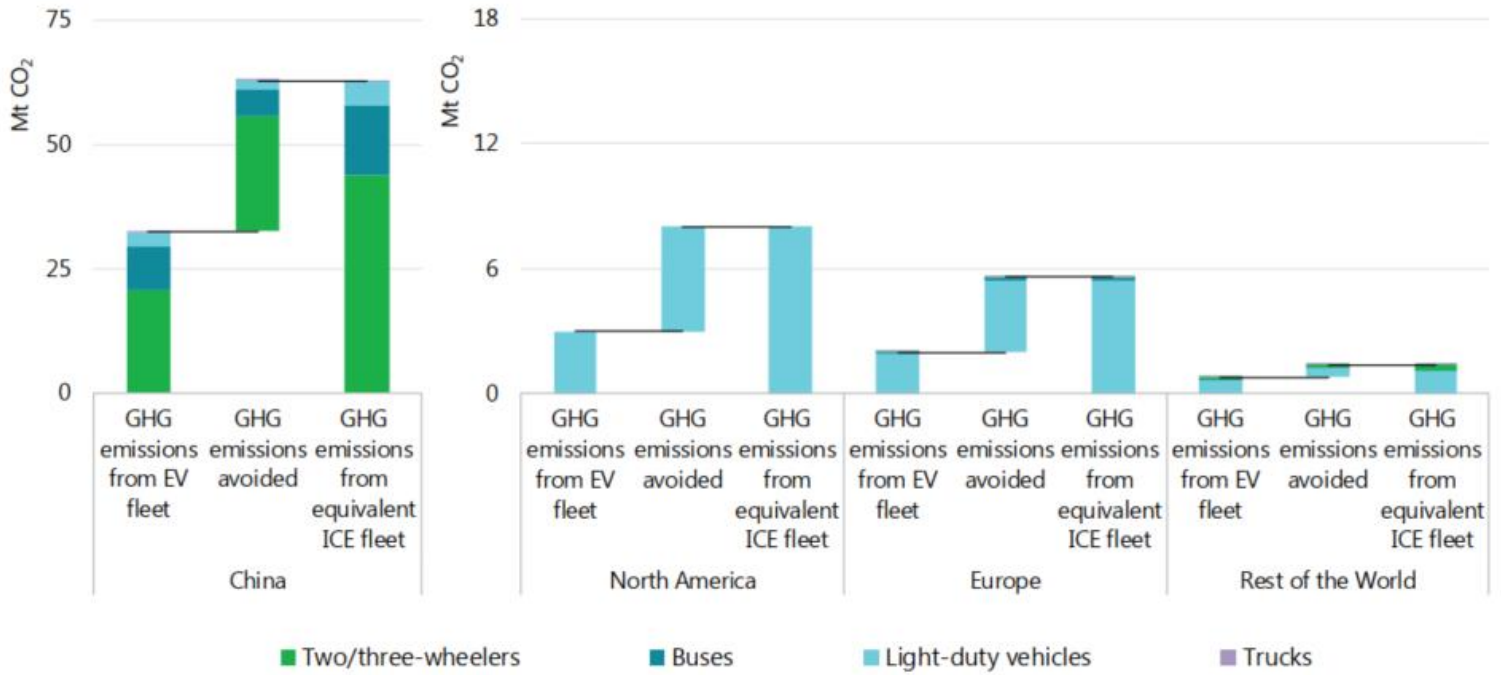
Figure 5: Co-Benefits of EVs Identified in Interviews with Nordic Consumers



Societal lock-in

- In 2018 EV stock emitted about 38 Mt CO_2e, saving about 40 MtCO_2e. (30 Mt in China only).
- Source of electricity?

Figure 1.7. GHG emissions avoided by EVs compared to equivalent ICE fleet by mode and region, 2018



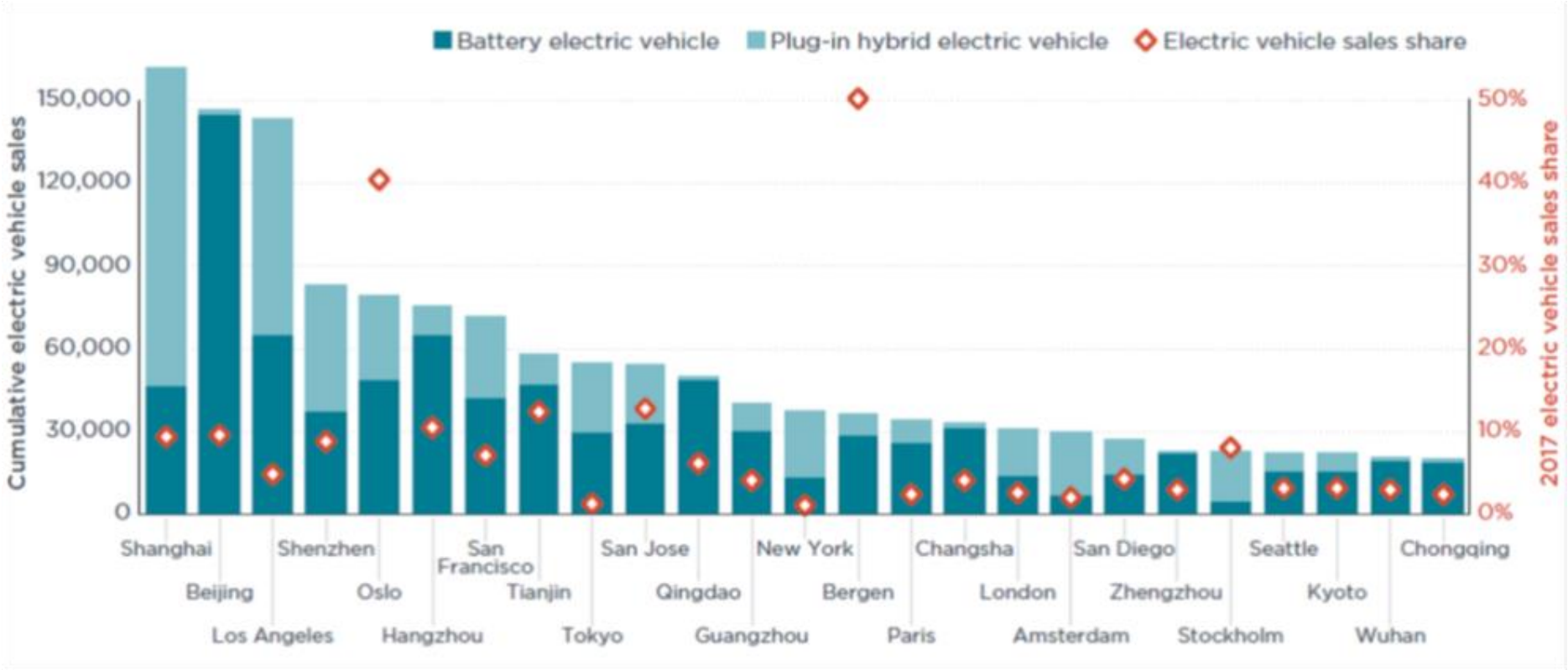
Notes: GHG emissions from an equivalent ICE fleet indicate the WTW CO_2-eq emissions that would have been emitted if the EVs would have been ICE vehicles of equivalent size. The carbon intensity of the national power systems account for transmission and distribution losses. Light-duty vehicles include cars and light-commercial vehicles. Buses include buses and minibuses. Trucks include medium- and heavy-freight trucks.

Societal lock-in

- Long tailpipe emissions (the whole lifecycle – 270 000km for all of them)
  - Tesla Model S P100D saloon – 226g/CO_2/km (US midwest).
  - 7-series BMW 750i xDrive – 385g/CO_2/km.
  - Mitsubishi Mirage – 192g/CO_2/km.
- Controversy about proper measurement – MIT and FT.

EV in cities

- 25 world cities accounting for 44% of global EV shales.
- By 2050 nearly 70% of the world´s population concentrated in cities.

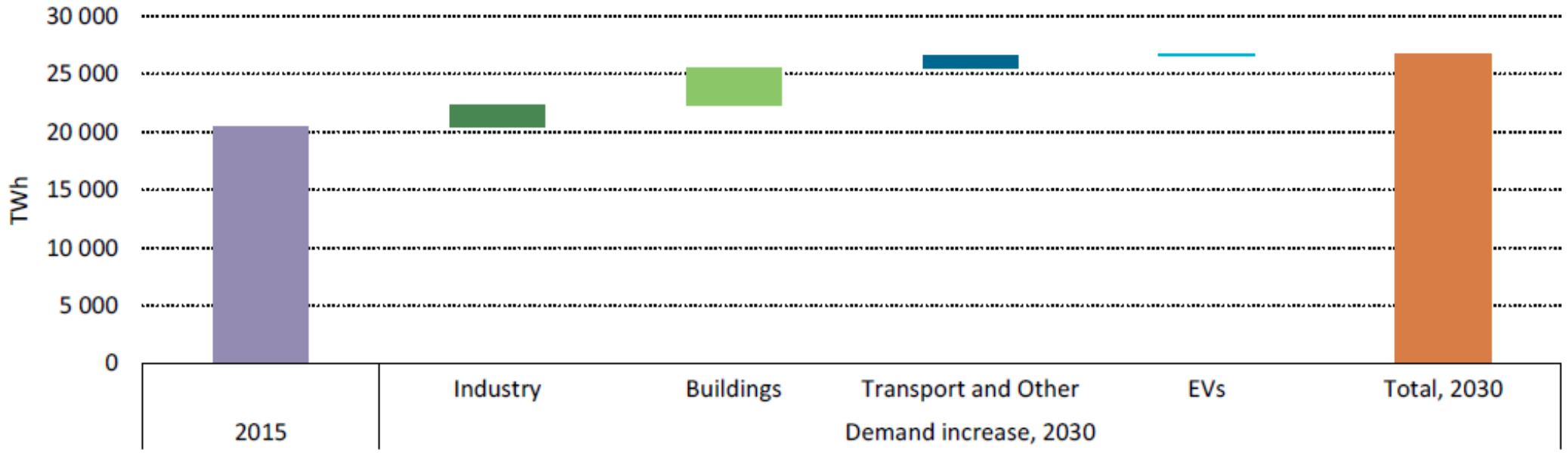


Electricity sector challenges

- Increased demand (now equal to the consumption of Switzerland, 68 TWh).
- Different patterns of consumption (overloading the grid).

- (Enforced?) adaptation of charging to the ability of the grid (low-price/demand periods).
- EVs may provide DSR services to the system across a wide range of time scales and to participate in electricity markets.
- EV batteries can store energy that may be used for other purposes than powering the vehicle, thanks to the opportunities offered by vehicle-to-grid or vehicle-to-home.

Impact of EV deployment on global electricity demand, 2°C Scenario



Dealing with waste

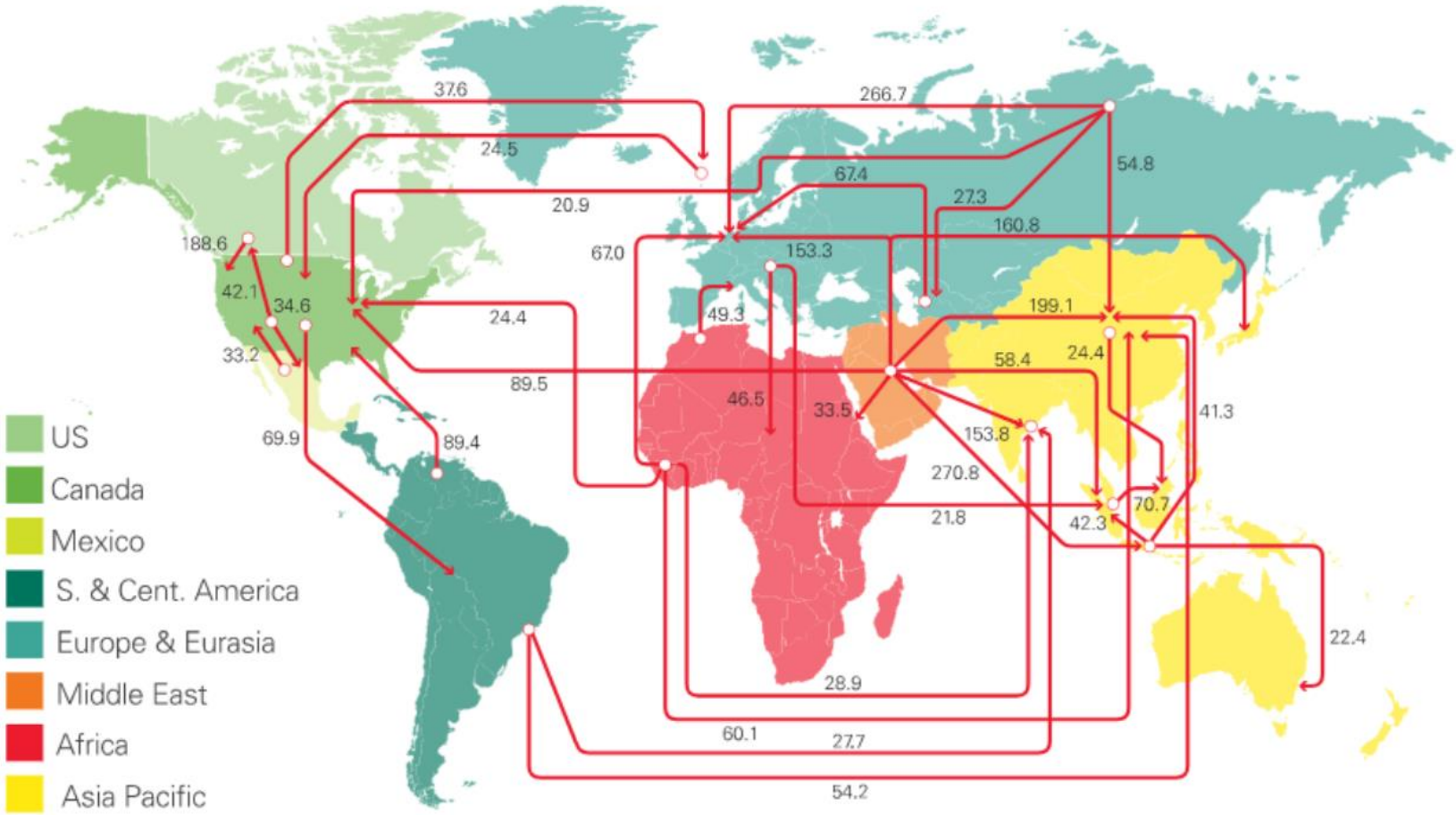
- Reusing of materials: using the old batteries as a stationary storage.
- Recycling of materials. 2018 data: 179 000 tons of batteries reaching their end of life, 83% of them for small appliances (cell phones, laptops, power tools). Of the total volume 97 000 recycled. Primarily in China (67 000 tons) and South Korea (18 000 tons).

Flow of money – global trade/money flows

- Projected EV stock in the New Policies Scenario would cut demand for oil products by 127 million tonnes of oil equivalent (Mtoe) (about 2.5 million barrels per day [mb/d]) in 2030, while with more EVs in the EV30@30 Scenario the reduced oil demand is estimated at 4.3 mb/d.
- In 2018, about 97 million barrels consumed per day.

= serious effect on stability of the international system.

Oil major trade movements 2016 (million tonnes)



Flow of money – impact on the national level

- China produces about 30% of worldwide vehicle production (larger than the US, EU and Japan combined).
- In US, automakers and their suppliers responsible for 3% of GDP and one of the largest sources of manufacturing jobs. Export of more than USD 692 bn in vehicles and parts.
- EU – 6.1% of total employment (13.3 mil workers), trade surplus of EUR 90.3 billion.
- Japan – 8.7% of workforce.
- South Korea – 7% of GDP.

- Redistribution of opportunities and wealth.

Role of the government

- The uptake of EV driven primarily by the policy environment. Policy measures makes EV more appealing for customers, while reducing the risk for investors and manufacturers.

- Public procurement programmes.
- Financial incentives (esp. upfront costs deliver best results) to facilitate the acquisition of EVs (Norway´s VAT reduction and vehicle registration tax exemptions…).
- Cutting their usage costs (free parking…).
- Regulatory measures at different administrative levels (fuel economy standards …).
- ICE vehicle bans.

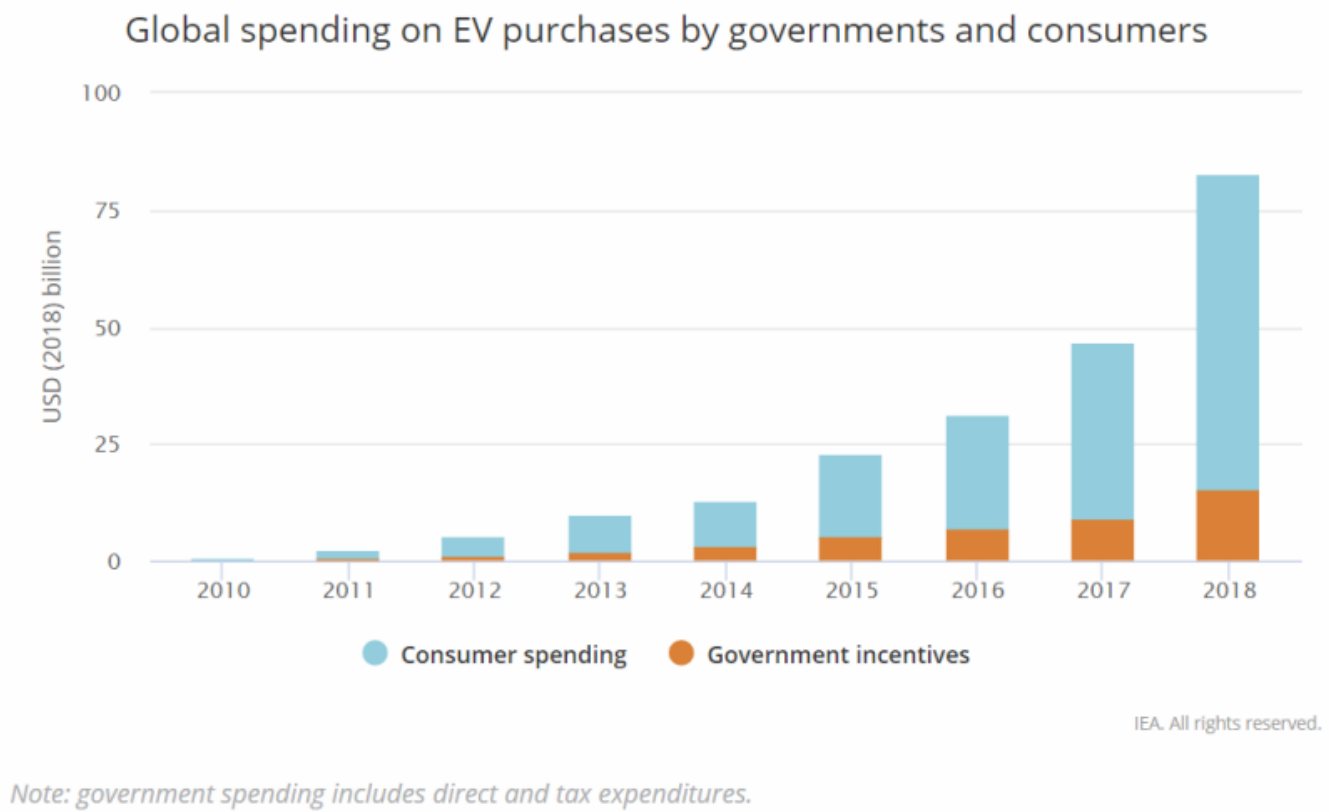
		Canada	China	European Union	India	Japan	United States
Regulations (vehicles)	ZEV mandate	✓*	✓				✓*
	Fuel economy standards	✓	✓	✓	✓	✓	✓
Incentives (vehicles)	Fiscal incentives	✓	✓	✓	✓		✓
Targets (vehicles)		✓	✓	✓	✓	✓	✓*
Industrial policies	Subsidy	✓	✓			✓	
Regulations (chargers)	Hardware standards**	✓	✓	✓	✓	✓	✓
	Building regulations	✓*	✓*	✓	✓		✓*
Incentives (chargers)	Fiscal incentives	✓	✓	✓		✓	✓*
Targets (chargers)		✓	✓	✓	✓	✓	✓*

*Indicates that it is only implemented at state/local level.

** All countries/regions in the table have developed fundamental standards for electric vehicle supply equipment (EVSE). Some (China, European Union, India) mandate specific minimum standards, while Canada, Japan and United States do not.

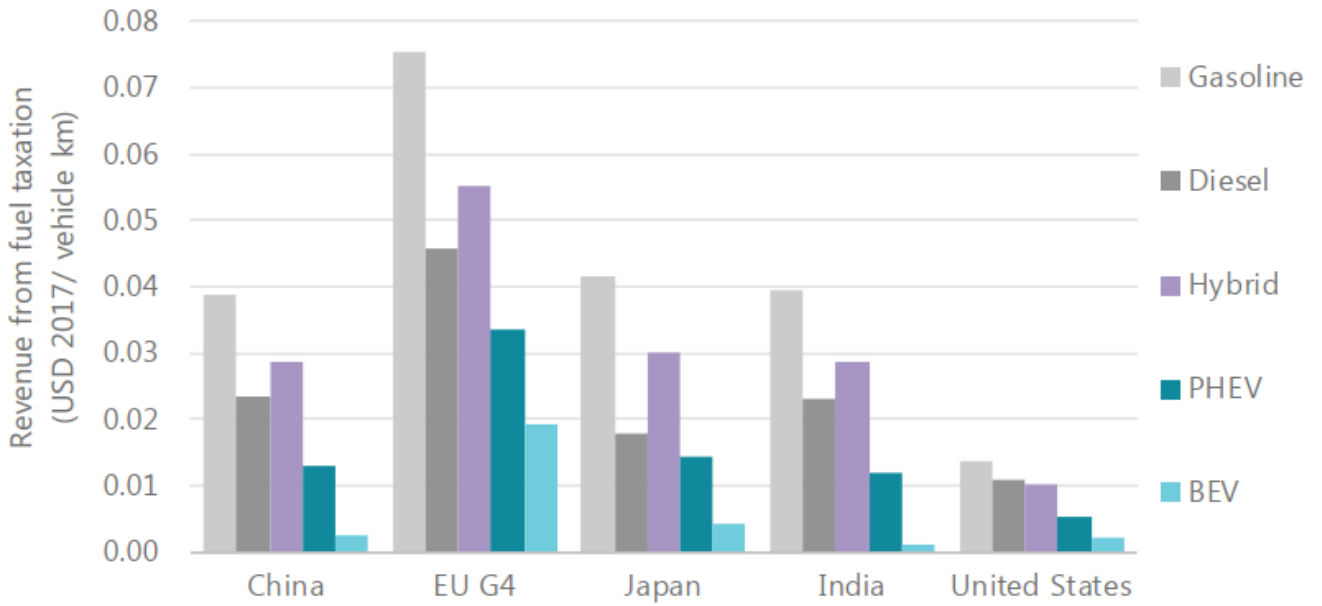
Future of subsidies?

- Ability to financially support PV?
- Shift from direct subsidies to demands on industry, standards.



Revenue from taxation of new cars based on energy use per vehicle km and powertrain type, 2017

- Income of the governments - The combination of taxes on transport vehicle and fuel use was estimated to be as high as 3.5% of GDP by OECD in 2014.



Notes: EU G4 includes France, Germany, Italy and United Kingdom. Average fuel consumption per powertrain is based on fuel economy values from the IEA Mobility Model and the Argonne National Laboratory GREET model, linked to the 2017 Worldwide Harmonised Light Vehicle Test Procedure (WLTP) values and market shares of vehicle size segments of the IEA-GFEI database on new LDV registrations with a real-driving correction of 20% (ANL, 2018; IHS Markit, 2018) (IEA, 2019b). PHEVs are assumed to be in all-electric mode for 60% of their vehicle kilometres and one-third using gasoline. Hybrids are assumed to use gasoline. Electricity taxes for India and United States are based on the weighted average of residential electricity consumption, sales tax and local taxes per state. Values for Japan, EU G4 and the United States (except US electricity tax) are based on the IEA World Energy Prices 2018 database (IEA, 2018e). Tax rates for China and India are estimates based on Bankbazaar (2018) and Avalara (2019).

Design selection

- PV most prefered variant.
- However, there is more – hybrids, hydrogen cars, LPG, CNG…
- Warning example of biofuels.

Complexity of the transition

- Feedbacks/visious circle.
- Tipping point? (Multiple designs unlikely).
- Time will be needed.

Sources

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- OECD/IEA (2017): Technology Roadmap: Biofuels for Transport
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- IEA. (2014) IEA and IPCC: Summary for Policymakers

Local demand profile and electric car charging in the EU on a typical day, B3DS, 2030.