Recent and on-going projects
in the Energy Technology Policy (ETP) transport group

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iTEM4, IIASA

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Outline

I. International shipping
   Data sources, methods, contributions to the IMO GHG strategy, and future engagement

II. Global Electric Vehicle Outlook 2018
   Report goals, scope in 2018, scope in 2019

III. The Future of Rail
   Project background, report goals, data sources and methods, current status

IV. The Global Fuel Economy Initiative
   Project background, report goals, data sources and methods, current status

V. Current and future methods for projecting demand in MoMo
   Current methods for generating passenger and freight demand
   Initial plans for revamping the methodology

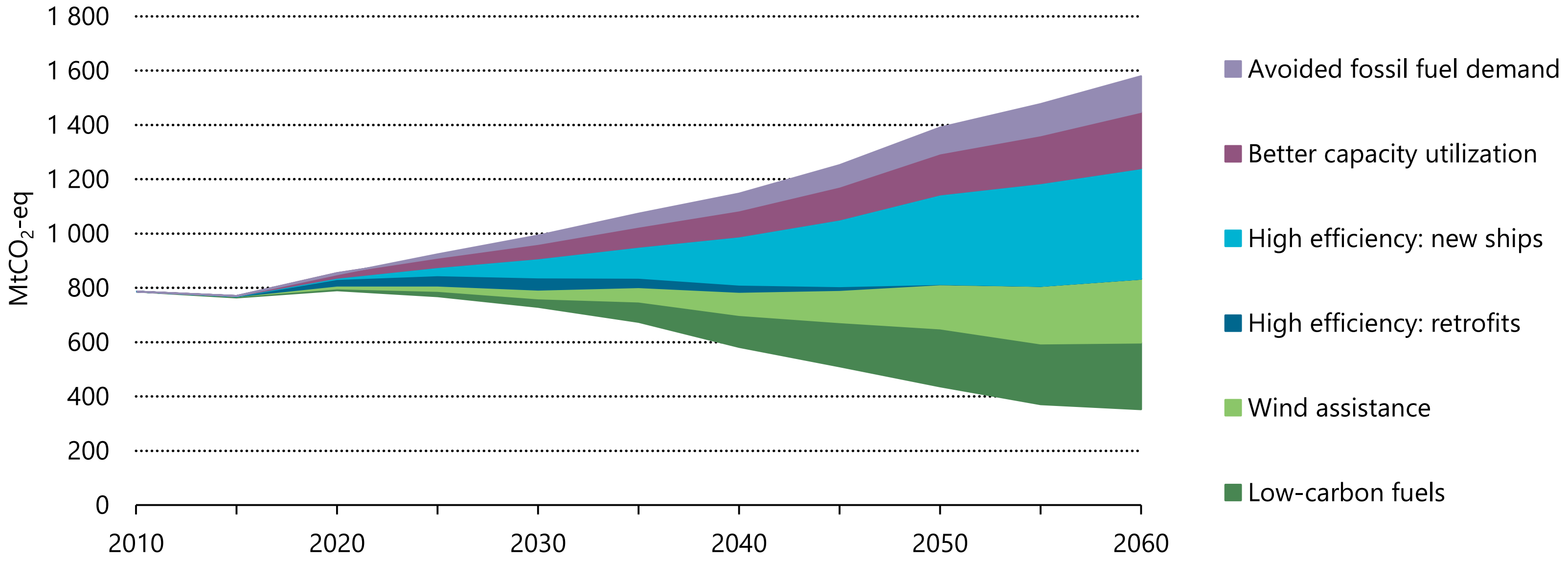
I. International Shipping - resources

- Evolution of Global Maritime Freight Energy demand and CO2 emissions: a BAU and 2DS Scenario
  Master's Thesis by Renske Schuitmaker, Utrecht University & IEA
- Lloyd's Register (UMAS; Tristan Smith, UCL):
  Zero-emission vessels 2030. How do we get there?
- Energy Transitions Commission: Reaching zero carbon emissions from shipping
- DNV GL: Maritime Forecast to 2050: Energy transition outlook 2018

Recent projections of maritime activity, energy demand, and emissions have sought to inform and influence the IMO GHG strategy, as well as future discussions

A broad portfolio of measures is needed

WTW GHG emissions in international shipping (freight) in the B2DS relative to RTS



The B2DS reaches a 50% reduction of GHG emissions between 2050 and 2060 compared with 2008.

Achieving B2DS targets requires immediate policy action

- **Raising the ambition of the EEDI**

- New ships are 50-60% more efficient by 2030 in the B2DS (relative to EEDI baseline)
- expand scope to **include operational energy efficiency requirements** to existing ships (existing ships are nearly 20% more efficient by 2030 in the B2DS)

- **Low-carbon fuel regulation** to mandate the adoption of low-carbon shipping fuels

- By 2030, WTW carbon intensity of marine fuel needs to be 5-10% lower relative to 2015
- By 2050, WTW carbon intensity of marine fuel needs to be close to 50% lower

- **Introducing CO2 taxes on fuels**, to support the implementation of above measures

- ETP model has 100 USD/tonne by 2030, but no specific carbon price for shipping was calculated

II. The Global EV Outlook 2018

iea.org/**gevo2018**

EVI flagship report by the IEA

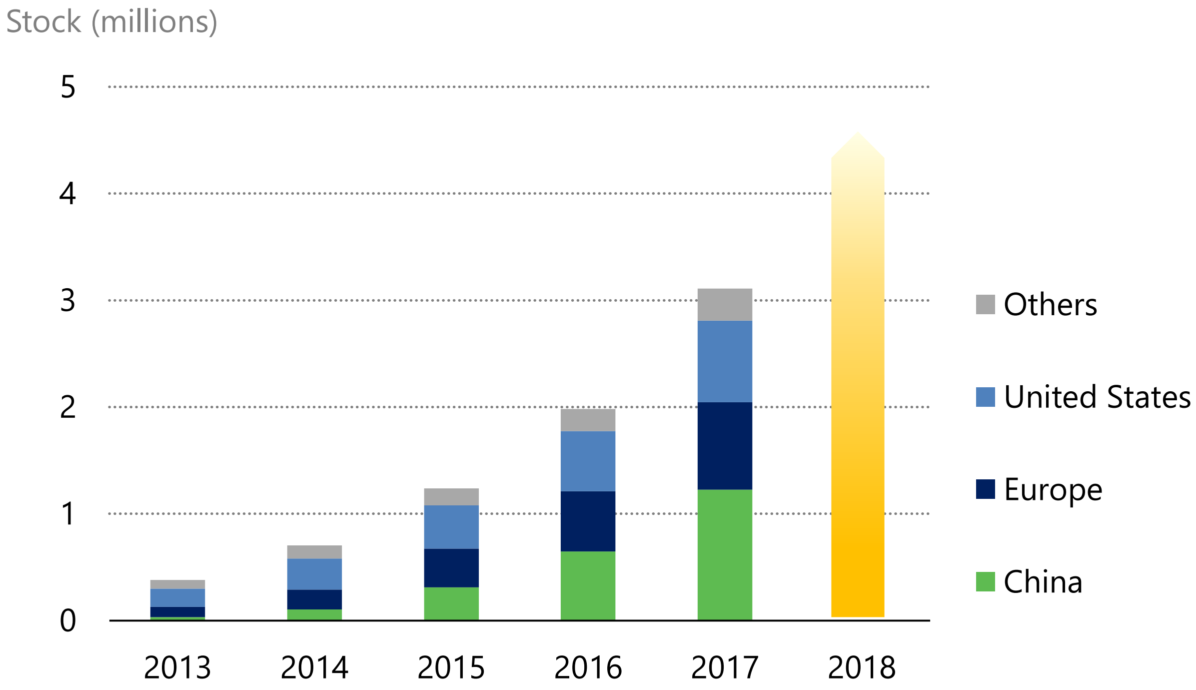
2018 edition includes

- Data reporting (EV stock, sales, EVSE, battery costs)
- Overview of existing policies in various world regions
- Battery technology and cost assessment
- Implications on the TCO of road vehicles – *across many vehicle types*
- Role of EVs in IEA low carbon scenarios (2030 timeframe)
- Electricity demand, oil displacement and GHG emission mitigation
- Battery material demand
- Policy recommendations

2018 edition also paired with the Nordic EV Outlook 2018

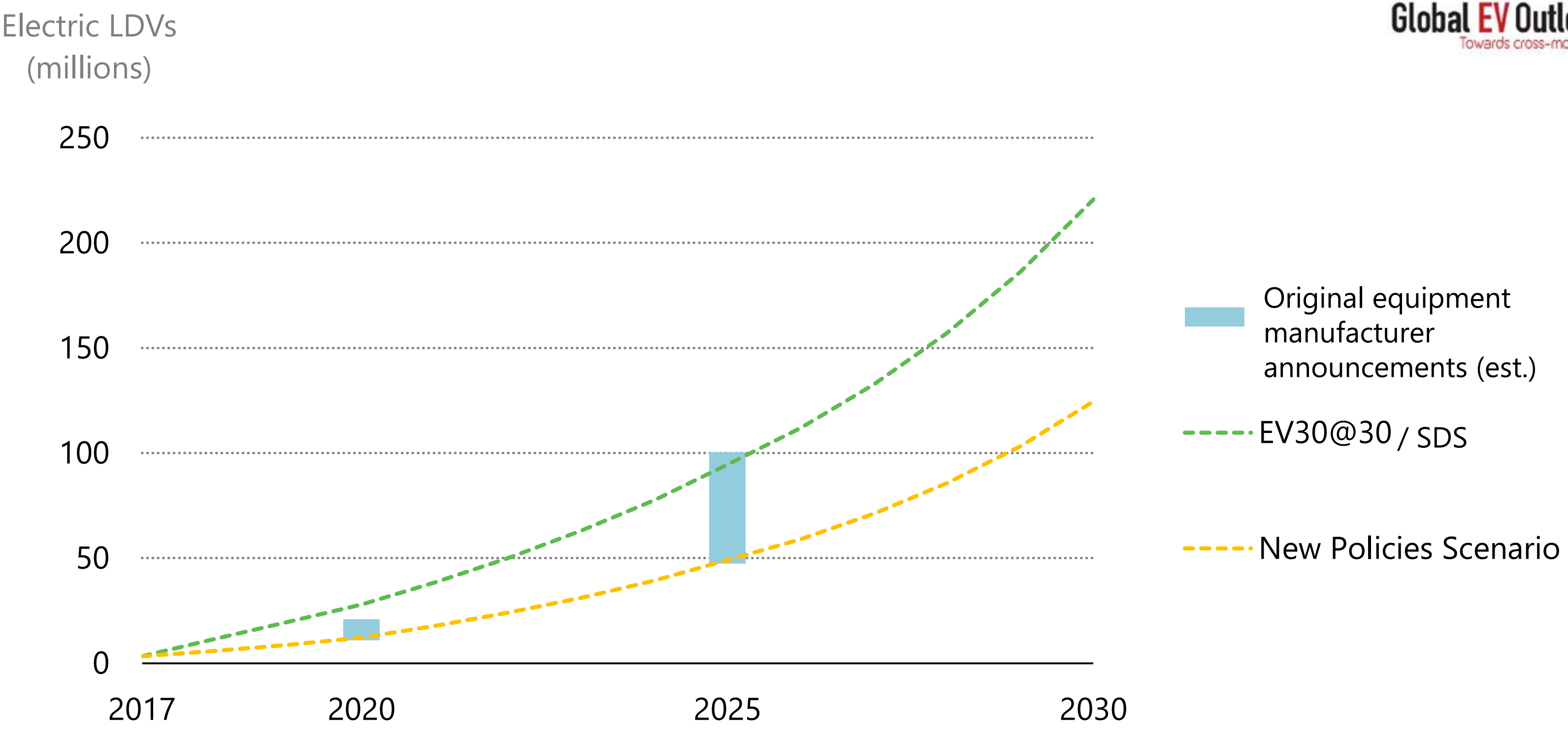
- Focus on one of the most dynamic global regions for EV uptake
- Opportunity to learn on policy efficacy and consumer behaviour

EV's expanding rapidly from a low base…



Annual sales of electric cars topped 1 million for the first time in 2017, and the global stock surpassed 4 million in summer 2018

… but major challenges achieving goal of 30% sales by 2030



Estimates based on manufacturers' projections suggest an uptake of electric LDVs in-between the *New Policies Scenario* and *EV30@30* by 2025

Electric mobility: Beyond cars to two-wheelers, buses and trucks



Electric 2-wheelers: major phenomenon in China, where there are 250 million in the rolling stock and 30 million sales per year

Low Speed Electric Vehicles: estimated at 4 million units in China (sales above 1 million). Not favoured by policy support but by cost and practicality (small size, no driving license/registration required)

Buses: 360 000 in China. Close to 90 000 sales in 2017. Stimulated by policy support.

Growing interest in C40 cities (better economics: not only local air quality or climate-driven phenomenon)

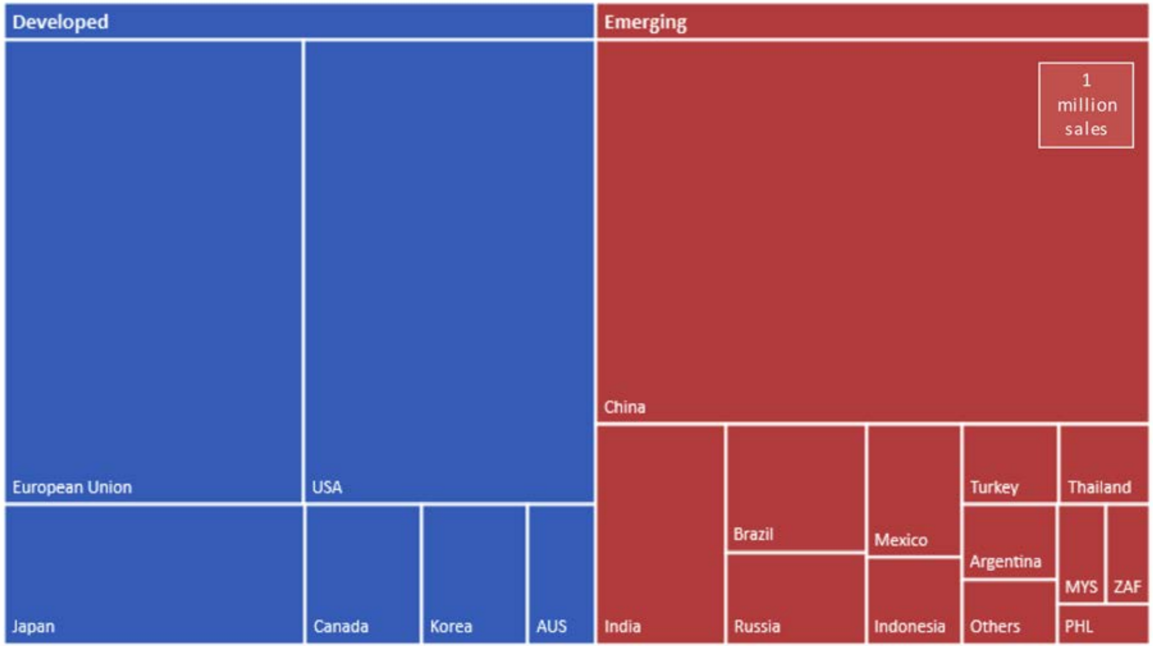
III. The Future of Rail:
Laying the track to meet energy and environmental policy goals

- The next installment in the IEA's 'Future-of' series on 'energy blind spots'
- Joint project between the IEA and the UIC (Union Internationale des Chemins de fer)
- Builds substantially upon joint annual data publications
  Railway Handbook: Energy Consumption and CO_2 emissions
- Focus on India (launch with the Minister of Railways, hopefully also with PM Modi)
- Other key data providers &/or partners:
  - UITP (Union Internationale des Transports Publics)
  - ITDP (The Institute for Transportation and Development Policy)
  - Jan Havenga, Stellenbosch University, South Africa (freight rail)
- India: TERI, India Railways

Thus far, the report has provided an opportunity to revisit historical data in major rail regions (OECD Europe, Japan, Korea, China, India, Russia, US and Canada) and modeling assumptions and methods.

IV. Global Fuel Economy Initiative (GFEI) benchmarking paper, 2018

Figure 1 • Yearly registrations in 2017 in the analysed markets

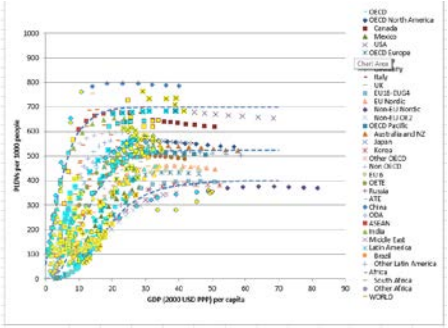


Sources: IHS Markit 2018

Increasingly detailed and robust data set and panel data statistical analysis undertaken by the IEA, in cooperation with the ICCT, UC Davis, UNEP and the FIA Foundation

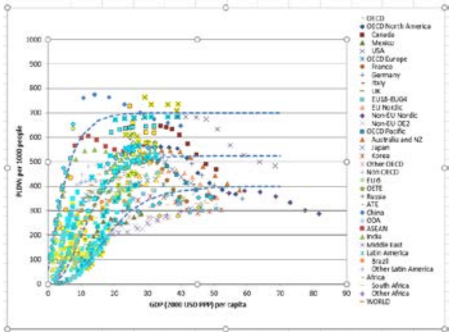
V. Demand generation in MoMo: passenger demand

- Passenger demand generation: based on urban / non-urban “S-curve” relationships between GDP per capita and three driving variables:
  - Vehicle ownership (separate consideration between PLDVs and 2&3-wheelers)
  - Vehicle mileage
  - Passenger car / 2-wheeler modal share
    (versus motorized mass transit – rail & bus)



NPS

2DS

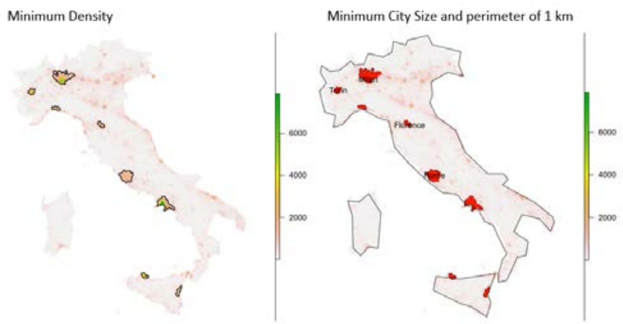


Example of Urban Personal vehicles ownership

MoMo’s current ‘personal vehicle’ projections build upon three Gompertz curve relationships, which evolve differently in urban and non-urban environments

Demand generation in MoMo: passenger demand

- The evolution of demand is modulated by policies,
- Policy effectiveness is estimated on the basis of city-level case studies (e.g. difference-in-difference or cross sectional comparisons); and elasticities
- The effectiveness of these policies is modelled/modulated as a function of the distribution of population density



Applying Threshold Criteria
Potential for Metro Access in Italy in 2015

Policy impacts are modelled based on city classifications, and estimated impacts on vkm, vehicle ownership, and modal shift; these are also modulated by population density

Demand generation in MoMo: passenger demand (cont)

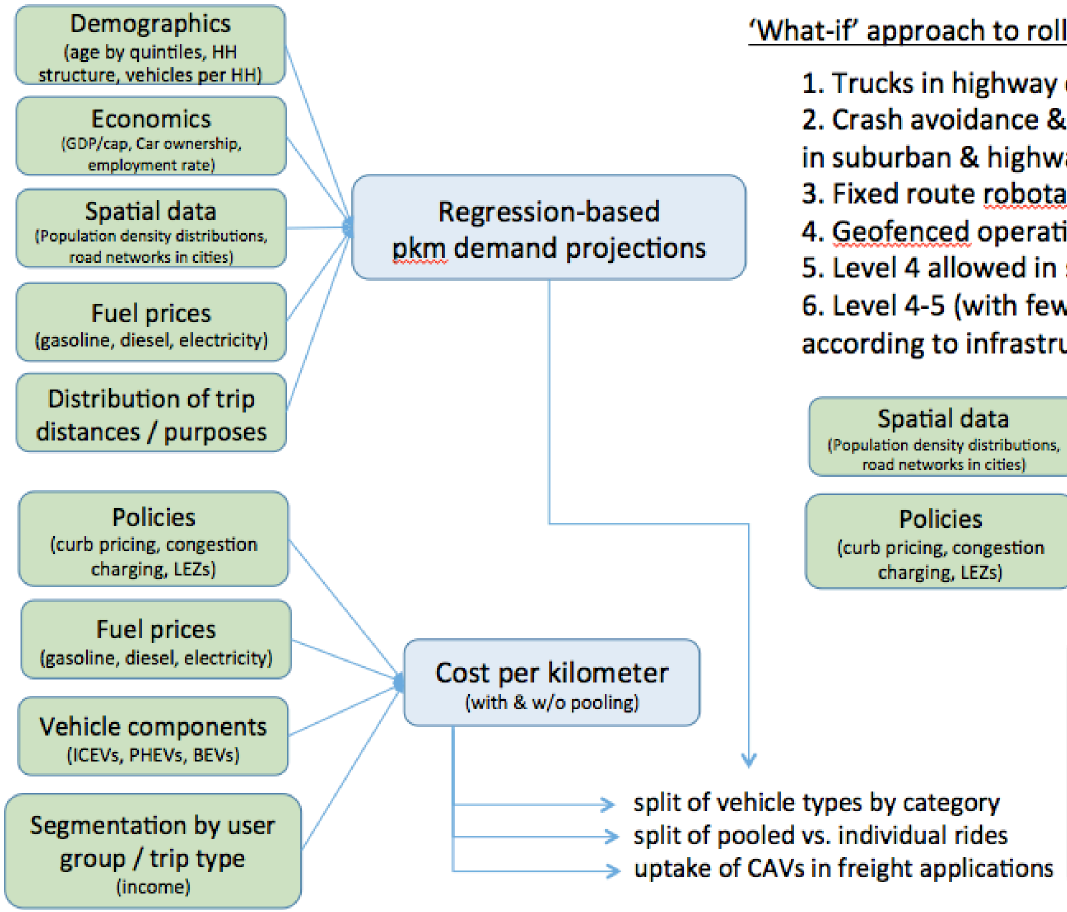
- Separate GIS analysis of the potential for modal shift between HSR, intracontinental aviation, and long-distance road travel being developed / refined for the Rail report.

Demand generation in MoMo: freight demand

- Trucking and rail: tkm per capita ~ GDP per capita + other variables (log-log)
- Shipping: link to ITF trade model

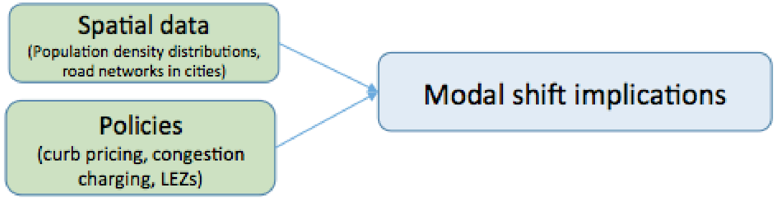
- Ideally, it'd be nice to tie all three modes to the ITF trade model

Demand Generation in MoMo – Current ideas



<u>'What-if' approach to rollout of CAV technologies in various use cases</u>

1. Trucks in highway operations: platooning
2. Crash avoidance & traffic flow improvements ('connectivity') in suburban & highway driving (v2v, v2i)
3. Fixed route robotaxis & robobuses
4. Geofenced operations in districts
5. Level 4 allowed in suburban & highway driving
6. Level 4-5 (with fewer and fewer 'hiccups') rollout in cities, according to infrastructure readiness



	Human driver	Autonomous driven
Privately owned		
Mobility service fleets		

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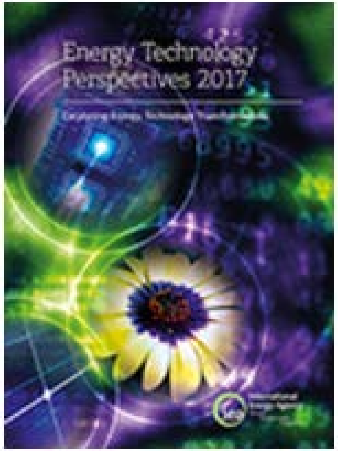
Supplemental slides

International Energy Agency (IEA) and the Mobility Model

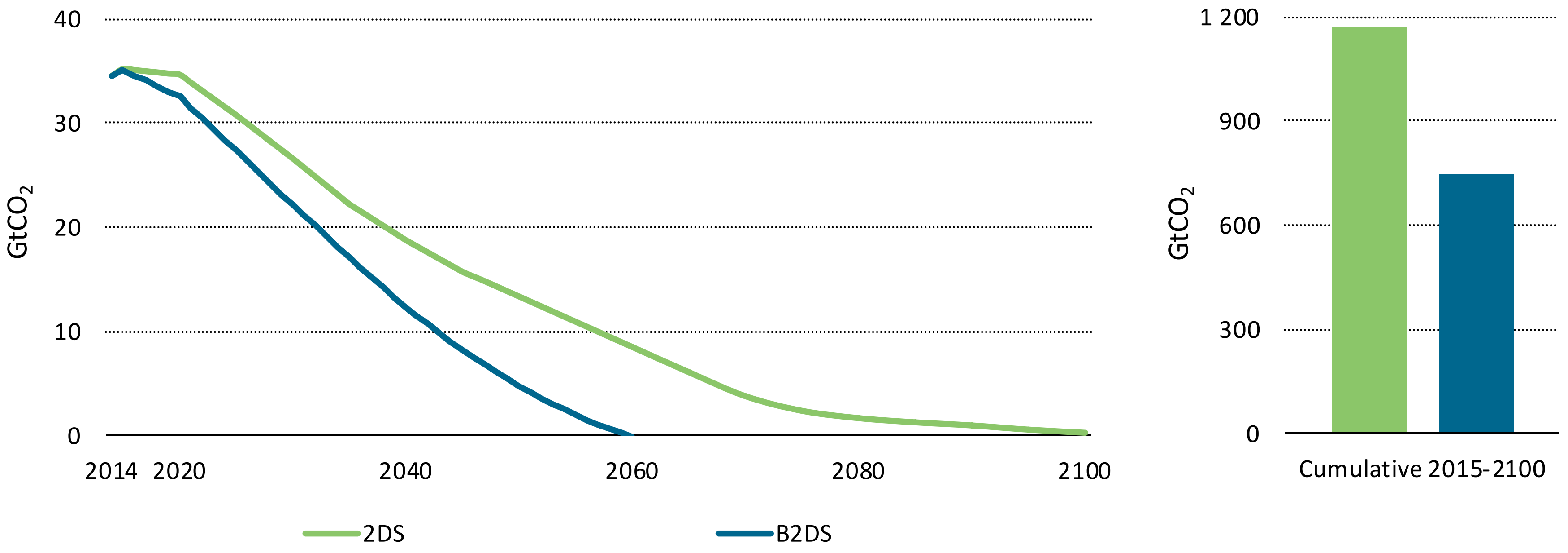
- "The IEA is an autonomous organisation that works to ensure reliable, affordable and clean energy for its 30 member countries and beyond"
  - **Increasing cooperation with non-members, mainly BRICS**

- In transport, development of the Mobility Model (MoMo)
  - Analytical tool used to elaborate the projections of transport activity, energy demand and CO2 emissions in Energy Technology Perspectives since 2006
  - The foundation of transport-related analysis in the Sustainable Policy and Technology Directorate
  - An essential tool for transport-related activities on…
    - energy efficiency: Global Fuel Economy Initiative (GFEI)
    - energy technology: Electric Vehicles Initiative (EVI)
    - cooperative efforts: Railway Handbook on Energy Consumption and CO2 emissions with UIC



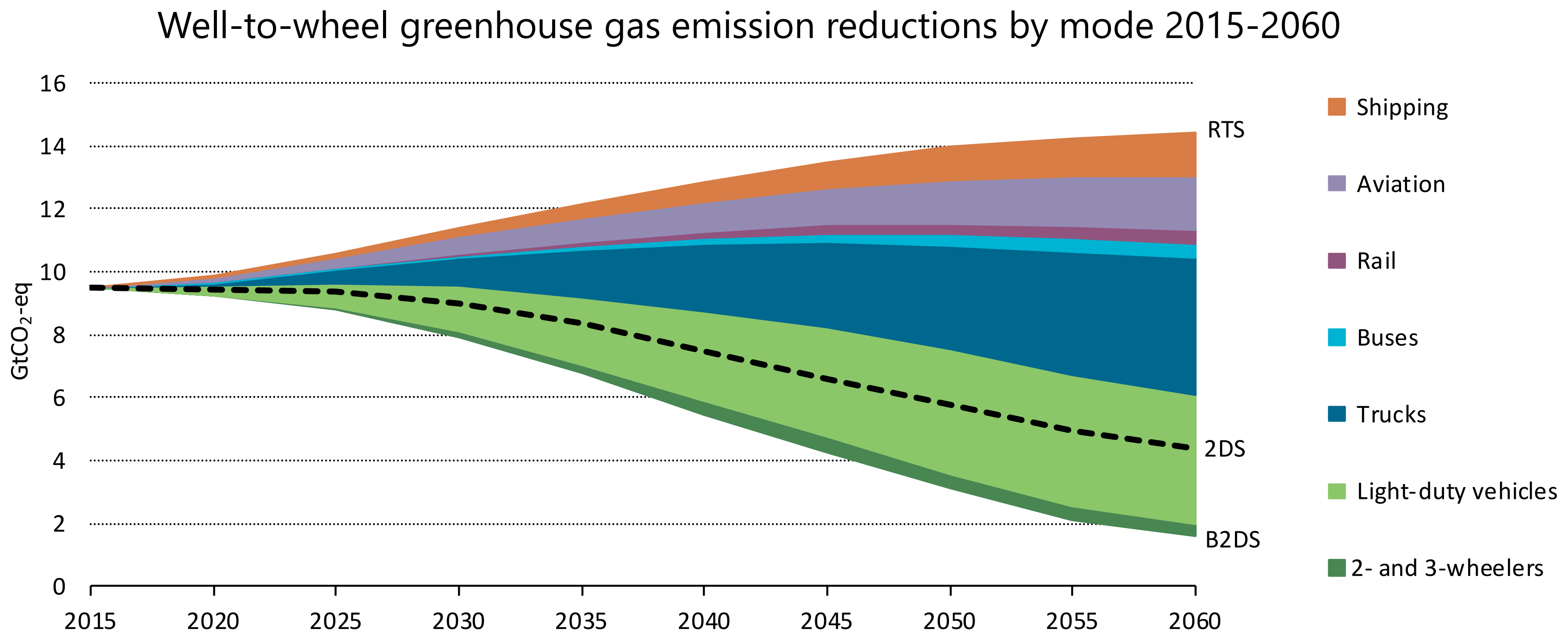
ETP 2017 and Shipping:
GHG emission budgets and trajectories for the global energy sector

The 2°C Scenario (2DS) and the Beyond 2°C Scenario (B2DS)



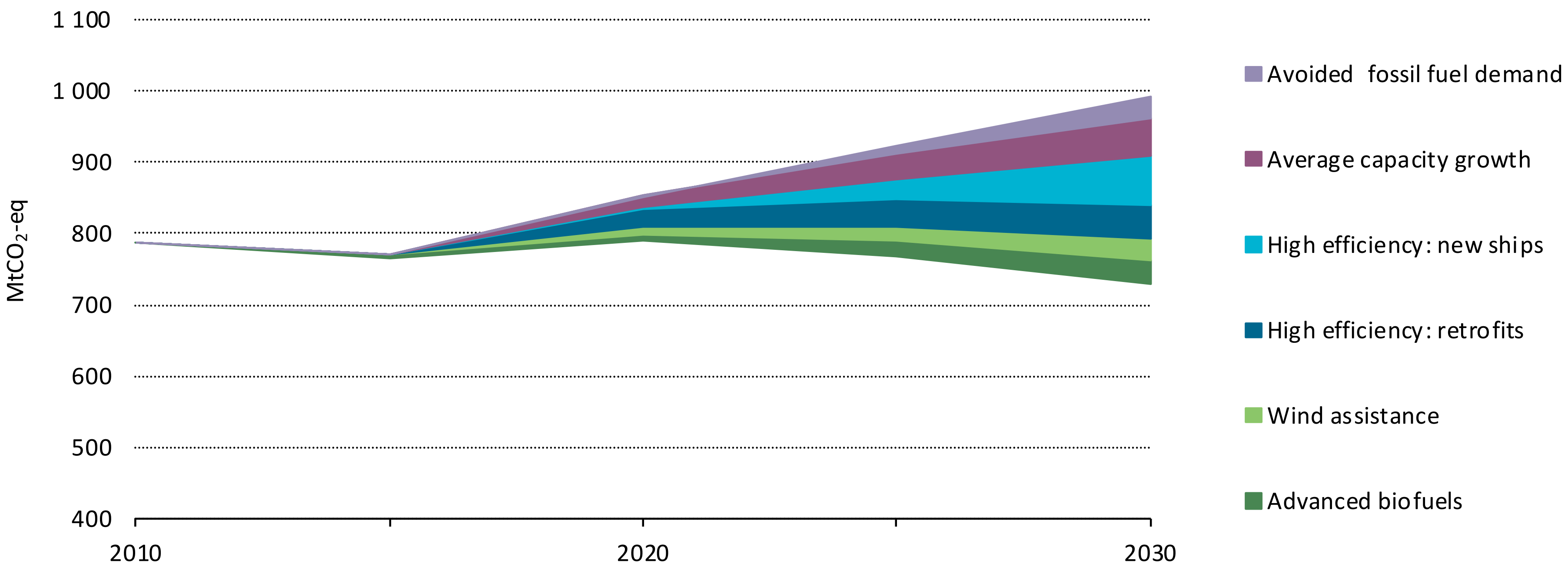
To meet the ambition of the Paris Agreement, energy sector CO_2 emissions need reach net zero in the second half of the century

ETP 2017 and Shipping:
B2DS: analysis of energy system decarbonisation, transport



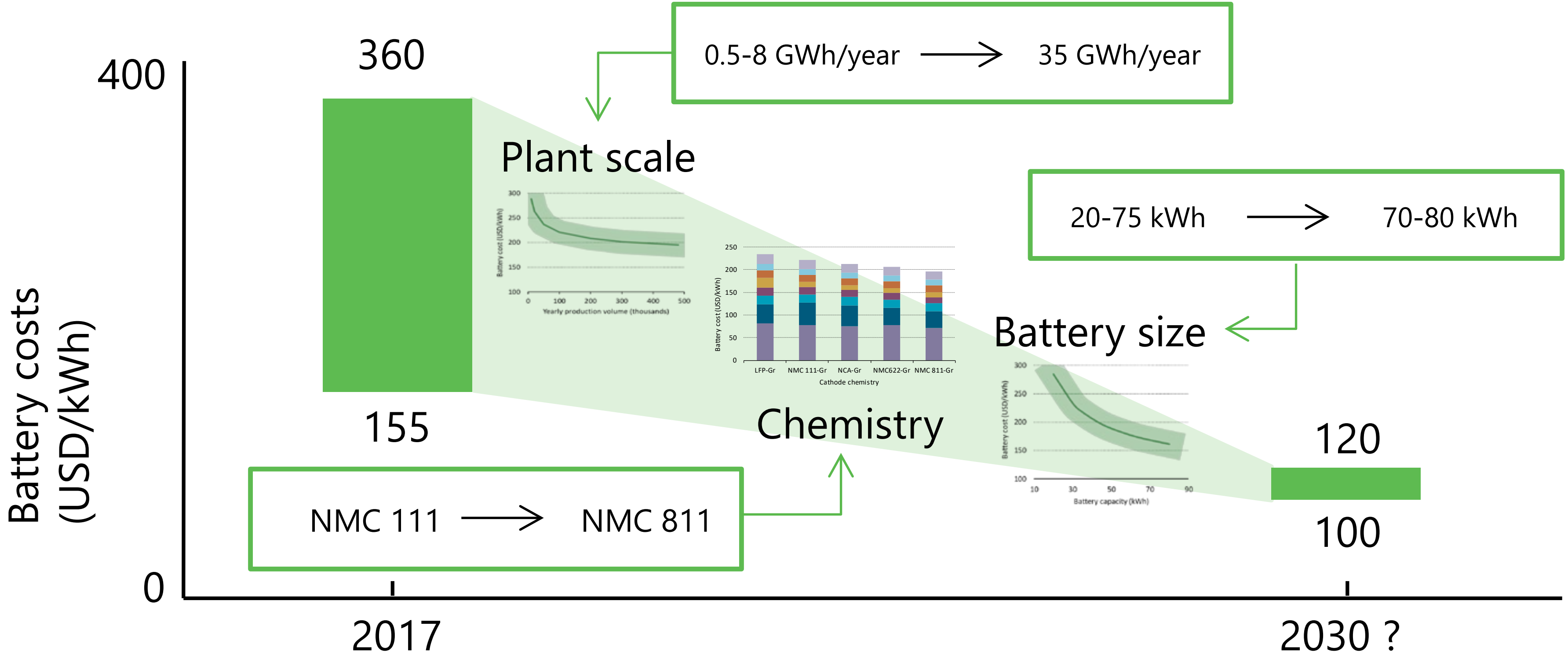
WTW GHG emissions from transport are 89% lower in 2060 than in 2015 in the B2DS, while in the 2DS they decline by 54% over the same period. All modes contribute to decarbonisation.

ETP 2017 and Shipping:
WTW GHG emissions in international shipping (freight) in the B2DS relative to RTS: 2010-2030



In earlier years the contribution of retrofits to reducing GHG emissions is significant

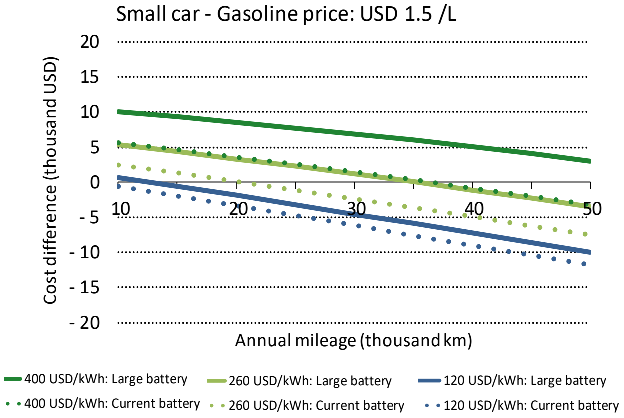
GEVO 2018: Lithium-ion batteries: further cost reductions within reach…



The combined effect of manufacturing scale up, improved chemistry and increased battery size explain how battery cost can decline significantly in the next 10 to 15 years

GEVO 2018: Implications for the cost competitiveness of EVs

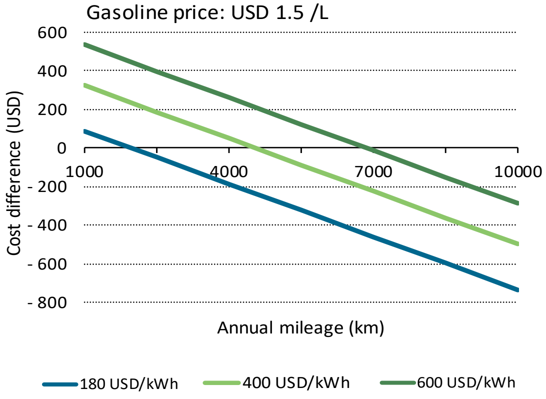
LDVs - BEV



BEVs are most competitive in markets with **high fuel taxes** and at **high mileage**

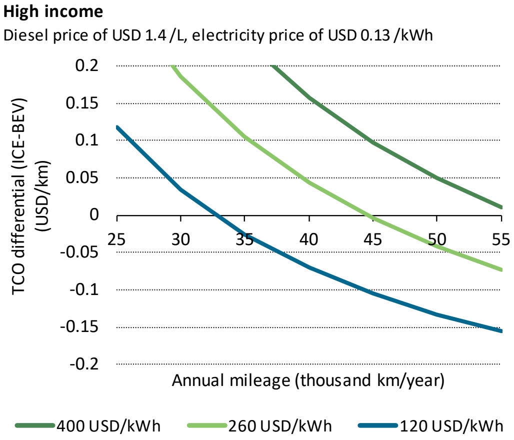
At a USD 120/kWh battery price and with EU gasoline prices, BEV are competitive even at low mileage

2-wheelers



The economic case for electric two-wheelers is strong: in countries with **high fuel taxes** electric two-wheelers **are already cost competitive** with gasoline models

Buses



Electric buses travelling 40 000-50 000 km/year are cost competitive in regions with **high diesel taxation** regimes if battery prices are below USD 260/kWh

GEVO 2018: Electric Vehicles Initiative (EVI)

Multi-government policy forum dedicated to conducting collaborative activities that support the design and implementation of domestic electric vehicle (EV) deployment policies and programs

In 2010, EVI was one of several initiatives launched under the CEM

Currently co-chaired by Canada and China, and coordinated by the IEA

Released several analytical publications, demonstrating leadership to strengthen the understanding of the opportunities offered by electric mobility to meet multiple policy goals

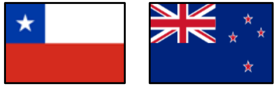
Instrumental to mobilize action and commitments (Paris Declaration on Electro-Mobility and Climate Change at COP21, Government Fleet Declaration at COP22)

Launched the EV30@30 Campaign in June 2017

Now launching the **Pilot City Programme**

Also working with the **Global Environment Facility** on the preparation of a project for the support of EV policy-making in developing regions

Members



in 2018

GEVO 2018: EV30@30 Campaign

EV30@30

Designed to accelerate the global deployment of electric vehicles

Sets a collective aspirational goal to reach 30% sales share for EVs by 2030

Launched at the 8th CEM meeting, in Beijing, by Minister Wan Gang

Implementing actions include:

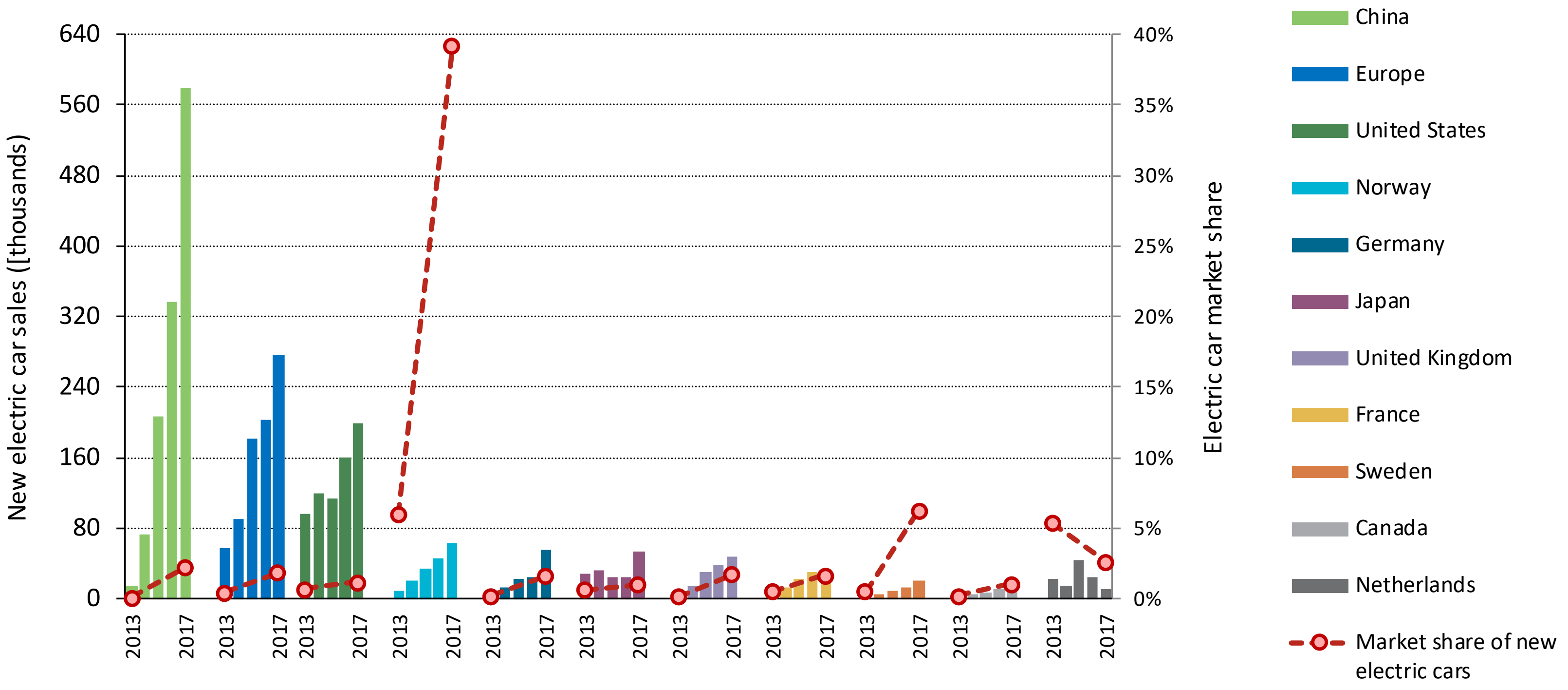
- Supporting the deployment of chargers and tracking its progress,
- Galvanising public and private sector commitments for electric vehicle (EV) uptake in company and supplier fleets
- Scaling up policy research and information exchanges
- Supporting governments in need of policy and technical assistance through training and capacity building
- Establishing the Global EV Pilot City Programme, aiming to achieve 100 EV-Friendly Cities over five years

Supported buy several partners

C40 CITIES · GFEI · NRDC · SLoCaT · M2020 · UN environment · UN-HABITAT · ZEV ALLIANCE

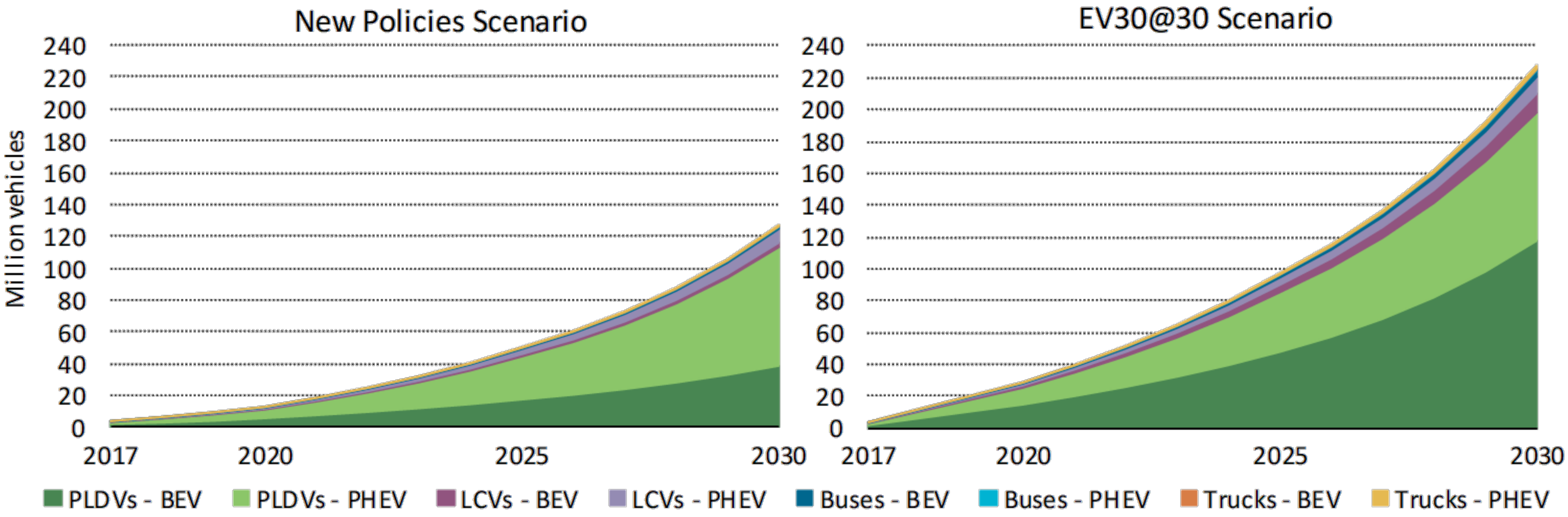
Members

GEVO 2018: Electric car sales are on the rise in all major car markets



China is the largest electric car market globally, followed by Europe and the US
Norway is the global leader in terms of market share, with 40% in 2017

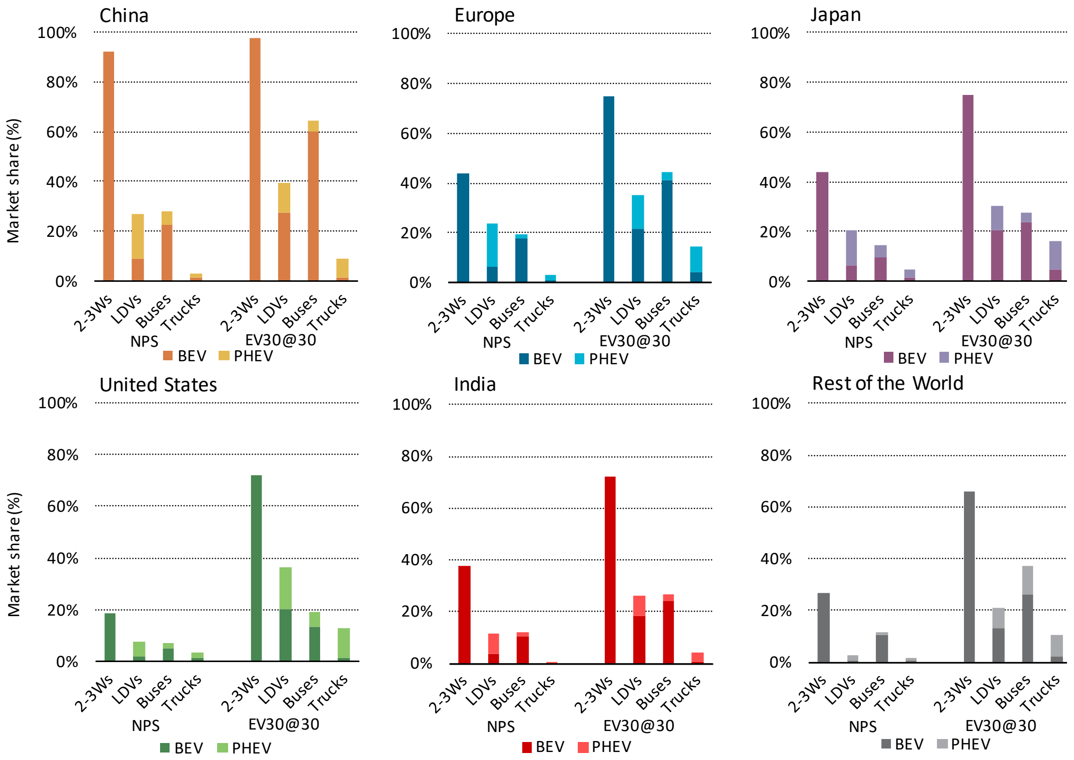
GEVO 2018: Global EV deployment under the NPS and the EV30@30 scenario



The EV30@30 Scenario sees almost 230 million EVs (excluding two- and three-wheelers), mostly LDVs, on the road by 2030. This is about 100 million more than in the New Policies Scenario

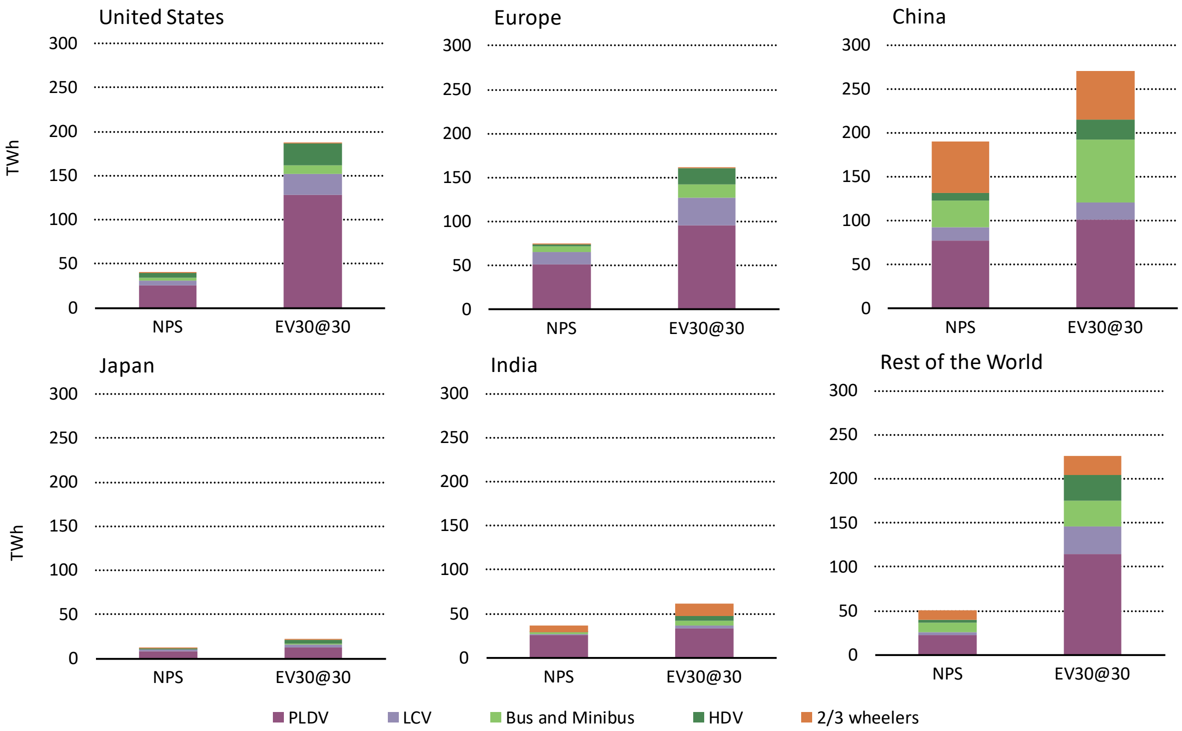
GEVO 2018: Regional insights in the GEVO 2018 scenarios

EV market share by mode in a selection of regions, NPS and EV30@30 scenario, 2030



China and Europe are the global regions with the fastest development of EVs in both scenarios and in virtually all modes

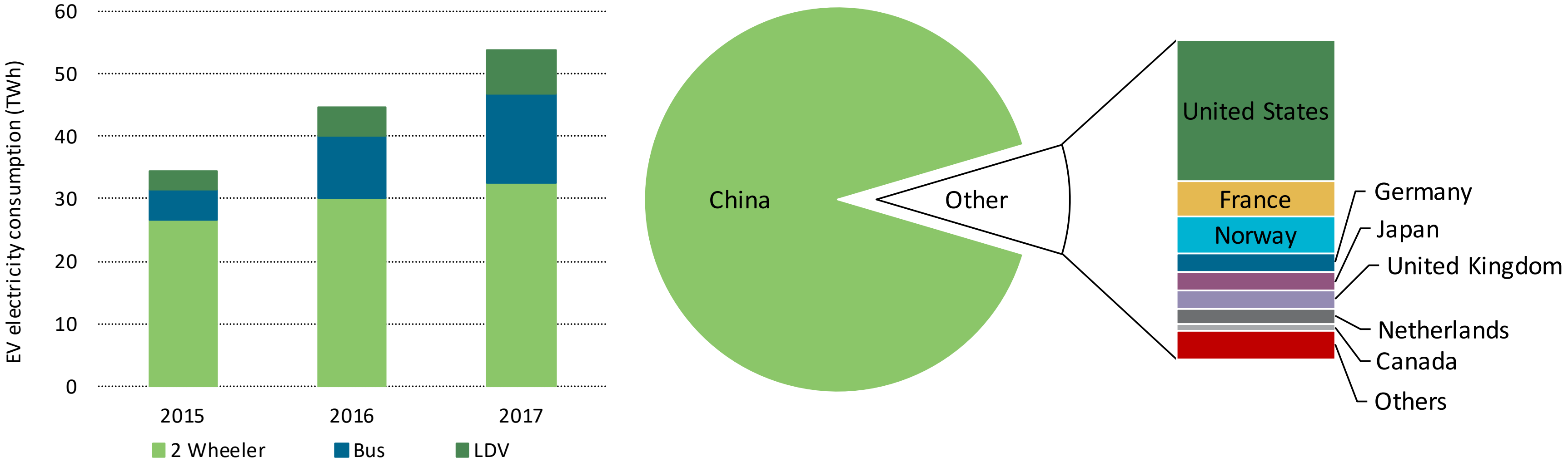
GEVO 2018: Power demand projections



Two-wheeler and bus electricity demand make China the biggest consumer of electricity for EVs. In the EV30@30 Scenario, electricity demand for EVs is more geographically widespread.

GEVO 2018: EVs lead to higher electricity demand…

Electricity demand due to EVs: 54 TWh (more than the electricity demand of Greece)

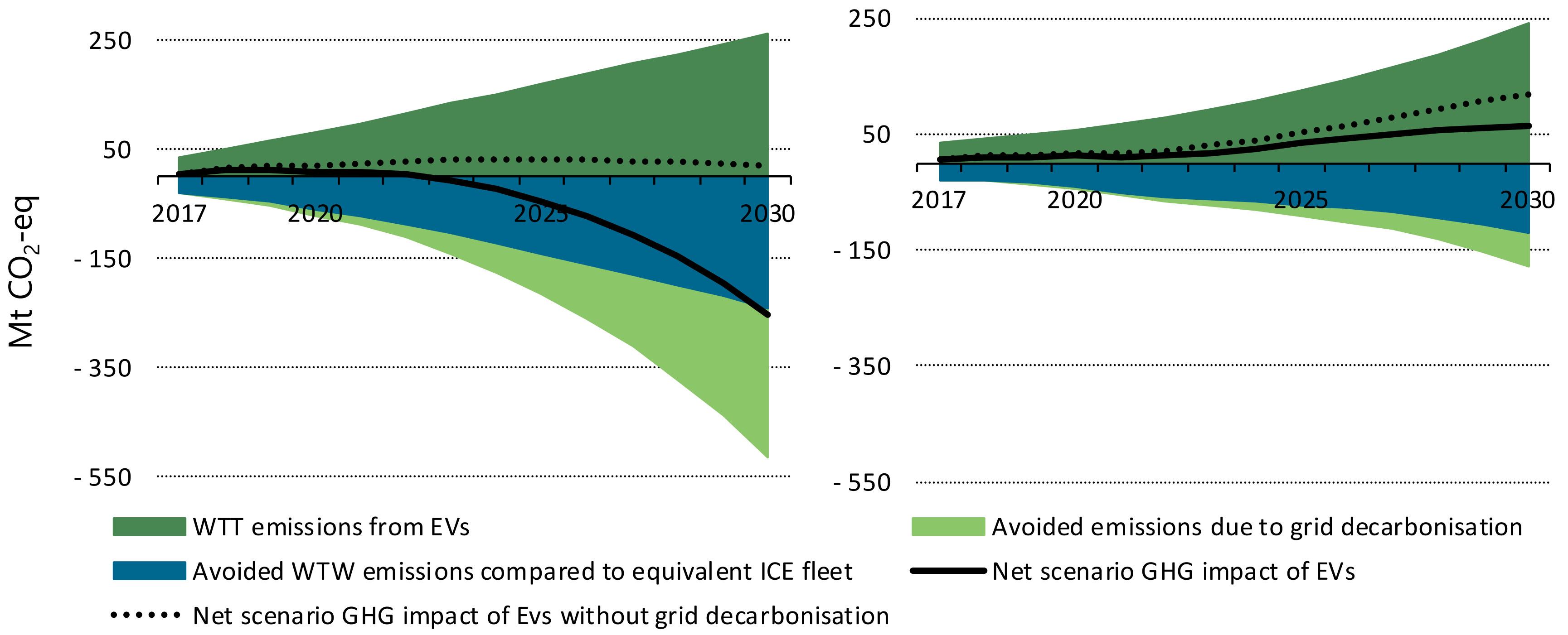


Around 91% of the power for electric vehicles in 2017 was consumed in China
The share of electricity demand from EVs was 0.8% in China and 0.5% in Norway

…but they enable reductions in oil use, GHG & pollutant emissions

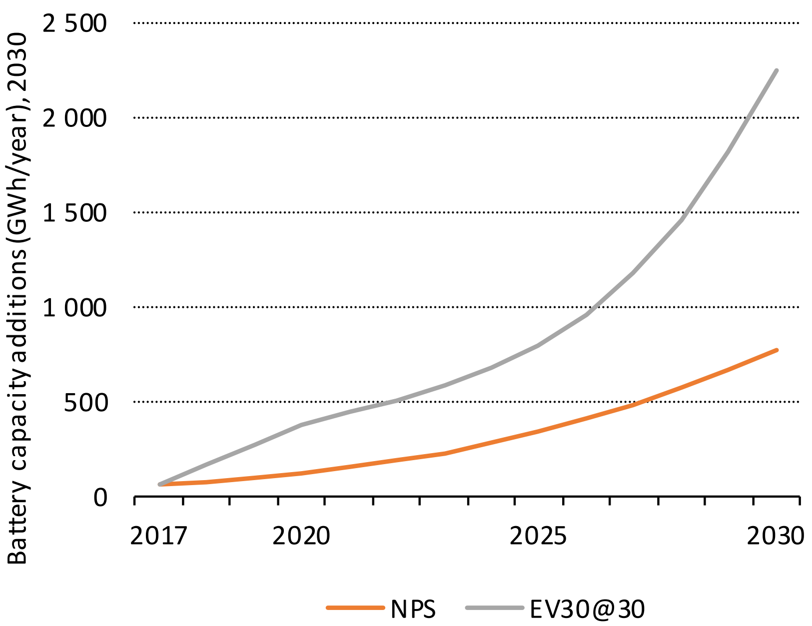
- EVs consume (in final energy terms) half to one third of the energy used by ICE powertrains
  - This is due both to the higher efficiency of the powertrain and the EVs' ability to regenerate kinetic energy when braking
- EVs displaced 0.4 mb/d of diesel and gasoline demand in 2017
  - The majority of the displacement is attributed to two- and three-wheelers (73%), the rest to buses (15%) and LDVs (12%)
- EVs also allowed to reduce global well-to-wheel CO_2 emission savings of 29.4 Mt CO_2 in 2017, and abated pollutant emission savings in high exposure areas (urban environments), thanks to zero tailpipe emissions

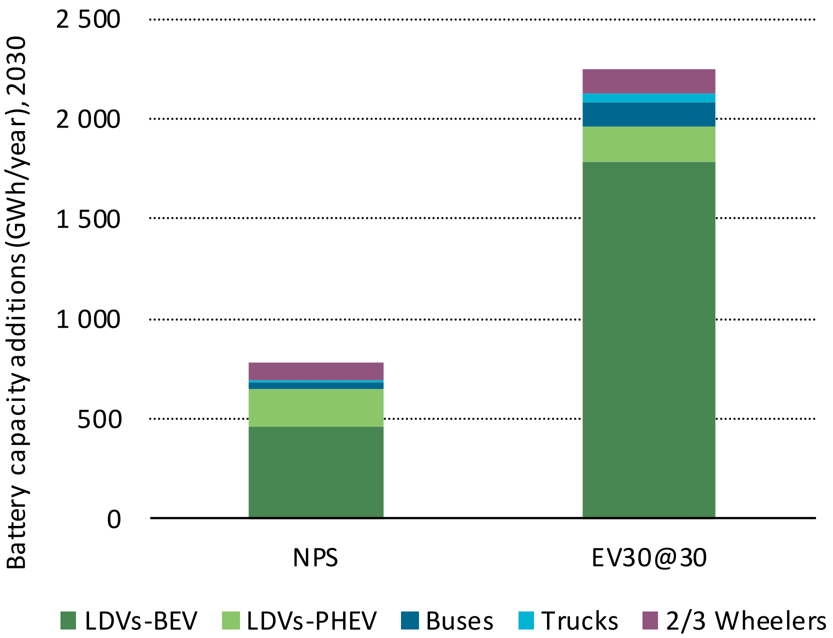
GEVO 2018: Vehicle Use Cycle GHG emissions



By 2030, WTW GHG emissions associated with the use of EVs are lower than those of equivalent ICE vehicles at a global scale, even if electricity generation does not decarbonise from current levels.

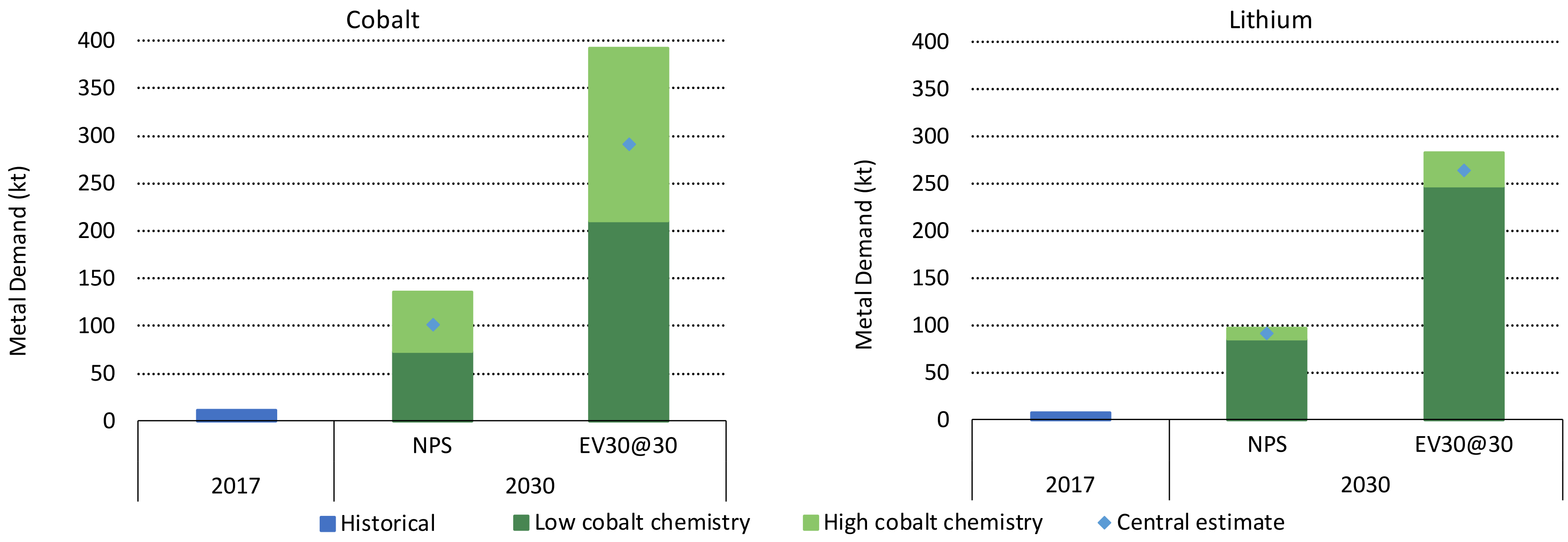
GEVO 2018: Battery capacity





Demand for battery capacity for electric vehicles, primarily PLDVs, is projected to increase to 0.78 TWh per year in the New Policies Scenario and 2.2 TWh per year in the EV30@30 Scenario and to 2030

GEVO 2018: Material demand



Lithium and cobalt demand from electro mobility in 2030 will be much higher than current demand
Developments in battery chemistry can greatly affect future demand

GEVO 2018: Policies favouring the transition to electric mobility

Carbon pricing of fuels

Public procurement

Bridging the price gap

Fuel economy standards

Local access regulations

Road pricing

Private & public EVSE rollout

Demand-driven & business-driven EVSE

Successful grid integration

Material demand management

Second life, end-of-life and recycling

GEVO 2018: 2017 policy updates: China

- New Energy Vehicle (NEV) credits mandate
  - Target of the NEV credit mandate is 10% of the passenger car market in 2019, and 12% in 2020
- Vehicle Subsidy Program: subsidies for the purchase of electric cars, dependent on three characteristics: the vehicle range (in km), energy efficiency (in kWh/100km) and battery pack energy density (in Wh/kg)
- Electric bus sales in China also promoted primarily by subsidies
  - Started in 2009 by the central government, supplemented by support from local authorities (pilot cities) and progressively reduced over time
  - Policy update in 2017 to prevent fraud: overall subsidy reduced and converted into operational subsidies to target the support scheme to transit operators of electric buses
- China is considering a national ban on ICE cars running on fossil fuels

GEVO 2018: 2017 policy updates: European Union

- Update of the CO_2 emissions standards for new cars and LCVs (to 2030)
  - Inclusion of an incentive scheme aiming to stimulate the uptake of zero- and low-emission vehicles
  - The incentive scheme reduces (by up to 5%) the overall CO_2 target for manufacturers that exceed the 2025 (15%) and 2030 (30%) low- and zero-emission vehicle market share thresholds (shares calculated using weights)
  - No penalty for non-compliance of low-or zero emission targets
- France, Ireland, the Netherlands, Slovenia, Sweden, UK (+ Norway) pledged to end sales of ICEVs by 2030 to 2040
- Selected examples of policies on zero emission buses:
  - Public procurement (Clean Vehicles Directive)
  - Netherlands: aims for all emissions-free bus sales by 2025 & all-electric stock by 2030
  - C40 fossil-fuel-free streets declaration: only electric buses would added to the municipal fleets of Barcelona, Copenhagen, London, Milan, Oxford and Paris (plus others globally)
- EU roadmap: aim to reduce its GHG emissions by 80% in 2050 compared with 1990 levels
  - Emissions from transport could be reduced to more than 60% below 1990 levels by 2050

GEVO 2018: 2017 policy updates: India

- Dynamic situation:
  - FAME: incentive scheme that reduces the upfront purchase price hybrid and electric vehicles (launched in 2015)
  - April 2017: vision aiming to have an all-electric vehicle fleet by 2
  - September 2017: Tata Motors won 1st public procurement EV tender by EESL
  - December 2017: SIAM white paper proposing a pathway towards all new vehicle sales being all electric by 2047 and 100% of intra-city public transport as all electric by 2030
  - February 2018: Ministry of Heavy Industries and Public Enterprises stated that it had not set any target for electric cars for 2030 and referred back to FAME scheme for EV policy
  - February 2018: launch of the National E-Mobility Programme by the Ministry of Power. Focusing on creating the charging infrastructure and a policy framework so that by 2030 more than 30% of vehicles in India are electric
- Greater coordination needed, but positive signs for EVs

GEVO 2018: 2017 policy updates: United States

- Federal level revision of fuel economy standards announced in April 2018
  Details of new standards still unknown
- California (granted a waiver by EPA to regulate CO_2 emissions) vowed to stick with the stricter rules
  - A number of other States followed California on this
- ZEV mandate also increased in ambition in California and other States
  - 1.5 million ZEVs and 15% of effective sales by 2025, 3.3 million in 8 States combined (California, Connecticut, Maryland, Massachusetts, New York, Oregon, Rhode Island, Vermont)
  - Target of 5 million ZEVs by 2030 in California

- There is a risk of a double standard in the US market
  - More stringent rules for cars sold in California and the States that follow its lead
  - Weaker rules for the rest of the States

GEVO 2018:
National and local announcements for EVs and towards the end of ICEs

Table 2.3 • Announced sales bans for ICE vehicles

Country	2025	2030	2032	2040	2045
France				ICE sales ban or 100% ZEV sales target	
Ireland		ICE sales ban or 100% ZEV sales target			
Netherlands		ICE sales ban or 100% ZEV sales target			
Norway	ICE sales ban or 100% ZEV sales target				
Slovenia		ICE sales ban or 100% ZEV sales target			
Sri Lanka				Fleet without ICEs	
Sweden					
Scotland			ICE sales ban or 100% ZEV sales target		
United Kingdom				ICE sales ban or 100% ZEV sales target	

● ICE sales ban or 100% ZEV sales target ● Fleet without ICEs

Table 2.4 • Announced access restriction mandates in local jurisdictions

Local jurisdiction	2024	2025	2030	2035	2040
Athens		Diesel access restrictions			
Auckland			Fossil-Fuel-Free Streets Declaration		
Balearic Islands		Diesel access restrictions		ICE access restrictions	
Barcelona			Fossil-Fuel-Free Streets Declaration		
Cape Town			Fossil-Fuel-Free Streets Declaration		
Chinese Taipei					ICE sales ban
Copenhagen			Fossil-Fuel-Free Streets Declaration		
London			Fossil-Fuel-Free Streets Declaration		
Los Angeles			Fossil-Fuel-Free Streets Declaration		
Madrid		Diesel access restrictions			
Mexico City		Diesel access restrictions	Fossil-Fuel-Free Streets Declaration		
Milan			Fossil-Fuel-Free Streets Declaration		
Oxford			Fossil-Fuel-Free Streets Declaration		
Paris	Diesel access restrictions		ICE access restrictions; Fossil-Fuel-Free Streets Declaration		
Quito			Fossil-Fuel-Free Streets Declaration		
Rome	Diesel access restrictions				
Seattle			Fossil-Fuel-Free Streets Declaration		
Stockholm			ICE access restrictions		
Vancouver			Fossil-Fuel-Free Streets Declaration		

● Diesel access restrictions ● ICE access restrictions
● Fossil-Fuel-Free Streets Declaration ● ICE sales ban

+ EV30@30 and country/state-level EV targets

ICE phase-out pledges have been mainly announced in Europe
China has also mentioned that it is considering the ICE phase out

GEVO 2018: Industry is mobilizing investment in large scale manufacturing

Country	Manufacturer	Production capacity (GWh/year)	Year of commissioning	Source
Operational				
China	BYD	8	2016	TL Ogan (2016)
US	LG Chem	2.6	2013	BNEF (2018)
Japan	Panasonic	3.5	2017	BNEF (2018)
China	CATL	7	2016	BNEF (2018)
Announced				
Germany	TerraE	34	2028	TerraE (2017)
US	Tesla	35	2018	Tesla (2018b)
India	Reliance	25	2022	Factor Daily (2017)
China	CATL	24	2020	Reuters (2017f)
Sweden	Northvolt	32	2023	Northvolt (2017)
Hungary	SK innovation	7.5	2020	SK innovation (2018)

Current battery factory capacity ranges between 0.5-8 GWh/year
Much larger plants (7.5-35 GWh/year), aiming to reap economies of scale benefits, already announced

GEVO 2018: Policy Recommendations
Focus on fuel economy standards and ZEV incentives/mandates

- Fuel-economy and tailpipe CO_2 emissions standards have demonstrated their efficacy to lead to improved ICE vehicle efficiency
- Standards must be sufficiently stringent to secure timely investment and help ramp-up production and supporting infrastructure
- Once legislated standards shall not be compromised by changes
- Standards can be coupled with differentiated purchase taxes
- Standards can also be coupled with ZEV incentives (more room for flexibility to manage technology uncertainties) or mandates (higher certitude on volumes)
- Life cycle approach desirable, but there is a risk of overlaps with other regulatory frameworks (such as those regulating emissions for the fuel supply chain) and implementation challenges
- Need to ensure that power generation and other fuels will also decarbonize (need for complementary measures in the power and fuel production sectors)

GEVO 2018: Policy Recommendations
Focus on local initiatives

- Public procurement
  - Co-benefits for municipalities and businesses:
    - → Bulk purchase reduces units costs
    - → Helps OEMs scale-up
    - → Kick-starts EVSE deployment and the emergence of EVSE-related businesses
  - Benefits for the public:
    - → Demonstrates the technology to the public, makes EVs familiar in the daily environment
    - → Facilitates EVSE roll-out and the emergence of publicly accessible infrastructure
  - Buses: procurement deals allowing to lift capital cost barriers
- Regulating access
  - Low-emission zones: complementary to national-level targets and bans, easier to implement, they can have significant impacts
  - Concerns over "clusterizing" the market: harmonized labelling can provide clarity to both consumers and OEMs
- Integrate electrification with Mobility as a Service

Complementing fuel taxes with road pricing

- In the medium-to-long term, with growing EV sales:
  - Conventional vehicle sales and activity decreases
  - Government revenues from gasoline/diesel taxation decrease
- Alternative road transport taxation solutions will need to emerge:
  - Km-based tax is a solution to maintain government revenues with multiple technologies on the road
  - This can include a time/congestion-based component to target vehicles most responsible for infrastructure wear and pollution peaks
- Current government revenues from fuel taxation would be maintained by
  - A tax of USD 0.01/km in US and China
  - A tax of USD 0.08/km in Europe and Japan

Supporting the roll out of private chargers

Private chargers have a number of advantages: low installation cots, low impact on the power grid (low power, possibility to enable night time charging)

Measures suitable for their support include:

- **Financial incentives**, aiming to reduce the cost of installation for early adopters. They are also relevant for fleets, and need to be adapted as the market emerges.
- **Regulatory instruments**, such as:
  - **Building regulations** requiring minimum levels for the number of "EV-ready" parking spots
  - **Changes in property laws** to to simplify and accelerate approval procedures for electric car owners to install and use charging infrastructure)

Supporting the roll out of publicly accessible chargers

- **Defining deployment targets** (in conjunction with vehicle deployment targets by mode)
- **Direct investment** (e.g. for the deployment of a critical mass of chargers, as well as for chargers to provide a minimum service level)
- **Financial support**, e.g. through financing from public entities at low interest rates, loan guarantees and other instruments covering the risk of default, and public-private partnerships, where the commercial risk is shared among private partners and the public sector
- **Regulations**, e.g. in the case of publicly accessible charger availability for individuals who do not have access to private parking
- The use of **open standards** is also important for vehicle-charge point communication and payment as a means to enable **inter-operability** between charging networks, increase innovation and competition, and reduce costs to drivers

GEVO 2018: Policy Recommendations
Achieving demand- and business-driven EVSE development

- Business cases are needed:
  - High-frequency use locations
  - Complementary revenues streams, such as parking fees and income from commercial activities enabling the use of charging points

- Government guidance and support/regulations should ensure:

- the availability of EVSE in less frequented areas ("universal" access and public service principles), via:
  - Public-private partnerships
  - Mandating EVSE providers to cover certain areas and encourage cross-subsidization of highly used EVSE towards less used EVSE

- Interoperability features and easy-to-use network for all

- Strong EV commitments also helps the private sector take ownership of EVSE roll-out (e.g. OEMs dedicated to establishing highway corridors)

GEVO 2018: Policy Recommendations
Ensuring that EVs are effectively integrated in the electricity grid

- Power generation: variable renewable capacity additions are breaking records
- Local power distribution: need to minimize the risk of local grid disruptions and the need for costly grid upgrades

→ Flexible charging is key
  - To accommodate efficiently variable renewable generation (e.g. daytime workplace charging when PV generates most)
  - To release pressure on the grid at high power demand peak hours
  - To avoid grid disruptions locally, provide frequency and load balancing services

→ How?
  - Default vehicle software allowing flexibility
  - Time-of-use pricing
  - Smart-meters
  - Regulatory environment favourable to aggregators
  - Who pays for local grid upgrades? Utility? EV owner x? All EV owners? Everyone?

GEVO 2018: Policy Recommendations
Managing changes in material demand from EV batteries

- Challenges (material procurement):
  - Fluctuating prices, stockpiling
  - Uncertainty for EV developments and battery technologies
  - Concentrated extraction (DRC for cobalt)
- Solutions:
  - Long-term contracts
  - Need clarity and certainty over future market → key area with national/local governments influence (ZEV mandates, targets, bans)

- Challenges (social and environmental sustainability):
  - Environmental impact of mining
  - Black market/child labour
  - Extremely untransparent supply chains
- Solutions:
  - Multi-stakeholder actions and signals (governments, civil society, NGOs, industry)
  - Sustainability standards to be developed, labelling

GEVO 2018: Policy Recommendations
Managing the battery end-of-life treatment

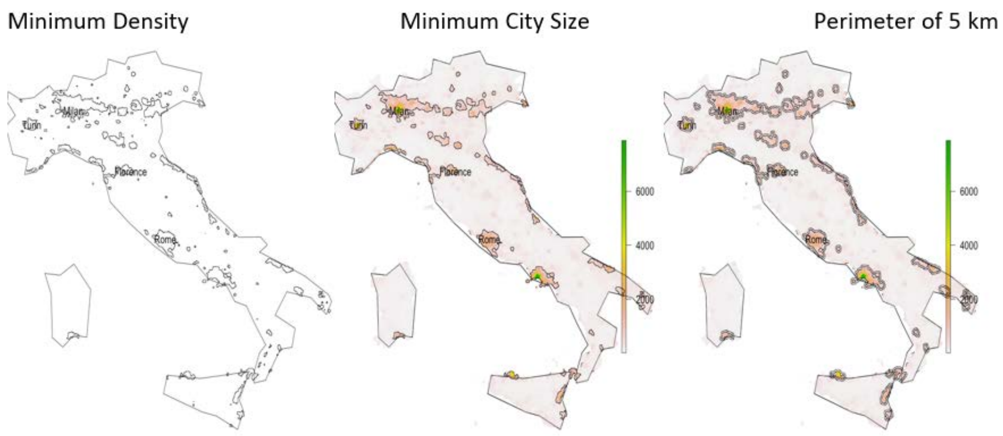
- Rules over legal responsibility for battery end-of-life (1st/2nd/3rd life)
  - Risk of disengagement and no battery management chains / recycling
  - Risk of landfilling in-country or abroad (consumer electronics battery problem)
- Certifications and traceability schemes along the lifecycle of batteries (material extraction, assembly, use, 2nd/3rd life, recycling/disposal)
- Encourage manufacturing design enabling recycling processes that allow the recovery of high-value materials minimizing costs and energy use
  - Regulatory framework mandating that batteries are suitable for physical separation?
  - Need for multi-stakeholder coordination to understand scope for feasibility without hindering technological advances in battery chemistries/manufacturing

V. Assessing policy impacts – reach of city-level policies

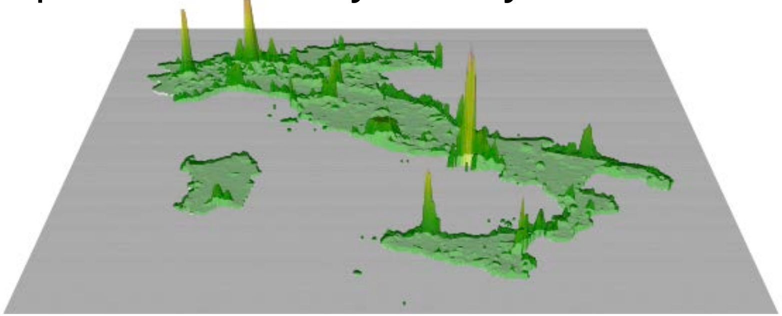
Population density and city size thresholds

Size Category	Mode	Density (people / km²)	City size (total residents)	Perimeter (km)
Small	Urban bus	400	50 000	5
Medium	BRT	675	125 000	1
Large	Metro & light-rail	900	750 000	1

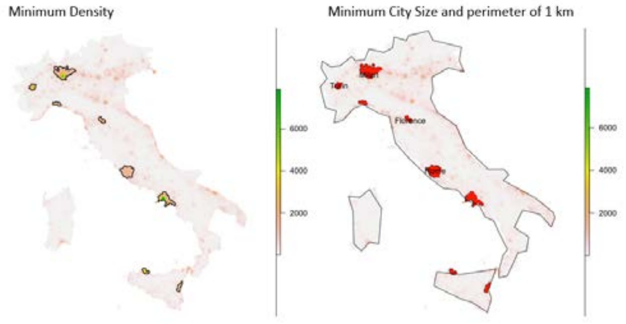
Applying Threshold Criteria
Example of Potential for Urban Bus Access in Italy in 2015



Population density in Italy (linear scale)



Applying Threshold Criteria
Potential for Metro Access in Italy in 2015



City sizes defined according to feasibility of public transit operations