PTOLEMUS
Consulting Group

FLEET ELECTRIFICATION

Global Study

FREE

ABSTRACT

The reference report on the migration towards battery electric vehicles

Has the time come for fleets to embrace electric?

Regulation and incentives are now pushing fleets to buy into electrification

Everywhere, legislation will push fleets to electrify…

In October 2022, when the European Union published provisional legislation under its 'Fit for 55' initiative that **effectively bans the sale of petrol- and diesel-powered cars and LCVs in Europe by 2035**, the automotive world took a major step towards an electrification.

Whilst the plan still requires ratification, it is a clear sign that the EU is forging ahead with the electric agenda and putting itself on course to become the world leader in electric drivetrain adoption for road transport.

In **the US, which has been lagging behind, things are changing too. The 2021 bipartisan infrastructure law represents a $7.5 billion investment in the US for electrification**, and with the **Inflation Reduction Act**, federal tax credits of up to $40,000 per vehicle are available for fleets.

Charging infrastructure immaturity is still an issue

It Is telling that there have been parallel activities regarding charging infrastructure, in the USA with the aforementioned Bipartisan infrastructure bill and the Alternative fuel infrastructure tax credit (AFITC).

Similarly in Europe, following Norway's lead*, Germany is heavily investing in an electrified future, with €6.3 billion to be spent on building/installing charging infrastructure by 2025.

But is this enough? **Our view is that the installation of charge points must be even more ambitious, if by 2035 Europe, North America and Asia Pacific wish to significantly electrify** everything from cars through to the heaviest of long-haul trucks.

Is it possible for fleets to electrify now?

This raises an important consideration for fleet managers: "If the charging infrastructure is available, should I adopt EVs into my fleet?"

The quick response is "yes", and this report gives both a "state of the nation" view of the situation whilst also providing a playbook of key considerations fleet managers must consider if they wish to

electrify their fleet(s) successfully and in a sustainable manner.

This report frames the key considerations that must be made on the availability of vehicles, suitability for purpose, charging infrastructure considerations and TCO comparisons versus ICE equivalents.

It also provides **case studies** of pioneering companies that have successfully implemented EVs into their fleets, **key suppliers** from the EV value chain, and also **recommendations as to how suppliers can help fleets** electrify their vehicles in the medium to long term.

Source: PTOLEMUS - Note: * Cf. Norway Vehicle Electrification Global Study

Infrastructure, energy cost and vehicle availability must be factored into a company's fleet electrification strategy

But not all vehicle types are fit for electrification…

PTOLEMUS' analysis reveals that, depending on the type of vehicle, the cost benefit of switching to electric is not always in favour of the EV. So whilst the "refuelling" cost for an EV is commonly cited as being significantly cheaper, once inspection costs, tyre replacement, insurance and financing are taken into account too, the economic case for an EV is not so clear cut. **This is especially the case for heavy duty vehicles.**

Furthermore, with the cost of electricity per kWh having rocketed in the last 12 months, "cheap" energy tariffs **are now so expensive that if an electric car were to use rapid charging stations only, the cost per mile would be €0.21, versus €0.22 per mile for a petrol-engined car, in the UK in 2022.**

The **TCO model we developed for this report** demonstrates that the immediate cost savings associated with electrification have softened significantly, and illustrates that **charging infrastructure, energy security and supply must be at the top of the agenda for governments and fleets,** and must be addressed in the forthcoming 3-5 years if lofty EU targets are to be achieved by 2035.

The global EV market will be multiplied 7 times by 2030!

The 2022 global fleet market consisted of 5 million battery-electric cars, vans, trucks and buses in use, with **nearly 43% of battery electric vehicles being accounted for by the European region,** whilst Asia Pacific represented approximately 35% and North America 19%.

Over the next 8 years, **North America is forecast to grow at the fastest rate**, in terms of vehicle registrations, – at 34% pa – through to 2030, whilst Europe, China and the rest of the world are expected to grow at 26% and 20% respectively.

Hence, PTOLEMUS forecasts the volume of battery electric commercial fleet vehicle registrations reaching nearly **15 million in 2030**, and contributing to an electrified global commercial fleet of vehicles in operation of **48 million.**

The message is clear that the paradigm shift is upon us and the world is finally pivoting to electric vehicles.

This report can help both public and private organisations understand the current challenges the industry faces and, more importantly, how they can overcome them!

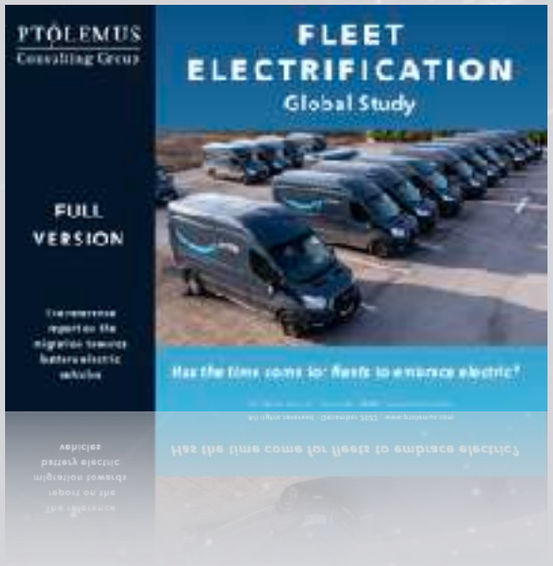
Thank you for your interest and please do not hesitate to come back to me if you have any comments or questions about this report.

Andrew Jackson

Research Director

Source: PTOLEMUS - Note: * Cf. Norway Vehicle Electrification Global Study

The first reference report for how and when fleets should complete the switch to electrification



Has the time come for fleets to embrace electric?

The first practical & independent one-stop guide on the transition

- **A 420-page analysis of the global fleet electrification landscape** based on:
  - 11 years of market monitoring
  - 17 interviews with key stakeholders
  - 6 months of desk research
- **A review of current regulatory and tax incentives to fleet electrification in the US, European and China**
- **A granular, objective assessment of current implementation challenges**:
  - Model availability constraints including lead times for key models
  - Unclarity on the cost profile & resale value
  - Charging practicalities & constraints
  - Range anxiety and reliability concerns
- **A detailed assessment of all total cost of ownership (TCO) components for**
  - Electric cars, eLCVs and eHGVs versus diesel equivalents
  - Covering depreciation, energy, taxes, insurance, financing, maintenance, consumables, tyres and tolls
- **A step-by-step guide on the process to follow to avoid failure, from the feasibility analysis to the operation of the vehicles:**
  - Fleet manager's must do list
  - Relevant suppliers and their duties
- **Insights from case studies of how 8 leading fleets have successfully electrified**
- **An assessment of the solutions to accelerate electrification:**
  - Infrastructure solutions (charging strategies, vehicle-to-grid, etc.)
  - Optimal procurement options (new / second hand)
  - Telematics-enabled solutions (suitability for conversion, battery health, etc.)
  - Fleet manager & driver training solutions
- An **in-depth assessment of 11 suppliers of electrification solutions**, including comparative tables of leasers, Telematics Service Providers and software providers
- A **2020-2030 bottom-up market forecast** encompassing and **Excel file with outputs and charts covering:**
  - **4 vehicle segments** including: Cars, LCVs, HGVs, and Buses
  - **Volume of EV registrations** to 2030
  - **Volume of EVs in use** to 2030
  - **27 countries**
  - **6 continents** including Europe, North America, Central & Latin America, Asia, Africa, and Oceania

The study answers the key strategic questions of fleets and their suppliers to succeed in electrification

What are the main challenges facing in fleet electrification?

What are the potential solutions to help increase fleet electrification?

What suppliers can / should do to support fleet electrification?

What will be the role of emerging players in the fleet electrification value chain?

In which region will electric fleets grow the most by 2030?

What is the strategy of major OEMs in fleet electrification?

Which suppliers are leading in the market?

What are the benefits of fleet electrifications?

What are the trends driving the electrification of fleets?

What is the impact of government legislation on the fleet electrification?

What will be the size of the electric fleet market in 2030 by segment and by region?

Which vehicle segments will move first to electric?

The report was written and reviewed by a team of 7 experts of 6 nationalities

Frederic Bruneteau

Managing Director, Brussels

The founder of PTOLEMUS, Frederic has accumulated **25 years of experience of the mobility & transport domains** and 18 years of strategic & M&A advisory.

He has become **one of the world's foremost experts of connected mobility** and is interviewed on the subject by publications such as the *Financial Times*, *Forbes*, the *Wall Street Journal* and *The Economist*.

He has led over 180 consulting projects and helped many world leaders define their strategy and implement it. Clients he has served include:

- **Fleet services providers** e.g. AGC, Arvento, Astrata, Bridgestone, BP, Danlaw, DKV, Easytrip, ENI, Fleet Complete, Hitachi, Nationwide Insurance, OMV, Telepass, TomTom, UTA & WEX;
- **Automotive OEMs and their tier-1 suppliers**: AGC Automotive, Bridgestone, Allianz Partners, AXA Partners, Cihon, CNH Industrial, Coyote System, Europ Assistance, HERE Technologies, Hitachi, Michelin, Otonomo, Scania, Telit, Toyota and wejo;

Frederic has led many **assignments related to electrification** and fully reviewed several reports related to fleets including the **Commercial Fleet Telematics Global Study** and the Connected Fleet Services Global Study.

He also supervised the work for our recent Norway Vehicle Electrification Global Study as well as this report.

Andrew Jackson

Research Director, London

With a career in market research spanning 15 years, Andrew has over **11 years of experience working in the automotive and industrial sectors.**

He has delivered **advisory services, custom projects, data and insights for fleet service provider and OEMs:** including: CNH Industrial, LeasePlan, Volkswagen, Hyundai.

Andrew has led and participated **in many automotive and telematics market research projects,** e.g.:

- Provided **forecasts for the growth of EVs in the UK**, to **a leading automotive media company**;
- Helped **a major manufacturing group** in evaluating the global landscape of **telematics strategies and applications of engine manufacturers and TSPs in the on-road, agricultural, industrial and marine markets**;
- Provided insights to **a major European telematics technology provider (TTP)** regarding the future of connected vehicles and in-vehicle payments;
- Helped **a leading global battery manufacturer** define its Eastern European sales strategy;
- **Led the global research and created 5-year sales forecasts for a major geospatial data analysis company's** go-to-market strategy;
- Provided insight and analysis on the automotive aftermarket for some of **Europe's key tier-1 suppliers.**

As PTOLEMUS' Research Director, Andrew directed, supervised and contributed to the research and writing of this report as well as the Commercial Fleet Telematics Global Study.

Alberto Lodieu

Senior Manager, Paris

Alberto has 14 years of experience in strategy and operations consulting, and has **participated in over 50 assignments**. He has specialised in the **mobility, connected cars, ETC & fleet services and insurance & assistance industries.**

He recently led the following projects:

- Assisted a leading global Fleet payment provider in defining its **European go-to-market strategy**;
- Assisted a top **automotive tier-1 supplier** in the **design and launch of a disruptive Fleet Telematics device**;
- Performed the commercial **and technology due diligence of a major insurance telematics provider**;
- Helped **a transport company** define its strategy and **evaluate the benefits of telematics;**
- Helped one of the world's largest assistance companies define its **European automotive telematics strategy**, value proposition and Minimum Viable Product;
- Helped one of the largest insurance groups **define its connected and mobility services strategy and value proposition;**
- Helped **a tier-1 automotive supplier** in its market entry and product strategy to enter the European aftermarket and embedded ETC markets;
- For **the European Commission**, conducted an impact analysis of mandating **positioning technologies** on mobile phones for emergency applications (E112).

Last but not least, Alberto has been leading our work to build **a global picture and forecast of mobility trends** and he notably led the research and writing of our landmark 750-page **Global Mobility Roadbook** (2019).

Alberto is fluent in Spanish, French, English and Italian.

The report was written and reviewed by a team of 7 experts of 6 nationalities

Dr. Sarmad Zaman Rajper

Research and Strategy Consultant, Brussels

A PhD in Business Economics from Ghent University, Sarmad has over 8 years of experience in research and business administration.

He has gained considerable research experience in the field of **EVs** and road-related projects.

In particular, **Sarmad performed his PhD thesis on the Prospects of EVs in Pakistan.**

He has participated in over 10 projects to help organisations meet their goals and objectives.

Since joining PTOLEMUS, Sarmad has participated in research and strategy projects, e.g.:

- Analysed the impact of EVs o the business of **a leading roadside assistance company** in the Nordic region
- Created a **global database on electrification and EVs**

Sarmad is fluent in English, Urdu and Sindhi.

Haili Zuo

Business Analyst, Paris

Haili is a Business Analyst with experience in research and consulting.

Within PTOLEMUS, she develops her knowledge and expertise **in commercial fleet telematics and Electric Vehicles.**

Haili's most important assignments include:

- Participated in PTOLEMUS' **Commercial Fleet Telematics Global Study**, researched and collected primary data and identified the key players in the market;
- Helped **a multinational telecommunications company** to enlarge its customer base in China by identifying 200+ potential customers with in-depth industry analysis;
- Participated in the research for this study**,** mainly focused on the charging infrastructure in Europe, USA and China

Haili is currently based in Paris and she is a Mandarin native speaker, is fluent in English and in Cantonese.

Matilde Gusmaroli

Business Analyst, Paris

Matilde is a Business Analyst with experience in research and consulting.

Within PTOLEMUS, Matilde develops and leverages her knowledge and expertise in **Usage-based Insurance and Electric Vehicles.**

Since joining PTOLEMUS, Matilde has contributed to several research projects:

- **The Norway Vehicle Electrification Study**, where she performed an in-depth review of the report;
- **The Fleet Electrification Global Study**, where she analysed and created profiles for fleet management suppliers.

Matilde is also a key contributor to developing templates, dashboards and reporting and visualisation tools skills.

She is currently based in Paris and is an Italian native speaker, fluent in English and Spanish.

Katrina Lin

Research Analyst, Brussels

Katrina is a Research Analyst with 3 years of experience, who has delivered several industrial studies.

Within PTOLEMUS, she has developed her expertise in **the commercial fleet and Electric Vehicles** through internal **industry research** and is responsible for updating industry logs.

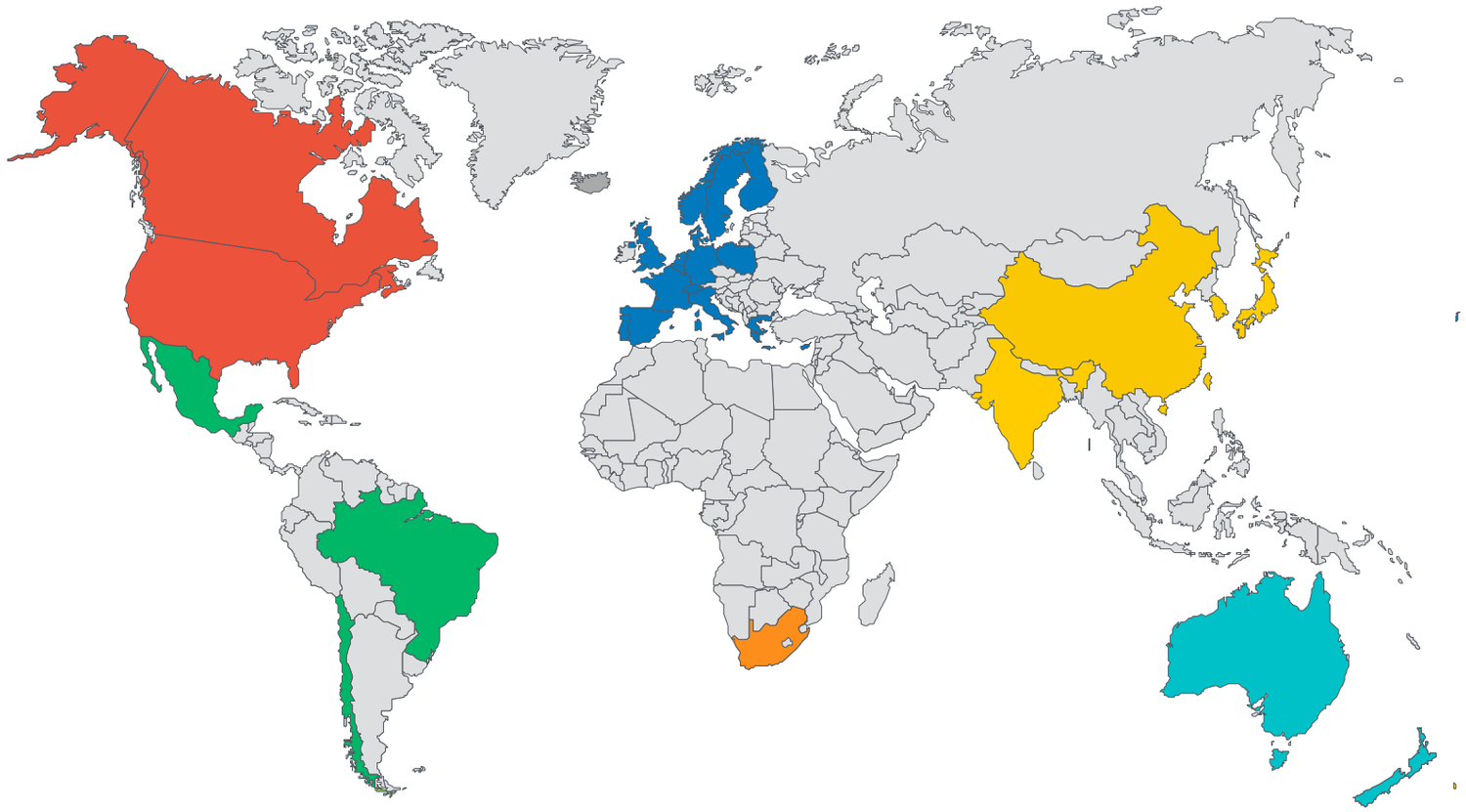
She has also contributed her analytical and research skills to the following projects:

- Created a global database on connected car services to update our **Vehicle Data Market Global Study;**
- Provided **a car data broker** with market sizing, forecasting, and trends of **mobility economy markets;**
- Helped **a global electronic tolling solutions provider** research ETC tenders in North America

Katrina is a fluently trilingual communicator in Chinese, English, and French.

Our forecast analyses the growth and penetration rates of electric vehicles in fleets across 6 continents

The 6 regions covered by the market forecasts*



Vehicle segments

- Company cars
- LCVs
- Buses
- HGVs

Battery electric vehicles

Non-battery electric vehicles

Source: PTOLEMUS; Note: LCVs = light commercial vehicles; HGVs = heavy goods vehicles - Note: *Cf. Section 6: Regional Forecast for more details. As North America, Europe and China in fact account for 95% of the BEV market, the remaining areas included in our forecast will be classified as "the rest of the world ».

PTOLEMUS followed a 5-stage process to ensure the relevance and high quality of this research

- Each research project begins with a thorough planning phase that defines the objectives of the research and what value it should bring to the reader
- Then we identify the sources and market intelligence required to meet the objectives of the report

The next stage is to design the "tools" required to successfully perform the project:

- **Questionnaire and survey design:** the questionnaires are designed to address the research requirements and evolve based on respondent feedback
- **Forecast model design:** the forecast model is designed to combine lagging and/or leading indicators

- **Secondary research:** Encompassing the collection of data from all relevant government and industry sources
- **Desk research: Leveraging of non-confidential PTOLEMUS internal IP** built-up from many consulting projects with fleets and fleet electrification solution providers
- **Primary research:** Split between company surveys and executive interviews, this phase uncovers the insights only known to industry insiders and not commonly covered by readily available secondary sources

- The team collates and analyses the facts, figures and insights collected during the research phase and creates the content
- PTOLEMUS aims at creating reports that are **"C-suite ready"** and applies the **"pyramid principle"** to every slide produced
- Ensuring that from the page headline to the final word, every page is easy to read, the content is cohesively written and the reader can gain **easily understandable insights**

- The final stage of creating the report is to share the content amongst the most senior personnel in the business, **leveraging years of experience in vehicle electrification** to, robustly stress-testing the insights, conclusions, and forecasts of the report and ensure that any content adjustments required are made, **thus ensuring the quality and reliability of insights.**

PTOLEMUS' forecast methodologies have been specifically designed to model the fleet BEV market

Scope of the fleet electrification forecast

Our forecast considers **historical data from 2010 to 2021**, and **evaluates current practices to promote EVs in 27 countries** around the world

- **For the vehicle market sizing and forecast, we include:**
  - Number of new BEVs registered
  - Number of other vehicles registered (incl. plug-in hybrid and hydrogen vehicles)
  - Number of BEVs in use
  - Number of other vehicles in use (incl. hybrid electric and plug-in hybrid electric vehicles)
- **For the fleet BEV market sizing and forecast, we include:**
  - Total battery electric company cars registered and cars in use
  - Total battery electric LCVs registered and in use
  - Total battery electric buses registered and in use
  - Total battery electric HGVs registered and in use
- **To generate our forecast for fleet BEV vehicle registrations from 2022 to 2030, we assess the 27 countries' EV progress & incentives:**
  - Number of new EVs registered and EVs in use
  - GDP per capita
  - Density of the charging infrastructure
  - EV incentives

Source: PTOLEMUS; Note: Vehicle categories include: PC, LCVs, Buses, HGVs

We would like to thank the following companies for their participation during PTOLEMUS primary research phase

ALD Automotive

ama ROMA

ARVAL BNP PARIBAS GROUP

avis budget group

BUREAU VERITAS

chargepoint

DANONE ONE PLANET. ONE HEALTH

EV SEMI-FLEET

EVP Solutions The Fleet Experts

ezero

Ford PRO

GUARDIAN FUELING TECHNOLOGIES

GILBARCO VEEDER-ROOT

IMERGE ELECTRIC FLEET SOLUTIONS

NEXTera ENERGY

PERPETUAL MOTION SALES STRATEGY

SIXT

SHERBET THE ELECTRIC TAXI Co

SIEMENS

VIRICITI

VOLTAGE IT building software that works

Table of contents

The report mentions 82 companies (1/2)

Company	Type
ALD Automotive	Leasing / fleet management company
Alphabet	Leasing / fleet management company
AMA Roma	Environmental services
Amazon	Logistics fleet
American Battery Solutions	Energy
Arval Europe	Leasing / fleet management company
AT&T	TSP
Athlon	Leasing / fleet management company
AvisBudgetGroup	Rental
Bureau Veritas Group	Inspection
BYD	OEM
BrightDrop	Truck manufacturer
ChargePoint	Energy
Citroën	OEM
Daimler Truck	Truck manufacturer
Danone	Logistics fleet
DHL	Logistics fleet
dpd	Logistics fleet

Company	Type
DST	Rental
DKV Euroservice	Fleet solution provider
E zero	Distributor
EV Box	Charger solution provider
EV Connect	TSP
EV Semi Fleet Corp	Truck manufacturer
EVgo	Charger solution provider
Element	Fleet solution provider
FedEx	Logistics fleet
Fleet Advisory Associates	Consulting
Ford Pro	OEM
Frito-Lay	Logistics fleet
G7	TSP
Genus ABS	Logistics fleet
Geotab	TSP
Gilbarco Veeder-Root	Charger solution provider
Glencore	Energy
GM	OEM

Company	Type
Guardian Fuel Technologies	Infrastructure
Hertz	Rental
Holman	Leasing / fleet management company
Honda	OEM
Hyundai	OEM
IKEA	Logistics fleet
Jim Pattison Lease	Fleet solution provider
Leaseplan	Leasing / fleet management company
LG	Elecrtronic
Li Auto	OEM
Li-Cycle	Recycling
Linetec services	Infrastructure
Loxam	Rental
Merchants fleet	Fleet solution provider
Merge Electric Fleet Solutions	Fleet solution provider
NextEra Energy	Energy
NIO	OEM
Nissan	OEM

Source: PTOLEMUS

The report mentions 82 companies (2/2)

Company	Type
Northvolt	Energy
Nuvve	Charger solution provider
Perpetual Motion	Leasing / fleet management company
Redwood Materials	Recycling
Renault	OEM
SF Express	Logistics fleet
SGS	Logistics fleet
Sherbet Taxi	Taxi fleet
Siemens	Fleet solution provider
SIXT	Rental
SK Innovation	Energy
Solvay	Recycling
Stellantis	OEM
Syrah Resources	Energy
Talon Metals	Energy
Tesla	OEM
Toyota	OEM
TotalEnergies	Energy

Company	Type
UPS	Logistics fleet
Veolia	Environmental services
ViriCiti	Software
Volkswagen	OEM
Volvo Truck	Truck manufacturer
Voltage	Software
Wey	OEM
Wheels	Fleet solution provider
Xpeng	OEM
Yodel	Logistics fleet

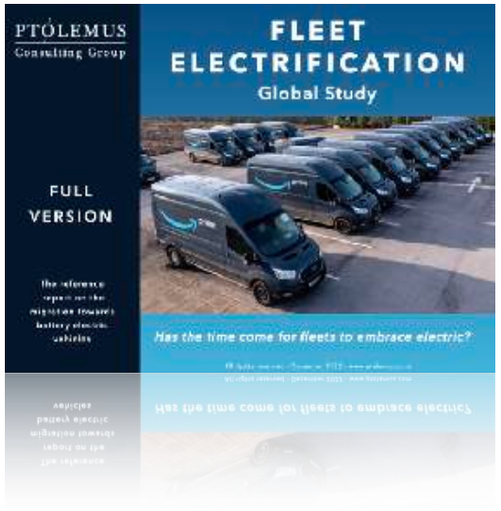
We use the following acronyms in this report

Acronym	Definition
AFIR	Alternative fuels infrastructure regulations
APAC	Asia-pacific
AVAS	Acoustic vehicle alert alarm
B&C	Buses and Coaches
BEVs	Battery electric vehicles
BMS	Battery management system
CAGR	Compound annual growth rate
CaaS	Charging as a service
CC	Congestion charging
CCS	Combined charging system
CPO	Charging point operator
CSR	Corporate social responsibility
DCFC	Direct current fast charging
EoL	End of life
ESG	Environment, Social and Governance
ETC	Electronic Toll Collection
EU	European Union
EMSP	e-Mobility service provider
FMC	Fleet management company

Acronym	Definition
EVs	Electric vehicles
EVSE	Electric vehicle supply equipment
GHG	Greenhouse gas
GIS	Geographic information system
GPS	Global Positioning System
GVWR	Gross vehicle weight rating
GWh	Gigawatt hour
HEVs	Hybrid electric vehicles
HGVs	Heavy goods vehicles
ICE	Internal combustion engine
ICEV	Internal combustion engine vehicles
IEA	International Energy Agency
kWh	Kilowatt per hour
LATAM	Latin America
LCVs	Light commercial vehicles
LEZ	Low emission zone
LDVs	Light delivery vehicles
MCS	Megawatt charging system
MCS	Megawatt charging system

Acronym	Definition
MCVs	Medium commerical vehicles
NEVs	New energy vehicles
NORAM	North America
OEMs	Original equipment manufacturers
OBC	On-board charger
PHEVs	Plug-in hybrid electric vehicles
PHYD	Pay-as-you-drive policy
PVs	Passenger vehicles
RSA	Roadside assistance companies
SoC	State of charging
SoH	State of health
TCO	Total cost of ownership
TSP	Telematics service provider
V2G	Vehicle to grid
ZEVs	Zero-emission vehicles

The study comes with a single, worldwide company licence



The reference report for how and when fleets should start and the transition towards electric

	Full report	Market forecasts	Full report + Market forecasts
Contents	• **Over 420 pages of analysis of the global fleet electrification landscape** based on: - 11 years of constant market surveillance - 6 months of research and analysis - 17 interviews with key stakeholders • **Granular analysis of the current state of fleet electrification**, including: - Industry supply constraints and mitigation strategies - TCO case studies comparing EV cars, eLCVs and eHGVs versus diesel equivalents • **An in-depth assessment of 11 suppliers of electrification solutions** to fleets, including comparative tables • **Case studies of how fleets have successfully electrified**, and how they did it	• **Excel file with outputs and charts** • **2020-2030 bottom-up market forecast encompassing:** - 27 countries - 6 continents including Europe, North America, Central & Latin America, Asia, Africa and Oceania - 4 vehicle segments: Cars, LCVs, HGV and Buses - Volume of EV registrations to 2030 - Volume of EVs in use, to 2030	**Includes both the full report and the market forecasts**
Company-wide licence	**4.990 €**	**1.490 €**	**5.990 €**

For more information and to order the study or enquire about our subscription model, email fleet@ptolemus.com

Source: PTOLEMUS

Note: Prices in euros, excluding VAT (VAT only applicable to clients located in Belgium)

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Global Study

Extracts from the full study

PTOLEMUS Consulting Group

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Fleet Electrification Global Study

PTOLEMUS

This reports covers the following 5 fleet segments

Commercial Road Transport (CRT)

- **LCVs (< 3.5t)** & **HGVs (> 3.5t)** are used for the **goods transportation and distribution** locally or abroad
- **Different drivers**, with **different driving behaviours** may drive the same vehicle in **shifts**
- **No personal use is allowed**
- HGVs, in particular, have a **high and international mileage**

Maintenance & utilities

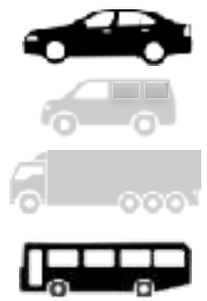
- **Light and some heavy commercial vehicles** operating locally and travelling **fewer miles than CRT fleets**
- Used by companies such as telecom operators, roadside assistance fleets as well as electricity, water or sewage providers

Rental & leasing

- Typically **passenger cars used for individual and business purposes**
- Includes short to long term rentals and cars used as part of urban and inter-urban car sharing schemes

Public sector

- Passenger cars and heavier vehicles designed for **mass transportation such as buses and coaches (B&C)**
- Passenger cars are frequently leased



Company cars

- **Passenger cars supplied primarily for business purposes**, (could be allowed for a personal use)
- Company cars are frequently leased
- We distinguish company cars from those given to a single employee, often as part of a renumeration package

Source: PTOLEMUS Note: HGVs: Heavy Goods Vehicles; LCVs: Light Commercial Vehicles; B&Cs: Buses & Coaches; CRT: Commercial Road Transport

We segment fleets in 3 segments based on the number of vehicles

Small or “mini” fleets

< 5 vehicles

- Often includes “grey” fleets, in which the vehicle is registered as a **private car**
  - A large proportion of these fleets are small, especially in **China and Latin America**
  - The operation of small or “mini” fleets is decentralised and the fleet manager has **less monitoring capacity on drivers**
- This category currently has the **least possibility towards electrification** because of high capital cost and maintenance

Medium-sized fleets

5 - 150 vehicles

- Many of the these fleets are **growing and are recently introduced to electrification**
- Medium-sized fleets could be **mix of multiple vehicle segments or just one**
- Medium-sized fleets test on simple models before expanding to the whole fleet
- It is expected that medium-sized fleets growth towards electrification would be **slow, constrained by capital budget and range anxiety**

Large fleets

>150 vehicles

- **Large fleets are generally managed by bigger corporations with hundreds of vehicles and multiple vehicle segments**
  - Car, van, truck, trailer
- Large fleets are expected to have the **easiest transition towards electrification** driven by corporate sustainability targets
- Large fleets are relatively **stronger to invest in electrification**

Source: PTOLEMUS, UK Department of Transport

Vehicle classifications differ between the regions

Europe

- There are 3 categories following the UNECE classification system, where trucks and vans used for goods delivery belong to Class N:
  - **N1**: under 3.5 tonnes (i.e. LCV)
  - **N2**: between 3.5 tonnes and 12 tonnes (i.e. MCV)
  - **N3**: over 12 tonnes (i.e. HGV)
- Similarly, for buses and coaches, the following categories apply:
  - **M1**: under 3.5 tonnes
  - **M2**: >8 seats but <=5 tonnes
  - **M3**: >8 seats and >5 tonnes
- In order to be consistent throughout this study, **we use the European classification of trucks as a standard to make the global analysis**

North America

- There are 3 categories including 8 specific classes based on gross vehicle weight:
  - **Light Duty Trucks**
  - **Class 1-3**: 0 to 14,000 lbs (0 - 6.5 tonnes)
  - **Medium Duty Trucks**
  - **Class 4-6**: 14,001 to 26,000 lbs (6.5 - 12 tonnes)
  - **Heavy Duty Trucks**
  - **Class 7**: 26,000 to 33,001 lbs (12 - 15 tonnes)
  - **Class 8**: over 33,001 lbs (over 15 tonnes)

China

- **China has in the last decade adopted the UNECE classification system** (as used by Europe), however, the old standard is still used by many businesses and institutions
- In this previous standard, there were 4 categories of vans and trucks classified by gross loading capacity:
  - **Mini**: less than 1.8 tonnes
  - **Light**: 1.8 to 6 tonnes
  - **Medium**: 6 and 14 tonnes
  - **Heavy**: 14 to 100 tonnes

Australia & New Zealand

- There are **2 categories of commercial vehicles classified by gross combination mass:**
  - **LCVs**: up to 3.5 tonnes
  - **HGVs**: over 3.5 tonnes

Latin America

- **HGVs are usually defined by the configuration of their axles,** e.g. in Colombia:
  - **2/3/4**: Rigid vehicle with 2/3/4 axles
  - **2S1**: Articulated formed by a rigid of 2 axles and semi-trailer of 1 axle
  - **2S2**: Articulated formed by a rigid of 2 axles and semi-trailer of 2 axles

PTOLEMUS

Source: PTOLEMUS - Note: LCVs: Light Commercial Vehicles; HGVs: Heavy Goods Vehicles

Depending on the size, type and classification of the vehicle, electrification trend and requirement can vary (1/2)

Fleet vehicle categories and key electrification features

LCVs

- Light Commercial Vehicles (LCVs) used for last mile delivery and urban transport
- With growing e-commerce operations, last-mile delivery, specially for parcels, food is increasing
- Electrification of LCVs depends on the purpose:
  - Easier transition for last mile deliveries
  - Complex for utility companies with higher payload because of range and battery consumption anxiety

HGVs

- Heavy Goods Vehicles (HGVs) are long haul vehicles that transport freight with a travel distance of at least 500 km per day
- HGVs would require a higher battery capacity >500kW in order to compensate their gross combination weight (GCW) and required range
- HGVs transition to EVs also requires sufficient public charging network installed in multiple countries at regular intervals, especially in rural areas

MCVs

- Medium Commercial Vehicles (MCVs) are similar to HGVs but with a lower gross combination weight (GCW) and driving range
- MCVs comparatively require a smaller battery capacity compared to a HGV
- This is due to the typical role given; travelling medium distances and typically returning to a depot overnight
- MCVs should have a relatively easier transition to electrification compared to HGVs, given their lower driven distances

PTOLEMUS

Source: PTOLEMUS,
Note: HGVs: Heavy goods vehicles; LCVs: Light commercial vehicles; MCV: Medium commercial vehicles

Depending on the size, type and classification of the vehicle, electrification trend and requirement can vary (2/2)

Fleet vehicle categories and key electrification features

- Company cars are used by individuals who have an average driving requirement of 50-100km per day
- Today, Car OEMs offer a vehicle driving range of average 350 km with fast charging solutions, which technically can accommodate the average company car driver
- OEMs offer smartphone applications for consumers to:
  - Manage travel distance
  - Charge management
  - Charge point locations

- Buses are relatively the lowest among the vehicles in use in any country
- Buses are generally used for public transport and tourism
- Public transport buses have an easier opportunity towards fleet electrification unlike tourism buses
  - Because of their lower driving range per day
- Electric buses are generally charged overnight in a bus depot

PTOLEMUS

Source: PTOLEMUS

Regardless of the type of fleet, electrification is driven by common objectives

- Firstly, fleets are one of the most significant sources of air pollution, **accounting for approximately 25% of global GHG emissions**
- **Electrification has emerged as a critical means of reducing CO_2 emissions**
- A number of regions are already leading the way in terms of deploying fleet electrification strategies to combat climate change and to meet environmental protection trends:
  - **Norway** will reach its **2025 target for 100% of new passenger cars, LDVs* and city buses to be electric**
  - **China aims at an EV penetration of 40% in total registrations by 2030**
  - **The EU** has announced a **ban on the sale of new vehicles equipped with ICE** from 2035**
  - **The United States** aim to have **half of all new vehicles sold zero-emissions by 2030**
  - **28 major countries have pledged to go all-electric by 2040** at COP26 in 2021
- In recent years, **many OEMs have shifted to the development and production of BEVs**, driving the development of the EV industry and broadening the choice of fleets
  - Following Tesla, Nissan and Renault, Ford has for example launched its F-150 electric pick-up truck in 2022
  - Numerous new electric OEMs have emerged from Arrival and Nikola to Rivian
  - This has encouraged **component and service suppliers across the industry to incorporate products and/or services for EVs**
- Fleet electrification can bring economic advantages because **the TCO*** of a commercial EV can be lower than that of a petrol or diesel equivalent,** due to:
  - **Higher efficiency of energy produced**
  - **Lower maintenance costs**
  - **Higher tax deductibility**
- Electrification is also a reflection of **the health concerns of drivers and the surrounding communities**

Source: PTOLEMUS, Climate Group, Statens Vegvesen, UK gov., European Parliament, China gov., White House

Note: *LDV: Light delivery vehicle (<3.5 tons), **ICE: internal combustion engine, ***TCO: Total Cost of Ownership

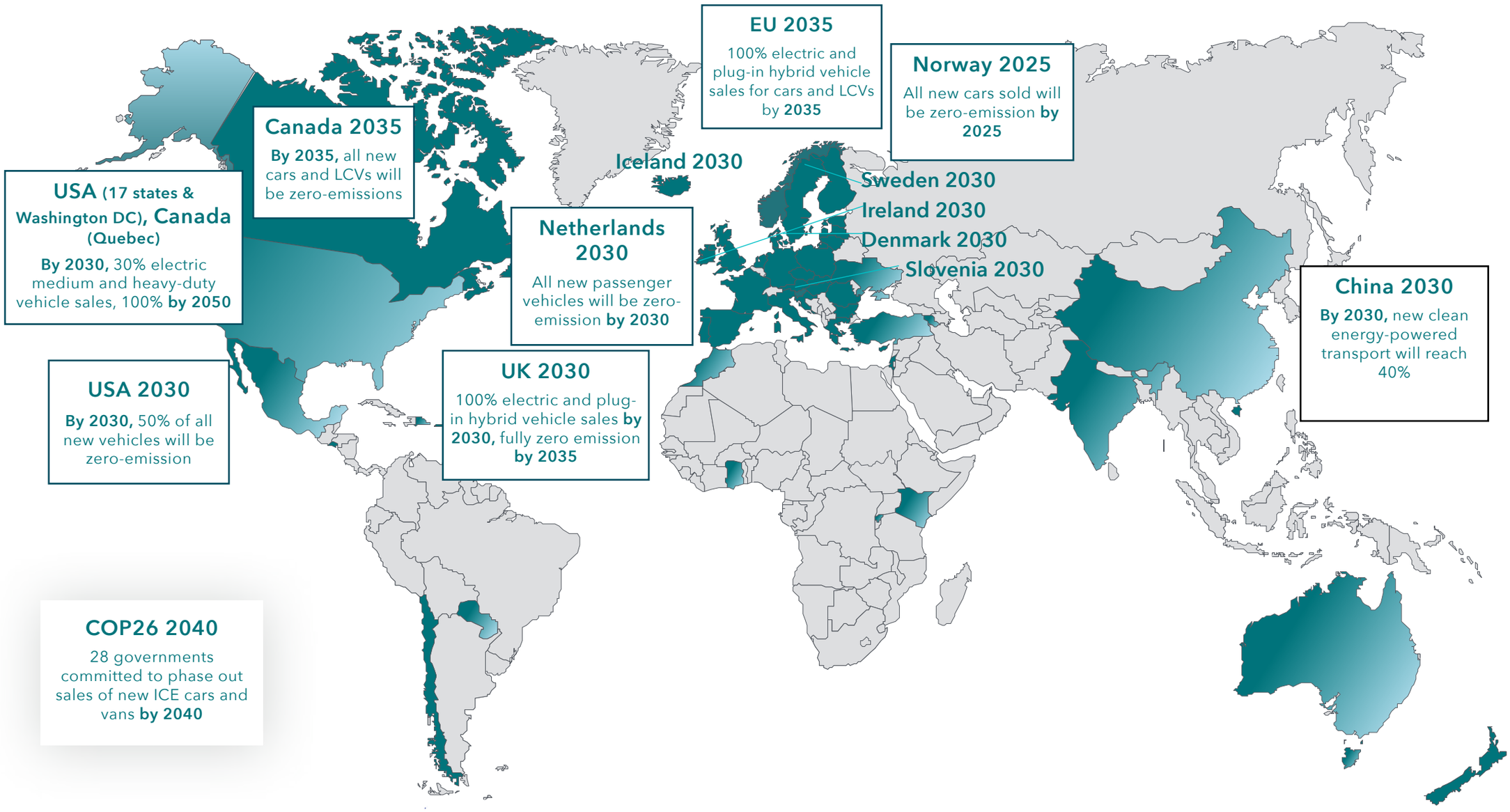
Globally, more than 40 countries have set a target to phase out the sales of ICE vehicles

Global electrification progress

Governments with official ICE phase-out targets

Electrification plan in place

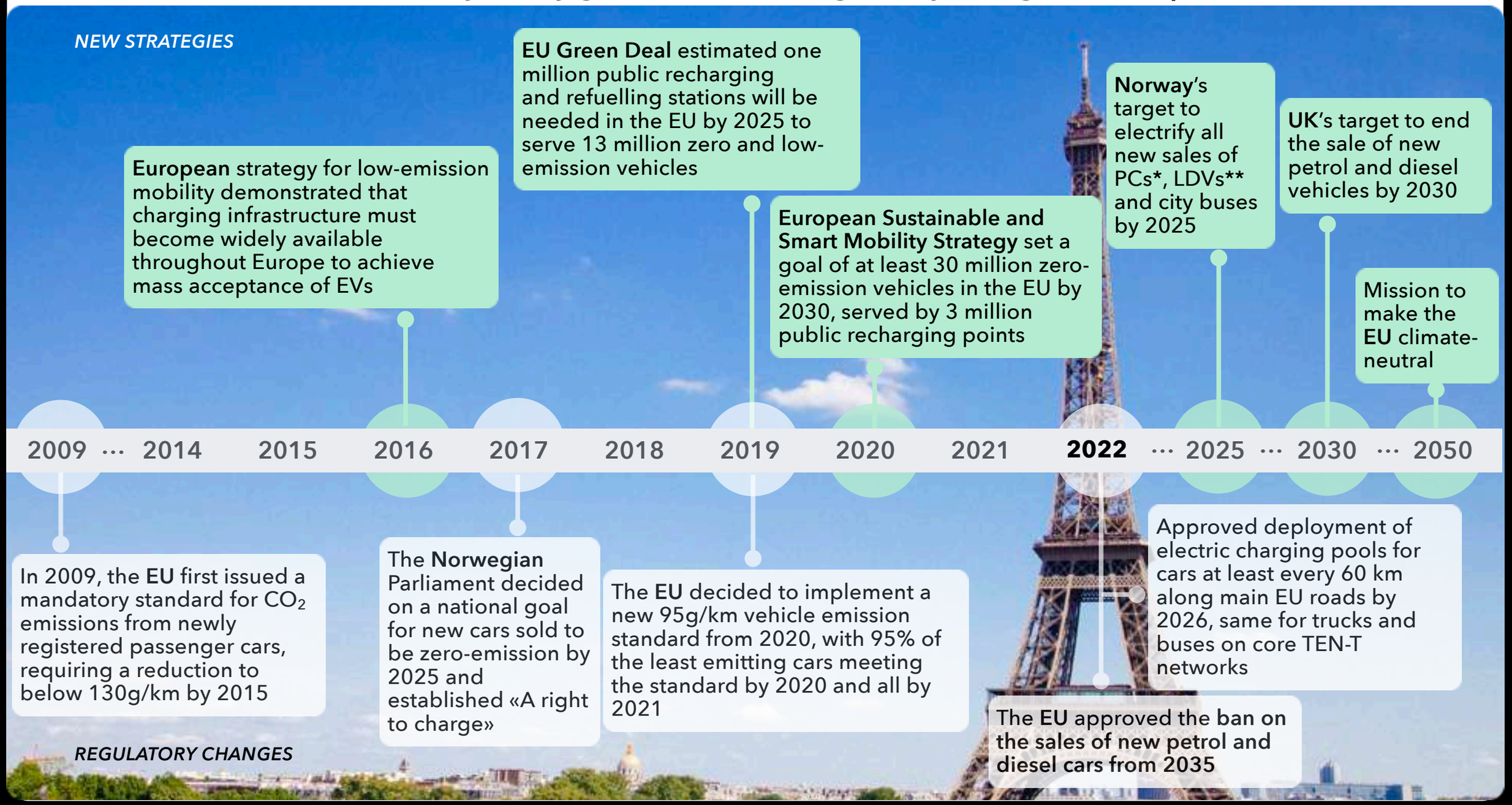
Not yet planned



Source: PTOLEMUS - Note: As of November 2022

Europe has become the continent most aggressively following an electrification policy

Summary of key governmental & regulatory changes in Europe

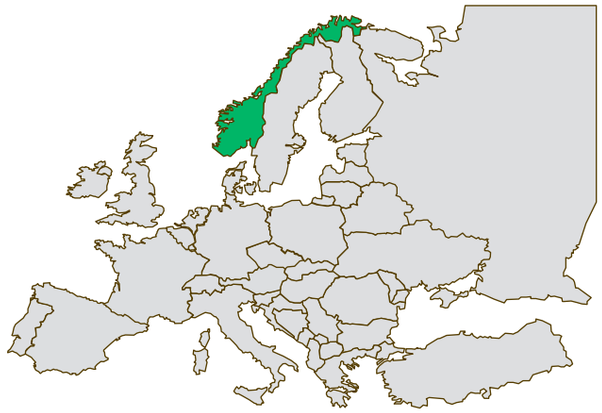


Source: PTOLEMUS, the EU Parliament, Statens Vegvesen, UK gov.; Note: *PC, passenger cars, **LDV: Light delivery vehicle (<3.5 tons).

Norway is a global leader in electrification, with over 470,000 EVs on the road and charge points every 50kms

Local benefits

- Up to **50% deduction** of the total amount on ferry fares for EV
- Up to **50% deduction** of the total amount on toll roads
- **Free to use bus lanes** for EVs carrying one or more passengers



Tax benefits

- **Purchase tax exemptions** worth of €15,000 on average
- **VAT (25%) exemption on leasing**
- A **20% reduction in company car tax** from 2022

Infrastructure

- Legislation to create **a "charging right"** for people living in apartment buildings has been introduced between 2017 and 2021
- **Fast charging stations have been successfully installed on all major roads** in Norway
  - Over 470,000 EVs, as of February 2022
  - One fast-charging station every 50km
  - 4,600 cars can fast-charge at the same time

Local EVSE* grants

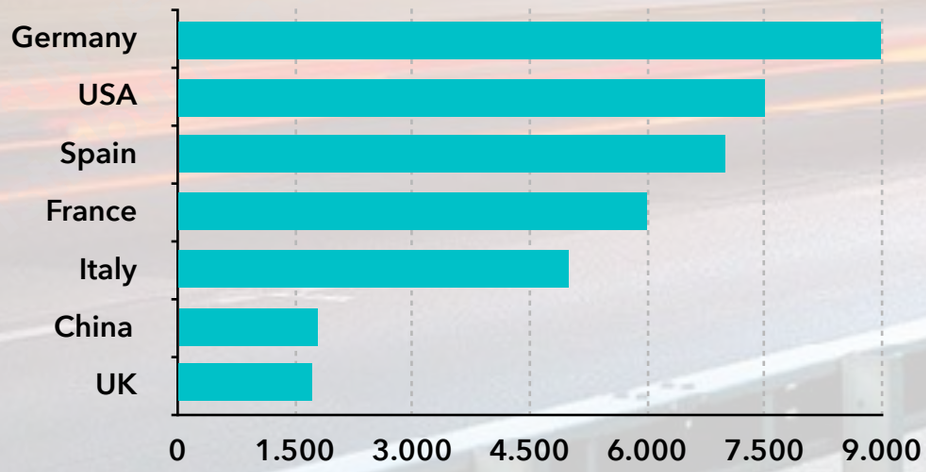
- **Oslo** offers EVSE grants of up to **NOK5,000 per charging point** and NOK1,000,000 per housing association
- **Skedsmo** offers EVSE grants of up to **NOK5,000 per charging point** and NOK250,000 per housing association
- **Asker** offers EVSE grants of up to **NOK5,000 per charging point** and NOK50,000 per housing association
  - Free charging
- **Baerum** offers EVSE grants of up to **NOK50,000 for the purchase and installation costs**
- **Trondheim** offers EVSE grants of up to **NOK5,000 per charging point**

Source: Norsk elbilforening, Trondheim kommune, Oslo kommune, Viken fylkeskommune, Asker kommune, Baerum kommune.
Note: *EVSE, Electric vehicle supply equipment.

Europe, North America and China are all using subsidies and tax incentives to meet electrification goals

- Europe, North America and Asia began to **provide support for zero-emission vehicle development in the 2010s**
- The most common policy has been **the award of purchase subsidies for EVs:**
  - Several countries have increased the amount of subsidies in recent years, Europe especially
  - **However there are exceptions, such as China decreasing subsidies year-on-year since 2019**

Maximum subsidies for BEV passenger cars $, (2022)



- Other promotional mechanisms include **tax incentives where exemptions for registration, ownership and company car taxes are applied**
  - Due to the popularity of company cars as an employee benefit in Europe, **France, Germany, Spain, and the UK have implemented company car tax incentives for EVs,** resulting in a sizeable electrified fleet
- In addition to subsidies, many countries have also **implemented penalties to force electrification**
  - Such as **California ZEV regulations in the US and China's Dual-Credit policy**
- In response to the increasing demand for EVs, **many countries are increasing governmental investment in charging infrastructure, and** providing subsidies to businesses and individuals for the installation of charging stations
- Countries are increasingly aligned in their strategic direction to reduce carbon emissions and increase the use of new energy vehicles
  - Norway is a leading example of how a country can electrify its vehicle fleet
- **However,** whilst the Bipartisan infrastructure law and Alternative fuel infrastructure tax credit are helping the US to start electrifying, **North America lags behind in most indicators**, as it has not implemented a phase out date for ICE vehicles

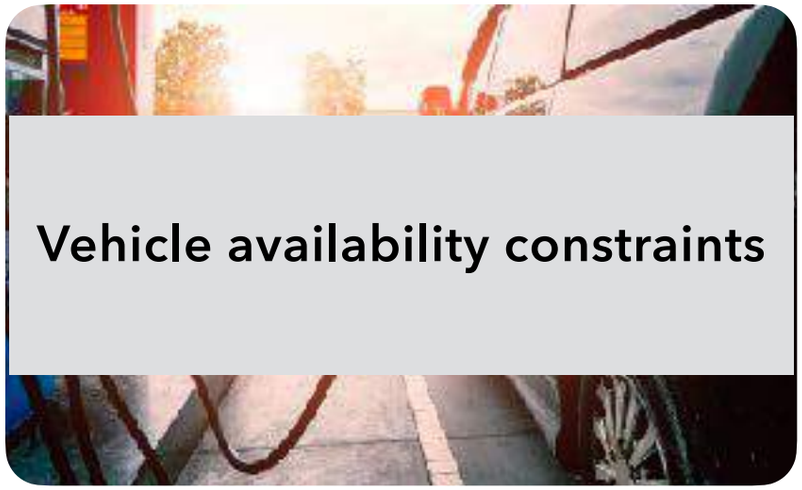
PTOLEMUS

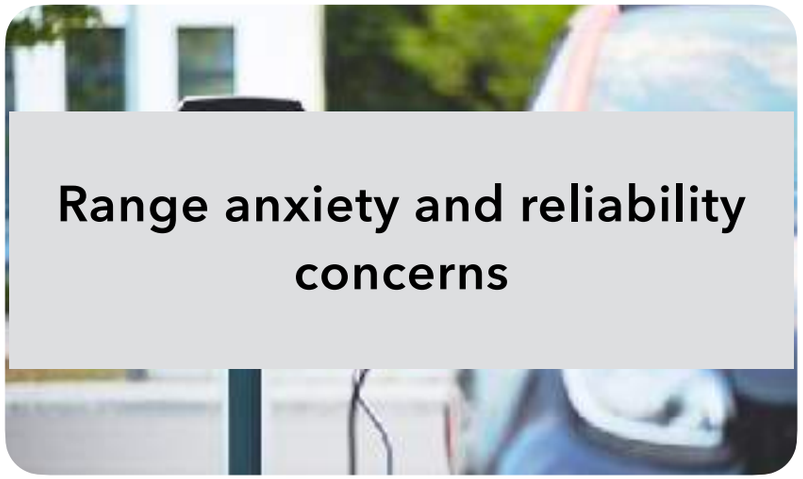
Source: PTOLEMUS

Fleet Electrification Global Study

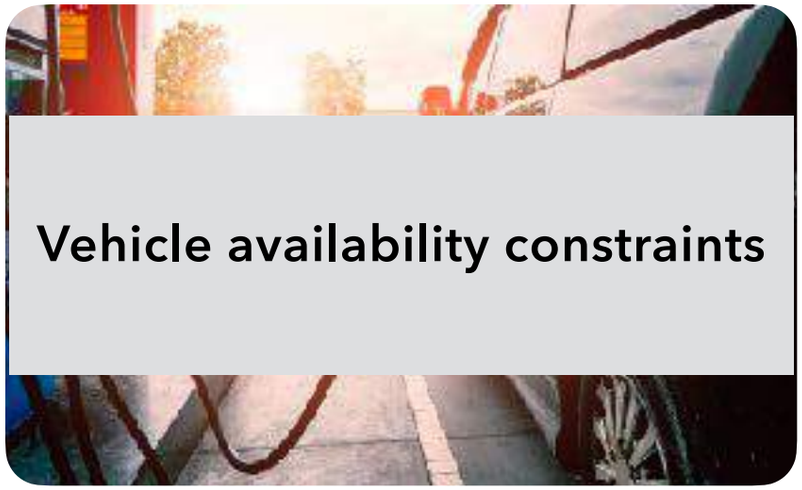
PTOLEMUS

There are 4 major constraints that prevent or discourage fleets from electrifying their vehicles





Availability constraints are a major issue preventing fleet electrification; companies must have a mitigation strategy



- The following issues that surround availability of EVs are commonly cited by fleets and are also encountered by the industry:
  - Lack of **vehicle availability** at point of purchase
  - Lack of range/**model variety** when considering EV purchase
  - Lack of **raw material availability** for battery manufacturing
  - Lack of **semi-conductors** for chipsets required for vehicle manufacturing
  - Concerns regarding the **lack of suitability** for purpose (i.e. does the vehicle payload and battery range meet the fleet operator's needs)

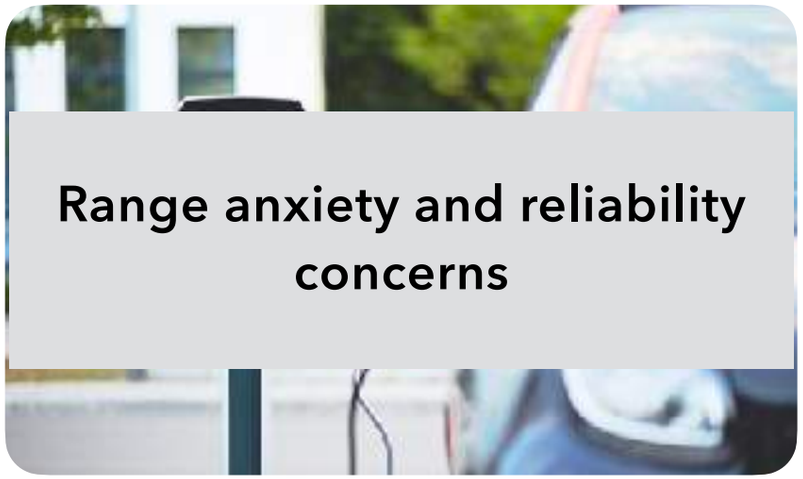
Source: PTOLEMUS

It is critical that the Total Cost of Ownership for ICE vs EV is compared, as it is not always cheaper to switch to an EV

- Total cost of ownership (TCO) constraints include the following issues which are cited by fleets as preventative to them adopting EVs:
  - Concern of **initial vehicle purchase price**
  - Lack of understanding of **how to align** the TCO profile of an EV with an equivalent ICE vehicle
  - Unfamiliarity of EV's **service, maintenance and repair costs**
  - Disruption due to the current **global energy crisis** and its impact of **electricity costs and availability**

Source: PTOLEMUS

Range anxiety and reliability are commonly cited for low EV adoption; fleet managers must split fact from fiction



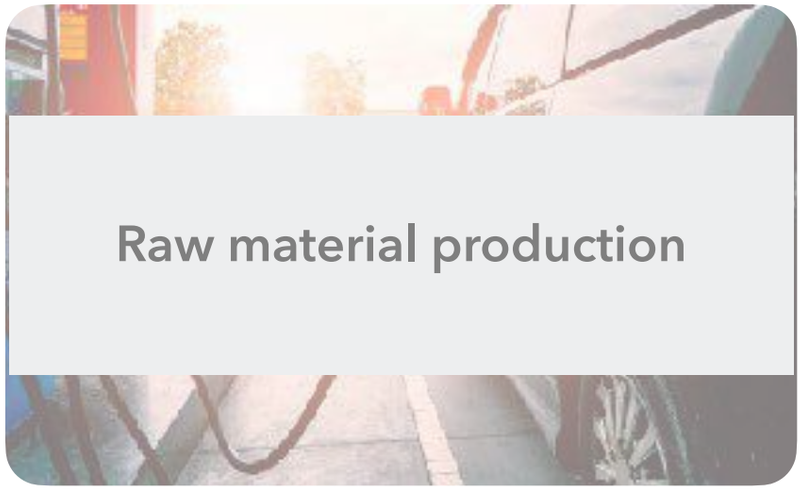
- Range anxiety and the associated reliability of EVs is a very common issue cited by fleet managers*, with answers being required to the following commonly asked questions:
  - Do **seasonal weather variations** cause range or reliability issues?
  - Does the **additional mass** contributed by the EV's traction battery cause any alternative/unfamiliar **service, maintenance and repair issues?**
  - Are there issues, obligations or challenges regarding the end of vehicle life and **recycling of batteries**?
  - Does the EV's traction battery provide a **suitable range?**

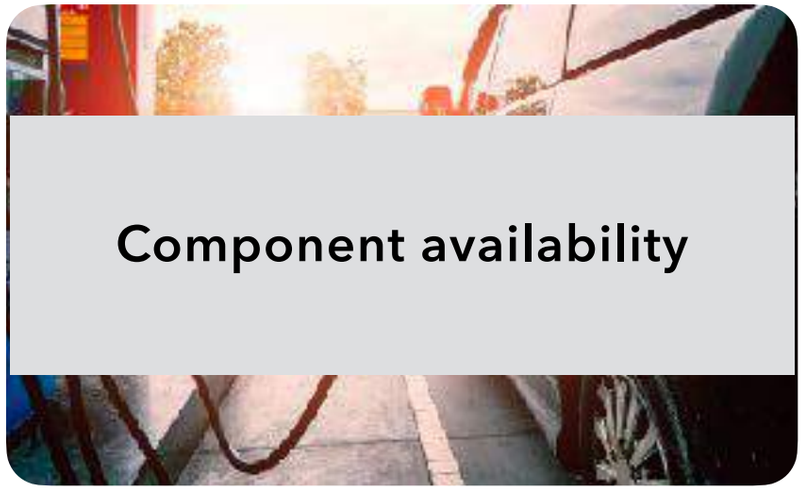
Companies must consider existing charging constraints for each EV segment, and if it aligns to its fleet operations

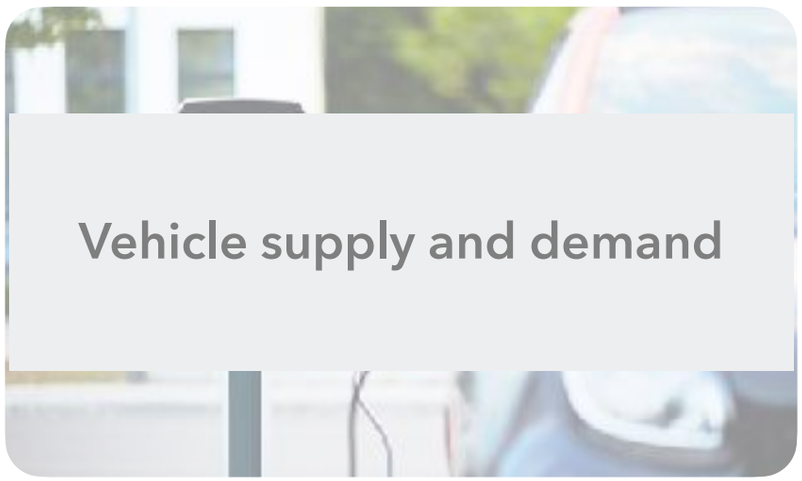
- Possibly the most divisive issue regarding electric vehicles
- The concerns surrounding the need for adequate charging infrastructure and regime for an EV fleet are very high, and require the following concerns to be addressed:
  - What are the fleet's **charging voltage requirements?**
  - What are the fleet's **charging cycle requirements?**
  - What are the fleet's **charge station compatibility requirements?**
  - What are the fleet's **charge point location requirements?**

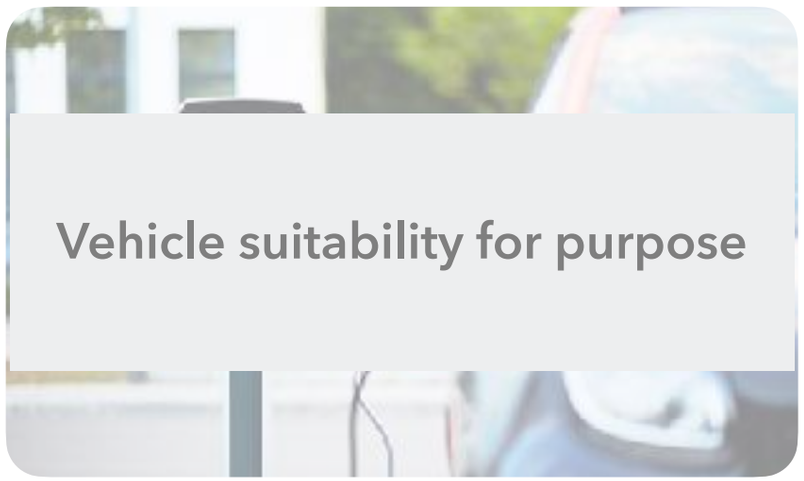
Source: PTOLEMUS

Companies must understand causes of component shortages and phase electrification to mitigate the impact









Source: PTOLEMUS

Semiconductor manufacturing is a complex process and Asian countries dominate fabrication and assembly

Semiconductor industry ecosystem for automotive applications

	Operation	Key locations	Major companies
Design	Semiconductor design	Global	Intel, Renesas, NXP, Samsung, Nvidia, Qualcomm
Manufacturing	Equipment manufacturing for fabrication	Japan, USA, Netherlands	Lam Research, ASML, Applied Materials, TEL
	Raw materials for chip (silicon wafers)	Japan, China, Taiwan	Okmetic, Shin-Etsu, SUMCO, GlobalWafers
	Fabrication and development of core processor	Taiwan, South Korea, China, Europe	TSMC, Samsung, UMC, Infineon, SMIC, STMicroelectronics
	Assembly and testing	USA, China, Taiwan	Amkor Technology, SPIL, ASE, JCET
	OEMS and tier-1 suppliers	Global	Volkswagen, Volvo, GM, Ford, Bosch, Continental, ZF

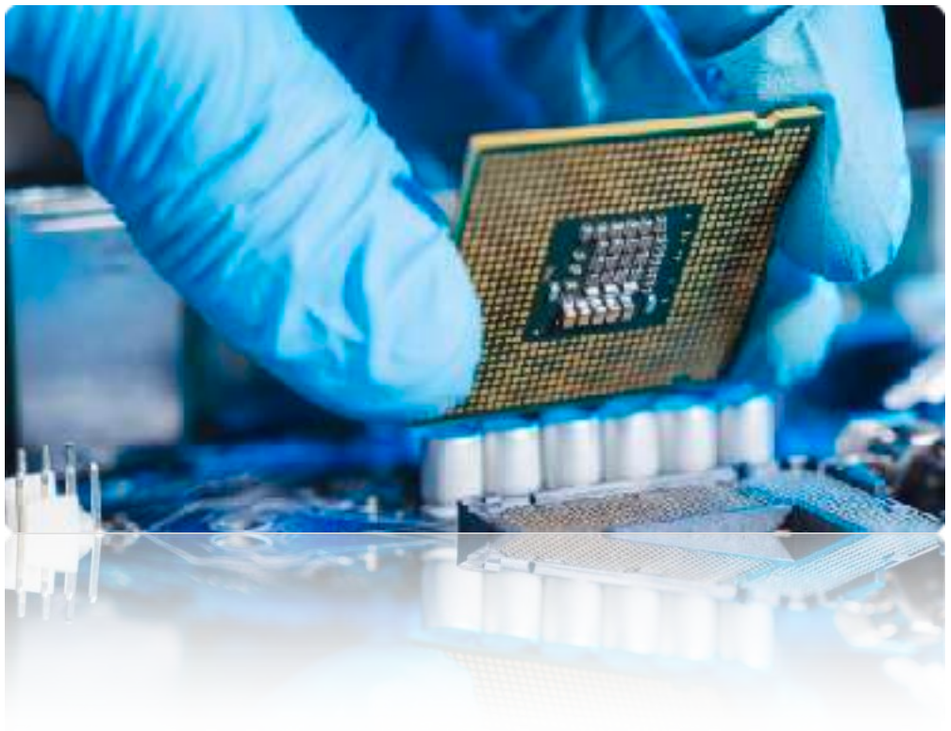
- Semiconductor manufacturing is a very complex process and involves **a lead time of at least 4 months**
- The process requires **precision, clean environments and expensive industry equipments**
- Throughout the semi-conductor manufacturing process, **companies on average invest 20-25% of their revenues in R&D**
- Industry players at each part of the process are required to be abreast of the latest industry know-how in order to sustain market share
- The **USA leads in the design and early stages** of semiconductor manufacturing while the later part of **fabrication, assembly, testing and packaging is dominated by Asian countries** especially Taiwan, China, Japan and Korea
- Whilst representing only **2-3% of the total vehicle's cost,** semiconductors are critical for the operation of the most basic features of a modern vehicle (such as door locks), so **a shortage of such components is a critical issue for OEMs**

Source: PTOLEMUS, Netscribes

The COVID-19 pandemic has triggered a semiconductor supply chain crisis, impacting automotive production

Semiconductor chip shortage problem

- 2020 started with the **unprecedented COVID-19 pandemic that was followed by a global semiconductor chip shortage**
- Until the pandemic, automotive **OEMs had enabled to manage a robust supply of chips using "just-in-time" supply methods**
  - This was initially **disrupted as supplies were not required due to a collapse in demand for new vehicles and a consequent idling of manufacturing by OEMs**
- Conversely, with lockdowns forcing individuals to either work from home or find new forms of personal entertainment whilst in confinement, **demand for personal electronic devices and computer hardware sky-rocketed**, resulting in the lack of **demand from vehicle OEMs being replaced** by demand from the consumer electronics industry
- Once demand began to return for new vehicles, and devoid of inventory, OEMs have found themselves with a **semiconductor chip shortage which had resulted in assembly lines halting,** causing major impact on the supply of new vehicles
- The OEM chip shortage has impacted **an estimated 8 million units loss of production** in 2021
- Furthermore, **EVs require an twice as many chips** as their ICE vehicle equivalent
- This has resulted in **longer delivery times for vehicles to reach dealers** and end users
- It has also resulted in **higher MSRP* as OEM manufacturing costs increase, and compromising vehicle features in order to save on the number of chips used in a vehicle**



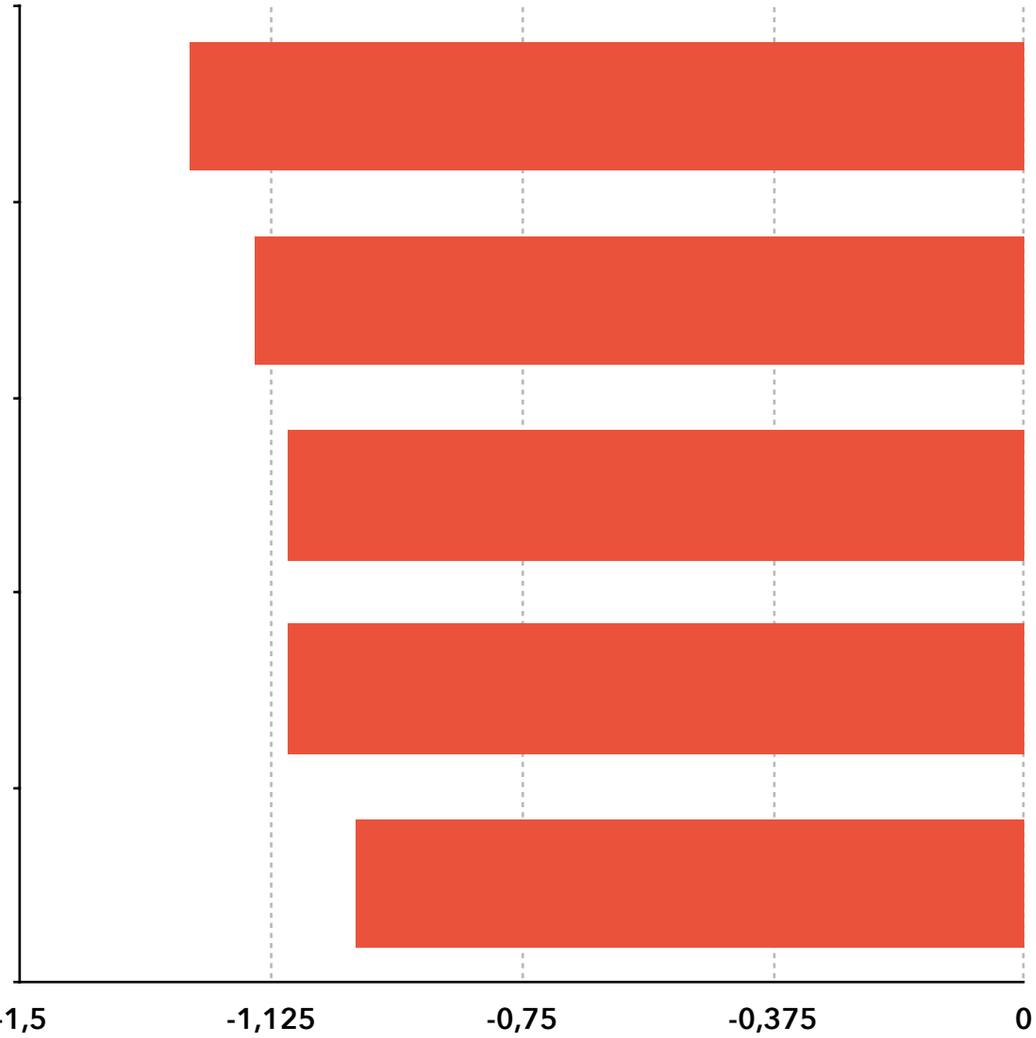
Source: PTOLEMUS, BBC (Image)
*Manufacturer's Suggested Retail Price

In 2021, the semiconductor chip shortage resulted in a global auto production loss of 8 million units

Automobile industry semiconductor chip crisis

- In 2021, the chip shortage caused an estimated global vehicle production loss of **approximately 8 million units**
- In vehicles, semiconductor chips are **used for sensors, control modules, infotainment and safety features**
- **Climate disasters** such as the Texas winter storm, Taiwan water crisis, semiconductor foundry fires have also contributed to the shortage of semiconductor chips available on the global market
- With megatrends such as **AI, cloud, IoT, Industry 4.0, robotics and autonomous driving, the demand for semiconductor chips is only going to increase**
- However, huge investments are pouring in to overcome this crisis:
  - In March 2022, **Intel** announced an **investment of €80 billion in the EU** over the next decade along the entire semiconductor R&D value chain

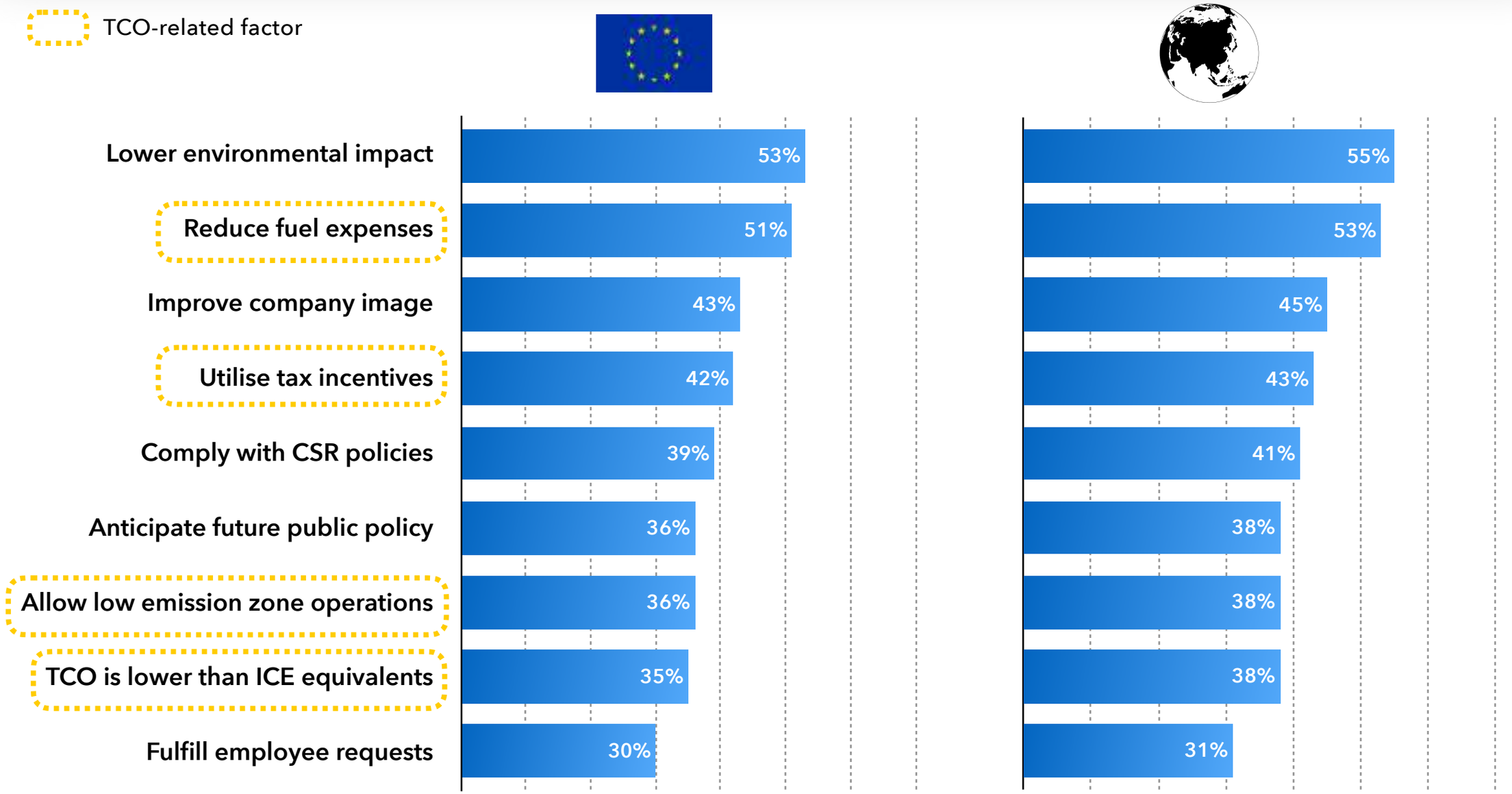
Production loss by major OEMs in 2021 due to chip shortages (million units)



Source: PTOLEMUS, CNET, Netscribes

In 2021, TCO-related factors accounted for 4 out of 9 reasons for fleets to electrify vehicles

Main reasons for fleet operators to electrify their vehicles



Source: Arval Mobility Observatory 2021 based on 5,200 interviews globally - Note: TCO: Total Cost of Ownership; LEZ operation allows shorter trips, thereby reducing fuel consumption and driving times

A fleet's Total Cost of Ownership (TCO) can be broken down into 10 components

The 10 components of a fleet's vehicle TCO*

Depreciation**	Value lost by the asset year by year, purchase value minus the theoretical resale value of the asset**
Energy	Fuel/energy consumption of the vehicle multiplied by the annual kilometres and the price at the pump of diesel or price per kWh
Taxes	Registration, ownership and insurance taxes applied to vehicles
Insurance	Comprehensive insurance of vehicle, driver and goods
Financing	Interest costs of financing an asset
Maintenance	Cost of preventive maintenance, repairs, spare parts, fluids servicing, replacement of "consumable" parts (i.e. brake pads)
Consumables	Charge per kilometre/mile of driving
Tyres	Cost of replacing or re-grooving tyres dependent on vehicle type
Tolls	Cost of tolls and other road-related charges and taxes

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Source : PTOLEMUS, Fleet Europe - Note: * Excluding driver-related costs; ** Depreciation rate depends on local tax rules

Taxation is an area where EVs have had exemptions and rebates, however increases are on the horizon

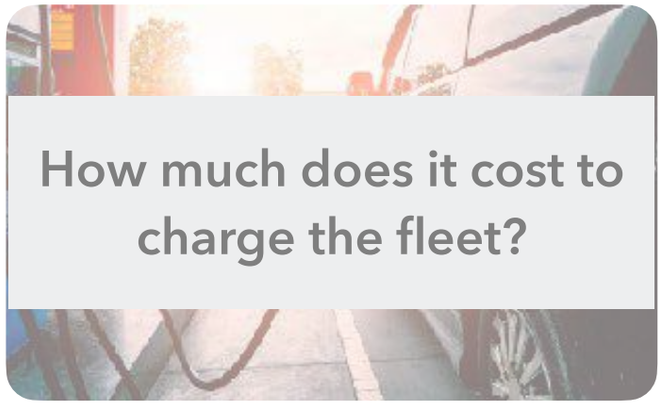
Impact of taxes in total cost of ownership

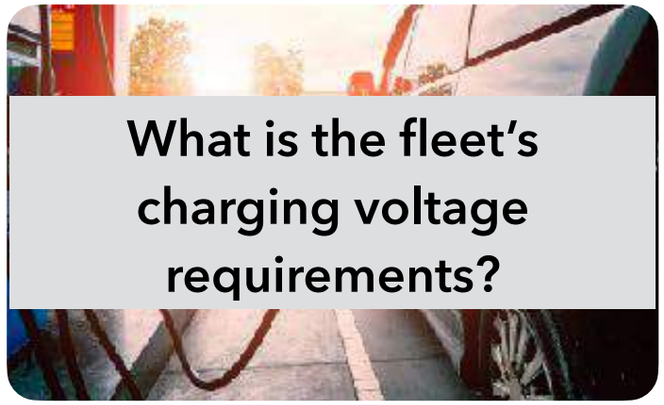
- Depreciation
- Fuel
- **Taxes**
- Insurance
- Financing
- Maintenance
- Consumables
- Tyres
- Tolls

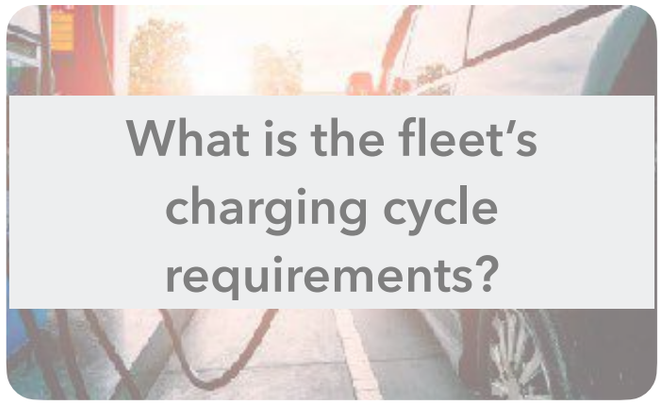
- **There are 5 main taxes for fleet vehicles**:
  - **Vehicle registration tax:** for the total lifetime of the vehicle
  - **Value Added Tax (VAT):** on the purchase price
  - **Ownership tax:** varies based on weight, type and number of axles
  - **Fuel tax:** varies based on the type of fuel (petrol, diesel, biodiesel and bioethanol)
  - **Insurance tax:** 20% of insurance cost
- In addition, governments levy tax on the income or revenue generated from the fleet business
- **EVs**, on the other hand, **are often exempted from some of these taxes and receive incentives***:
  - In France, for example, they are **exempted from the weight penalty tax, as well as the CO_2 taxation** and the government grants incentives **for fully electric or plug-in hybrid cars**
  - In the UK, EVs are **fully exempted from road tax and congestion charges**
  - In China, EVs have a **purchase tax reduction**
  - The US introduced a **clean vehicle credit worth up to $7,500**

Source: PTOLEMUS, Wallbox, EDF energy, US Energy department - Note: Norway Vehicle Electrification Study

In order to adopt electrified vehicles, there are 4 charging infrastructure questions that fleets must ask and address

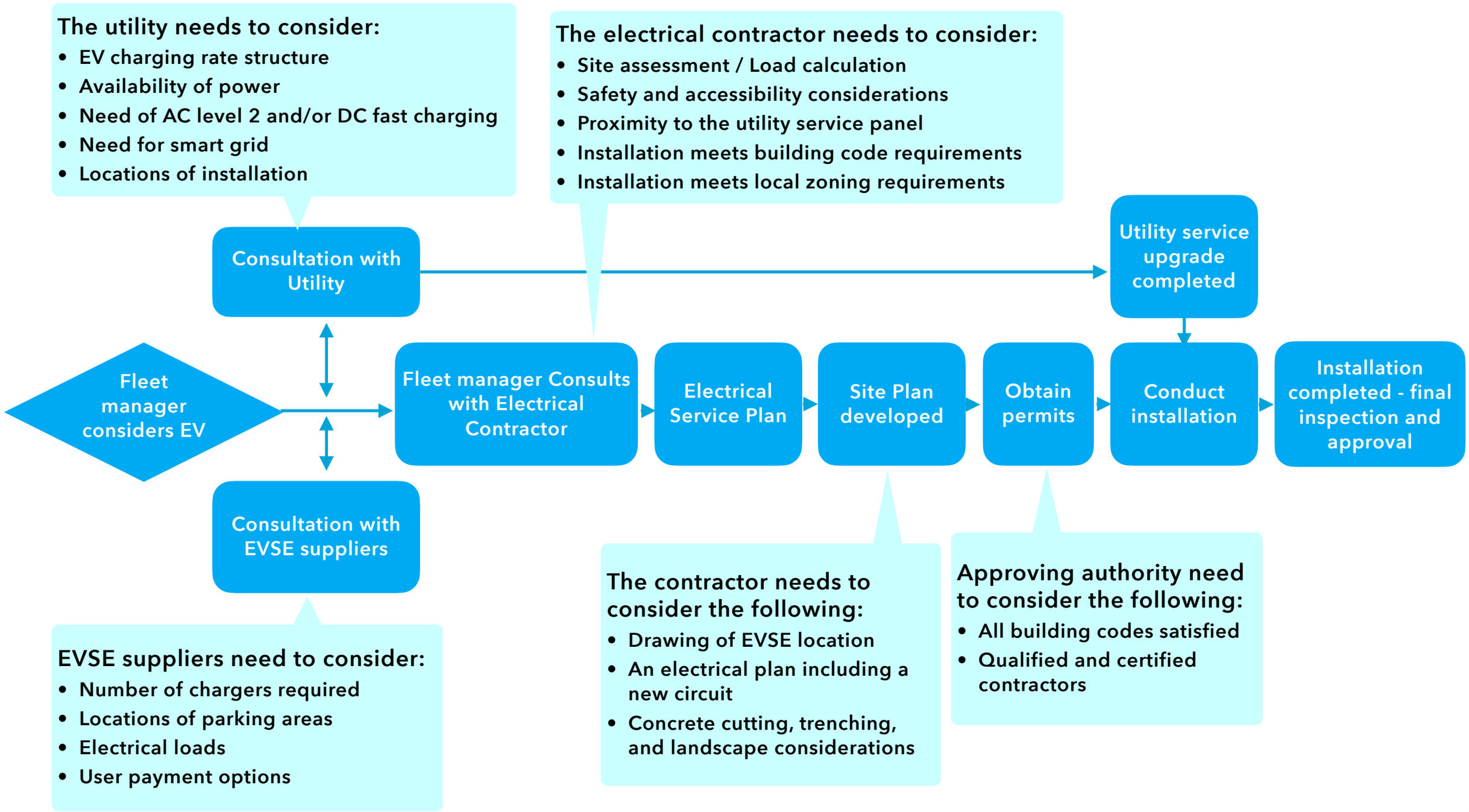






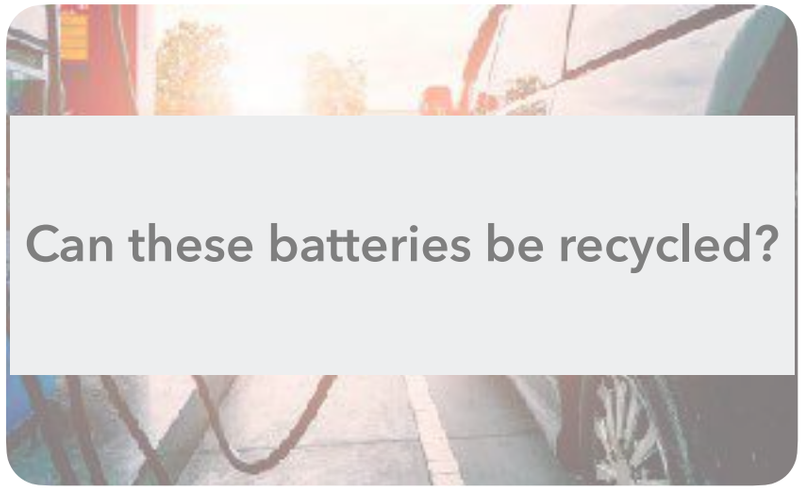
Source: PTOLEMUS

Fleet managers should consult with utilities and EVSE suppliers for charging infrastructure installation



Source: eTec (2010), Electric Vehicle Charging Infrastructure Deployment Guidelines for the Oregon I-5 Metro Areas of Portland, Salem, Corvallis and Eugene

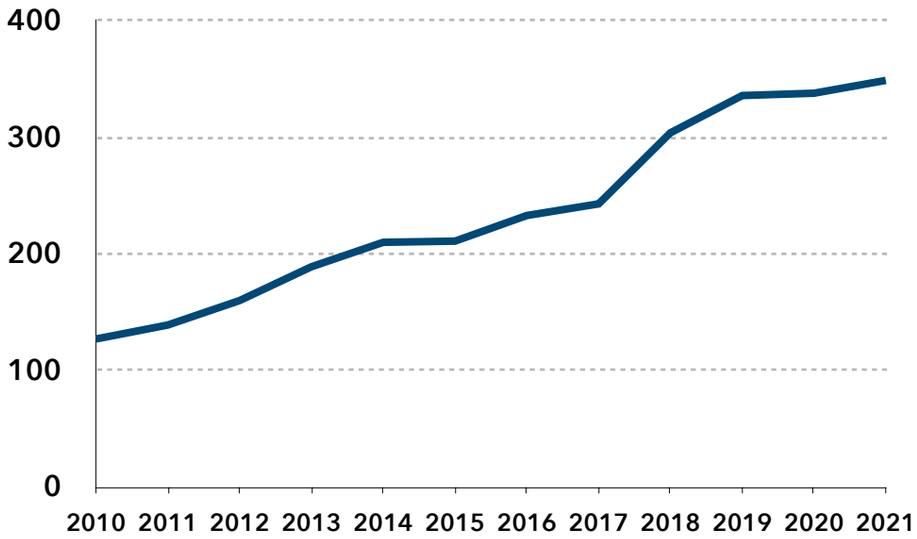
To adopt electrified vehicles, there are 4 battery-related questions that fleets must internally be able to answer



Although the range of EVs is improving, they still lag behind conventional vehicles

The current range of battery electric vehicles

Average range of battery electric light-duty vehicles
(km, 2010-2021*)



Shortest and longest range of BEVs by segment**

- As of 2021, a typical **battery electric light-duty vehicle**, which could be a car or van, can cover around **349km** on a single charge
- Data from the International Energy Agency (IEA) shows a **175% increase** in average range compared to **2010 levels** and a **50% increase** compared to **five years ago** in terms of the average range capability of battery electric light-duty vehicles
- Battery electric HGVs are being designed to provide longer ranges compared to other vehicle segments due to the **bigger battery size** and **capacity**:
  - **Tesla Semi** is estimated to cover 500 miles (around **800km**) with a single charge. PepsiCo will be the first customer and receive the vehicles in December 2022
  - The maximum range record of electric **buses** was made by **Man's Lion's City E 12** on a test monitored by TÜV SÜD in May 2021, with 550km in 24 hours. The Man's Lion's City E 12 is available for fleet managers in the market
  - As for electric LCVs, a **fully charged ID.Buzz Cargo** by **Volkswagen** can operate a maximum of around **400km** under the Worldwide Harmonised Light Vehicles Test Procedure (WLTP)
  - The maximum range for a **battery electric car** is **600km** by Tesla's Model S under WLTP
- According to a trial conducted in Norway, range has **less impact** on **short-haul vehicles** as charging can happen during the daytime routine of the vehicle
  - The electric truck operated 24/7, through three different shifts without any downtime, shifting large amounts of rock from its operations within a Norwegian city.
  - The state of its charge never fell below 50% because it was able to be charged while waiting to be loaded
- Despite the continuous expansion, the range of EVs **falls short** when compared to ICE vehicles
  - According to the **US Department of Energy** (DOE), in 2021, the average ICE cars range **in the U.S**. is approximately **664km**, which is **twice as far as** the typical EV could travel on a single charge

PTOLEMUS

Source: PTOLEMUS; Electric Vehicle Database; MAN; Tesla; Volkswagen; Office of Energy Efficiency & Renewable Energy of the U.S.
Note: *Data from IEA; **Data collected from Electric Vehicle Database and organised by PTOLEMUS

Fleet Electrification Global Study

PTOLEMUS

IKEA aims to achieve 100% zero-emission in its last-mile deliveries by 2025*

Creation: 1943

HQ: Netherlands

Staff: 225,000

Revenues: €41.9 billion (2021)

Vehicles: 10,000**

EVs: 2,500***

Electrification target: 100% in 2025

Retail

- IKEA is a **Swedish multinational conglomerate headquartered in the Netherlands** that creates and markets ready-to-assemble furniture, kitchen appliances, home accessories, and various other products and services
- IKEA, founded by Ingvar Kamprad in 1943, has held the title of **largest furniture retailer in the world since 2008**
- The company is also renowned for its focus on cost management, operational details, and ongoing product development, allowing it to keep its products competitively priced
- With most stores located in the suburbs of cities, emissions from vehicles going to and from these stores account for around 15% of IKEA's total carbon footprint
- Aiming to become climate positive by 2030, IKEA is targeting on **100% of IKEA home deliveries in Ingka Group** - the biggest IKEA franchisee - will be emission-free as soon as 2025

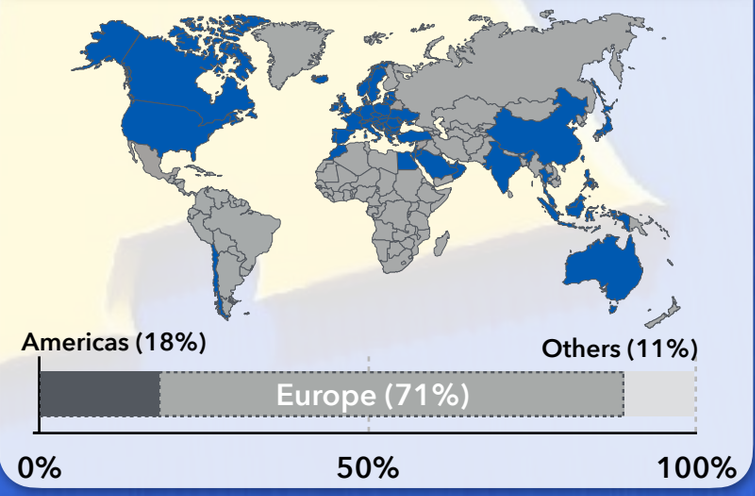
Source: PTOLEMUS, IKEA - Note: *Target applies to the biggest IKEA franchisee, INGKA Holding B.V., with 363 stores in 32 markets; **PTOLEMUS estimation; ***In June 2021, about 25% of IKEAs customer delivery fleet was electric

To reach 100% EVs in home delivery by 2025, IKEA is partnering with different EV service providers in each country

Company fleet details

- IKEA outsources most of its delivery services to third-party providers. About **10,000 vehicles** globally are owned or operated by delivery partners such as DHL, UPS, and PostNord
- **In 2017,** IKEA, together with the Climate Group and 10 other companies, **founded the EV100+, a transport leadership commitment to electrify fleets**
- IKEA began with a **smaller closer-range target of electrifying 5 cities by 2020**: Shanghai, New York, Los Angeles, Paris and Amsterdam
  - The goal was reached in Shanghai in 2019, through a partnership with DST, a Shenzhen-based company that leases electric trucks and vans
  - The goal was accomplished in New York and Los Angeles in 2021 through a partnership with Fluid Trucks, an online EV rental company
  - Paris is still on its way to achieving this target through its collaboration with **Renault** and **MAN** who are helping IKEA design an EV truck
  - Amsterdam was able to reach the pledge thanks to its collaboration with MAN and BYD
- Aiming to **reach 100% electrification on home delivery by 2025,** IKEA is collaborating with different EV service providers in different regions
  - In the UK, IKEA **partners with DX**, a logistics, parcel freight, and secure courier services provider, beginning a **3-year project to build an EV fleet for use in its delivery and logistics partnership with IKEA**
    - ✓12 initial electric vans operating out of DX depots in Southampton and Warrington are used in the first phase that began in August 2022
  - **In Canada, IKEA partners with GoBolt**, a last-mile delivery provider, to deploy 30 electric vehicles across the country in 2022
  - **In Vienna, Quantron,** a company specialising in electric mobility, recently delivered 30 electric Q-Light vans to IKEA
- **Besides light-duty vehicles, in 2022, IKEA committed to the transition to zero-emission heavy-duty vehicles by 2040**
  - IKEA started a **pilot project** with **Volvo Trucks** in 2022, in which IKEA will introduce Volvo's electric heavy-duty vehicles in its Poland factories for internal transport flows

Global footprint*



Environmental benefits

- By 2030, IKEA is aiming to reduce GHG emissions from customer travel and home deliveries **by 50%** compared to FY16

Cost savings

Depending on the **vehicle ownership**, cost savings can vary

For the partnerships with EV service providers, in some cases, IKEA needs to pay for the vehicle **rental plans** as well as increase **the pay scale to drivers** per delivery as it is cheaper to rent a diesel vehicle than an EV

PTOLEMUS

Source: PTOLEMUS, IKEA - Note: *In terms of revenues in 2021

Through partnerships with EV service providers around the world, IKEA is accelerating toward its 2025 goal

Timeline of events

2019

Reached its goal of having 100% electric home deliveries in the city of Shanghai with a new partnership with Beiye New Brother Logistics Co. and DST

IKEA tested new EV prototypes with Renault and MAN Paris and Berlin

IKEA Retail U.S. joined Corporate Electric Vehicle Alliance to help companies accelerate their transition to EVs

2020

19 out of 30 IKEA's markets deployed EVs

Partnership between IKEA and Fluid Truck to support its EV fleet in New York and Los Angeles

Partnership between IKEA and Quatron, a company that specialises in electric mobility, to support the fleet in Vienna

2021

3 all-electric FUSO eCanter light-duty trucks were delivered to IKEA Japan for home delivery

IKEA joined forces with the four major global companies by committing to EV 100+ to transition to zero-emission heavy-duty trucks

Partnered with DX for 3 years to establish a fleet of electric delivery vehicles in Northern Ireland and the UK

2022

Expanded EV partnership with Bolt Logistics to deploy 30 EVs across Canada

KEA US worked with Electrify America and Electrify Commercial to offer ultra-fast public charging stations and delivery fleet EV charging to more than 25 IKEA retail locations across the US

2030

Objective to become carbon neutral

Objective of halving emissions of workers & customers accessing their physical touchpoint

Source: PTOLEMUS, IKEA

IKEA is successfully electrifying its delivery fleet in pilot cities by using a combination of vehicle purchasing and rental

Electrification roadmap

2010 – Tested the potential of using EVs for customer deliveries in Paris, France

2014 – Partnered with Nissan to provide charge points for free in stores in the UK

2017 – IKEA committed to a 100% of zero-emission vehicles fleet

2018 – Home delivery in 5 cities will be 100% zero-emission by 2020

2019 – Shanghai achieved 100% zero-emission on home deliveries

2022 – IKEA committed to 100% zero-emission on heavy-duty vehicles by 2040

Key take aways from IKEA's fleet electrification success

- IKEA started the exploration of fleet electrification in **2010** when EVs were still a niche proposition, giving IKEA **first-mover advantages**
- IKEA **accelerated its fleet electrification** by becoming a founding member of EV100 in 2017
- In June 2021, about **25% of IKEAs** customer delivery fleet was electric, and the company aims to increase this number to **29%** by the end of FY22
- Its success can be credited to its **precise targets** for **2020 and 2025**, with different steps to reach the goals
- IKEA Shanghai first achieved the zero-emission home delivery goal in 2019:
  - IKEA Shanghai built out **local partnerships** to source vehicles and plan out enough charging infrastructure
  - IKEA Shanghai **outsourced** its warehouse and logistic services to a local warehousing and distribution company, Beiye New Brother Logistics
  - Beiye New Brother Logistics worked with **DST**, a **leasing company**, to manage the deliveries via electric trucks and vans
  - Throughout this process, IKEA was also trying to **change customer behaviours** to encourage low-emissions transport. For example, IKEA sited **smaller stores in urban cores** which are accessible by public transportation
- As a furniture retailer, IKEA does not own a large number of vehicles because massive vehicles purchase will tie its **financial resources**. Therefore, the lack of full control of their delivery fleet becomes a challenge to IKEA's fleet electrification
- However, since IKEA is a business giant with a large amount of home delivery orders, it has **more bargaining power** when choosing its delivery suppliers
  - IKEA **partners with startups and SMEs** with a focus on zero-emission deliveries around the world, enabling IKEA achieves their zero-emission target and reduces costs compared to partnering with large logistic companies
- For its owned vehicles, IKEA electrifies them via **purchasing from OEMs**
  - For example, it purchased 3 light-duty trucks from FUSO Japan, a part of Daimler Truck AG
- In a parallel activity, IKEA has also been developing its charging infrastructure
  - **By 2014**, IKEA had already installed more than 100 charging points in stores for customers and suppliers across **19 countries** in the world
    - ✓ All 18 IKEA stores in the UK have charging points by December 2013
    - ✓ 55 Blink charging stations is available in IKEA USA in 2014
  - **By 2021, the goal of installing EV charging stations at all stores in 32 markets was achieved**

Source: PTOLEMUS analysis, IKEA

Fleet Electrification Global Study

PTOLEMUS

We have developed a 5-step journey that suppliers can follow to help fleets electrify their vehicles

A guide for fleet managers

1 Evaluate the current fleet and the need of electrification

- Before going electrification, there are **five questions** that fleet managers should consider:
  - What goals did the company set for **greenhouse gas emissions/ carbon neutrality?**
  - What is the **time frame** of the electrification? Is it urgent, and should it start right now?
  - What is the **budget** for fleet electrification?
  - What has the company done toward electrification? Can any resource be used?
  - **How many vehicles** in the fleet can be electrified? What **type of vehicles** are they?
  - What is the **expectation** of fleet electrification in terms of **environmental and cost savings?**

2 Identify key processes

- We divide the electrification journey into **5 key activities** and map them out in the coming slides:
  - Feasibility
  - Acquisition model
  - Access to infrastructure
  - EV telematics
  - Maintenance and insurance
- Bear in mind the answers from step 1 and the 5 critical activities developed by PTOLEMUS; fleet managers can **assess** their **advantages and disadvantages** in the fleet electrification journey

3 Map relevant suppliers

- Depending on steps 1 and step 2, a fleet manager can now identify **potential suppliers** to support their fleet electrification during the different stages of the journey
- Some suppliers can cover one or two specific steps, while others can provide more **comprehensive fleet electrification solutions**

4 Appraise these suppliers

- Fleet managers **appraise** the solutions that identified suppliers offer
- Assess their relative advantages and disadvantages
- Leverage the best practices and supplier profiles of this report to compare all solutions

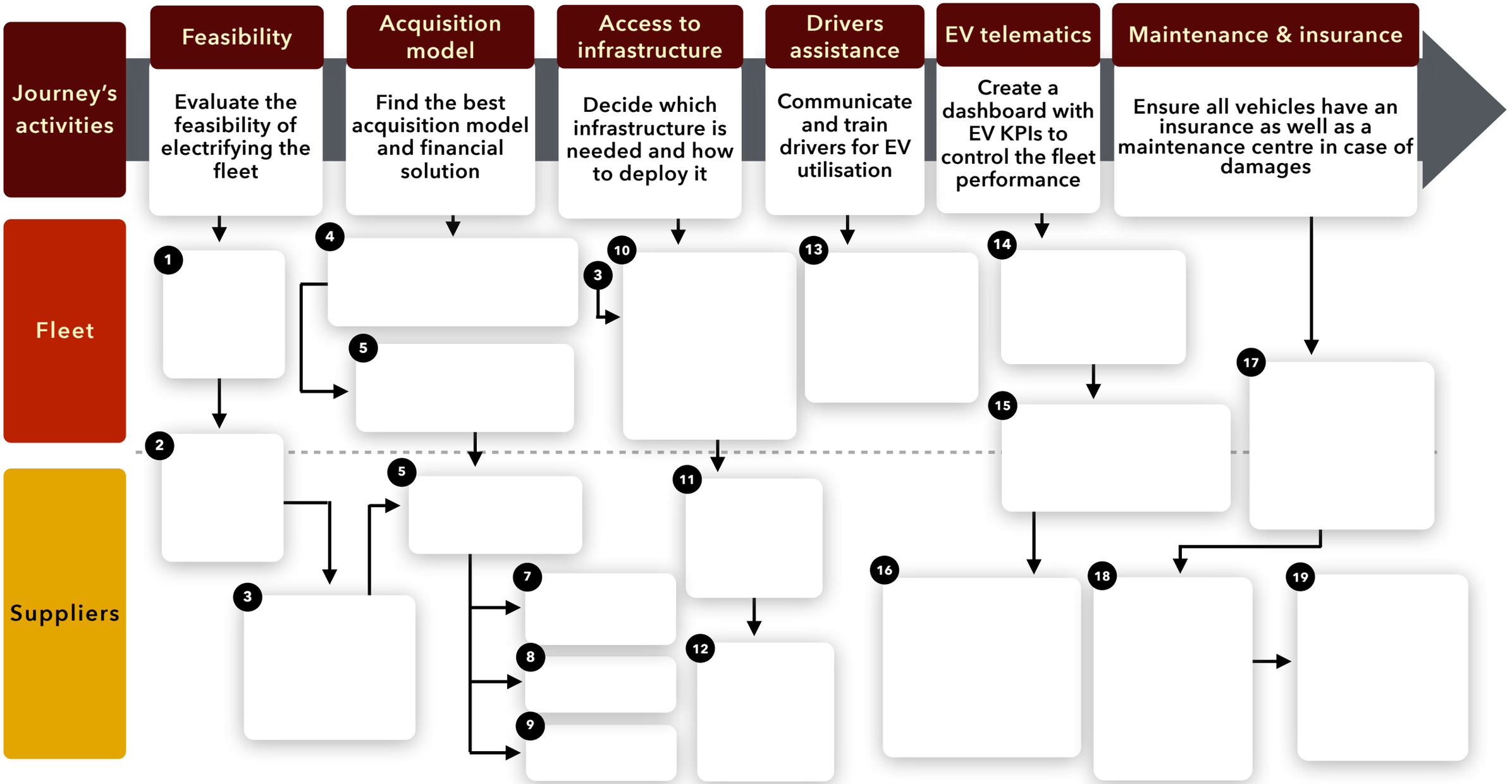
5 Sanity check before implementation

- After those 4 steps, fleet managers should have a **sanity check** before starting the electrification processes:
  - Review and refine the estimated **emissions reductions**
  - Calculate the estimated **total cost of ownership** and **potential cost savings**
  - Draft out the **internal review** with senior managers and communicate with drivers

Source: PTOLEMUS

We have mapped the activities starting from the initial feasibility assessment through the whole electrification

Map of the **electrification journey** with partner activities



A plan covering all steps is needed to ensure a successful transition to an electric fleet

- Electrification is a complex process which needs to cover all activities
- A company, depending on its internal infrastructure and knowledge, can decide how much to rely on suppliers
- It is important to chose wisely suppliers depending on the needs and preferences of the fleet
  - In order to optimise such a process, relationship with partners and companies can be established to have a smoother process
  - Each company has its strength, weaknesses and comparative advantages which have to be leveraged

Source: PTOLEMUS

Fleet Electrification Global Study

PTOLEMUS

Smart charging, vehicle to grid, megawatt charging and wireless charging are future of charging solutions for EVs

Smart charging

Controls charging in expensive time (peak hours)

Vehicle to grid charging

Gives electricity back to grid and saves bill

Charing infrastructure is one of the main barrier towards the adoption of EVs. In this section, we present solutions that can save operational cost of charging EVs and load management

Megawatt charging system

Suitable to electric trucks to provide ultra fast charging

Wireless charging

Avoids the use of expensive infrastructure

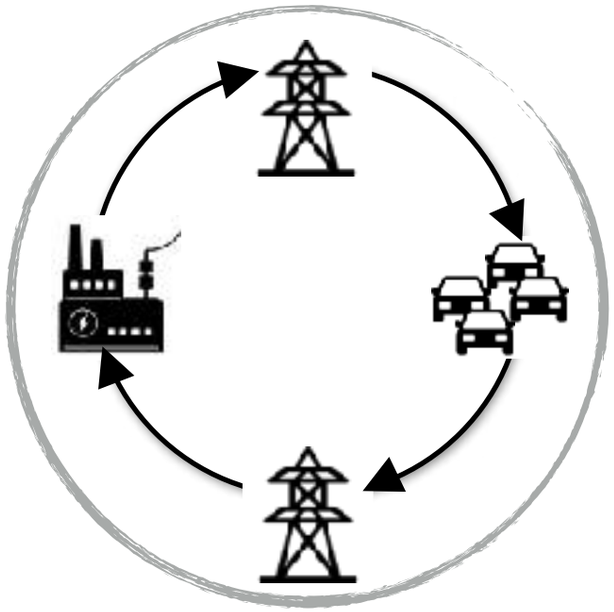
Source: PTOLEMUS

Technology investment, supply chain challenges are currently the key barriers to the implementation of V2G

Barriers to V2G adoption at economies of scale

Substantial investment

- Today, **EVs do not include DC to AC current conversion adapters** on board which constrains AC charging infrastructures to offer V2G services
- A 2019 V2G Britain report mentions that
  - The cost of the V2G hardware, currently is high at £6,000
  - However, **it is expected to lower by 2030 between £656 - £1,164** considering 7.5% of the global fleet participates in V2G
  - The main components of the V2G charger that impacts the cost are the **DC charger and the inverter** used for the conversion of the current
- The charging and discharging process is controlled by a **software algorithm**
  - **R&D for developing a controlled energy management software** impacts the investment cost
  - Similar to hardware as **V2G matures, software costs will be commoditised**



Infrastructure planning - Electric grid

- **US utilities are planning their biggest spending to upgrade ageing grids** and prepare for V2G electric vehicles
- The V2G is most beneficial when power is consumed through the renewable energy resources
- It would take several years for renewable energy to reach full-scale implementation

Supply chain issues-Vehicles

- Currently, **OEM models that offer commercial bi-directional charging is limited**
  - Tesla currently does not equip models with bidirectional charging
  - However, in 2018, **Elon Musk hinted that revisiting V2G for Tesla would not be a bad idea**
- **Nissan Leaf and Nissan e-NV200 are commercially offering V2G**
- **Ford F-150 lightning** is offering V2G with Ford Charge Station Pro hardware
- **GM is exploring** V2G capabilities with San Diego & Electric
- **Hyundai is running a pilot with V2G in the Netherlands** with its IONIQ 5 model
- **Chinese manufacturer BYD, is introducing** Type A electric school bus in the US with V2G capabilities
- From 2022, all **Volkswagen BEV models with the MEB platform will be V2G capable**
- Full scale implementation of V2G by OEMs depend on pilot successes

Source: PTOLEMUS, V2G Britain

Utilities must identify which sites are feasible and require improved grid connections for MCS

Challenges

- As MCS require high powered cables and significant grid capacity, fleet operators will **have to wait longer to install fast charging**
  - This is more evident **in the US**, where DCFC can typically take 1-2 years due to delays for parts, such as transformers
  - MCS is a new technology that may require more time due to equipment installation and groundwork
  - Depots may be located in rural areas with limited grid capacity and outdated cable connections
- The **simultaneous connection** of long-haul electric trucks can **overload the grid**
  - Combined MCS fast charging and overnight charging will require approximately 12.5% more grid capacity than just overnight charging
  - Areas with limited grid connection can experience blackouts due to the simultaneous connection of many EVs
- The siting of MCS can be more difficult than other fast charging stations because it **requires more space** to fit both charging equipment and trucks, and it also needs to be installed **at a point in the grid that can support the power draw (10MW or more)**
- Commercial electricity rates could be higher when using MCS fast charging during peak hours in the US
  - Trucks that require higher-power charging must pay a higher bill that includes both energy and "**demand charges" for the maximum power used during a billing cycle**

Solutions

- Ensure a **reliable supply chain** for MCS equipment and parts
- Utilities must provide connections where there is a high demand for MCS for long-haul EVs
  - **The routes with the highest MCS charging demand** should be identified
- Areas that have limited grid connection should be **upgraded with a powerful grid** to avoid blackouts
- **Optimise the charging behaviours** of electric truck drivers
  - Avoid peak-hour charging
  - Fast charge with MCS during the day and overnight charge with CCS to avoid excessive usage of MCS
- **Subsidies or other financial support** may be provided by the government for **charging infrastructure for medium and heavy-duty vehicles**, such as MCS
  - In North America, Tesla and environmental groups are lobbying the government to set aside 10% of the 7.5 billion Bipartisan Infrastructure funding for medium- and heavy-duty vehicle charging infrastructure
  - The EU EV charging Masterplan estimates that an investment of €45 billion is required for trucks and buses to install charging points and upgrade the power grid by 2030
    - ✓ a portion of the €45 billion may be allocated to the construction and installation of MCS infrastructure

Source: PTOLEMUS, ACEA, Tesla.

We identify 2 ways in which fleet managers can mitigate the supply shortage of electric vehicles

1 Consider the used vehicle market

- One way to mitigate impractically long delivery lead-times is to **consider vehicles available in the used vehicle market**
- This is approach is highly dependent on the specific fleet's requirement, and as such, "nearly new" or used vehicles **may not be a practical option**
- This approach does vary, based on the type of vehicle required, as **electric car supply** in the used market is buoyant, LCV supply is relatively constrained (though improving), and specialist vehicles such as buses, coaches and HGV are highly uncommon
- OEMs are increasingly **providing warranties** (and are also being mandated to provide warranties in some regions) on their products for a minimum 8 years or 100,000 miles/160,000km

2 Select vehicles that have an acceptable delivery lead-time

- Some OEMs are experiencing supply chain delays **more acutely than others**
- **Fleet managers must research delivery lead times** prior to ordering. It is also critical that **how and OEM is mitigating delivery lead-times** is investigated, when in the selection phase of purchasing EVs
  - Companies such as Tesla have developed alternative software programming to reduce chip dependency and maintain acceptable delivery lead times
  - OEMs are also investigating how to completely re-design the CAN-bus network of their vehicles to **reduce chipset dependency**
  - Some OEMs have resorted to **removing functions, to temporarily reduce chip dependency** to enabling shorter delivery times, but also a disparity between vehicle specifications available and also delivered (versus ordered spec).
- Fleet managers should identify which companies can provide them with the vehicle volume (and specification) they require so that timely **delivery of EVs can be made that fits their business electrification objectives/roadmap**

Telematics in EVs can be used to monitor battery status, GPS tracking, charging locations and driving style

Introduction to telematics for EVs

- Telematics can help to **monitor fleet vehicles and manage operations** efficiently using mobile connectivity
- It provides such features as:
  - GPS tracking
  - Monitor driver behaviour
  - Fuel consumption
  - Efficient maintenance of the vehicle
- Whilst fleet telematics is prevalent for ICE vehicles, the tools available for EV-specific purposes is still in its infancy
- Currently, the most crucial service available for EVs is focused on **suitability assessment:**
  - It helps fleet managers **to assess how best to transition from ICE vehicles to EVs based on the fleet's typical pattern of use**
- EV telematics services can also be used to manage:
  - The **battery and charge status** of the EV
  - **Provide remote diagnostics**
  - **Provide routing and geolocation services**
- EV telematics enables the fleet manager **to optimise vehicle routing** based on battery range
- This can include the ability to **plot the most efficient and cost-effective route via charging station locations**
- For EVs, telematics can also indicate the driver behaviour:
  - **Driving style** can be assessed to ensure efficient use and reduce **wear and tear to the vehicle**

Source: PTOLEMUS, Trackm8 (Image)

CASE STUDY: The SEAI fleet electrification trial has seen overwhelming demand

- The Sustainable Energy Authority of Ireland (SEAI) is conducting a pilot scheme called **the EV Commercial Fleet Trial**, which allows local businesses to test **50 BEVs, 30 M1 vehicles and 20 N1 vehicles for up to 12 months**
  - The authority is also **providing charging units to fleet managers** as well as **a contribution of either 80% of installation costs or €1000**
    - ✓ If businesses disagree to use SEAI charging facilities, evidence of an independent operational charging strategy should be provided to SEAI
- **Requirements/ mandates for the program**
  - Data on EV usage is tracked to develop analytics
  - Insurance is mandatory for business owners while using these EVs
  - SEAI will perform surveys to understand businesses using EVs
  - In the case of an independent charging strategy by business owners, SEAI to be allowed access to monitor charging methods
- **Who can apply**
  - All businesses (small/ medium and large) encouraged to apply
  - Businesses without fleets could also apply
  - All businesses (small/ medium and large) to identify the vehicle type they would be interested in the trial
- **Why SEAI is conducting these trials**
  - Ireland has an ambitious target to reduce 50% of emissions from the transport sector by 2030
    - ✓ The target of 50 million EVs on Irish roads by 2030
  - The trial will help the companies understand about electrification of vehicles
    - ✓ Understand charging cost
    - ✓ Driving experience
    - ✓ Charging schedules
  - This will allow SEAI to analyse the financial and CO_2 savings achieved by EVs conversion
- Due to **overwhelming demand from businesses**, the trial, whilst active, is **no longer open to new applications** from businesses

seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Ministry of Transport: "The findings from this trial give us real-world feedback and provide evidence to encourage businesses to switch to electric"

Source: PTOLEMUS, SEAI

Fleet Electrification Global Study

PTOLEMUS

We followed a 3-step methodology to forecast the number of new BEVs registered for and in-use by fleets

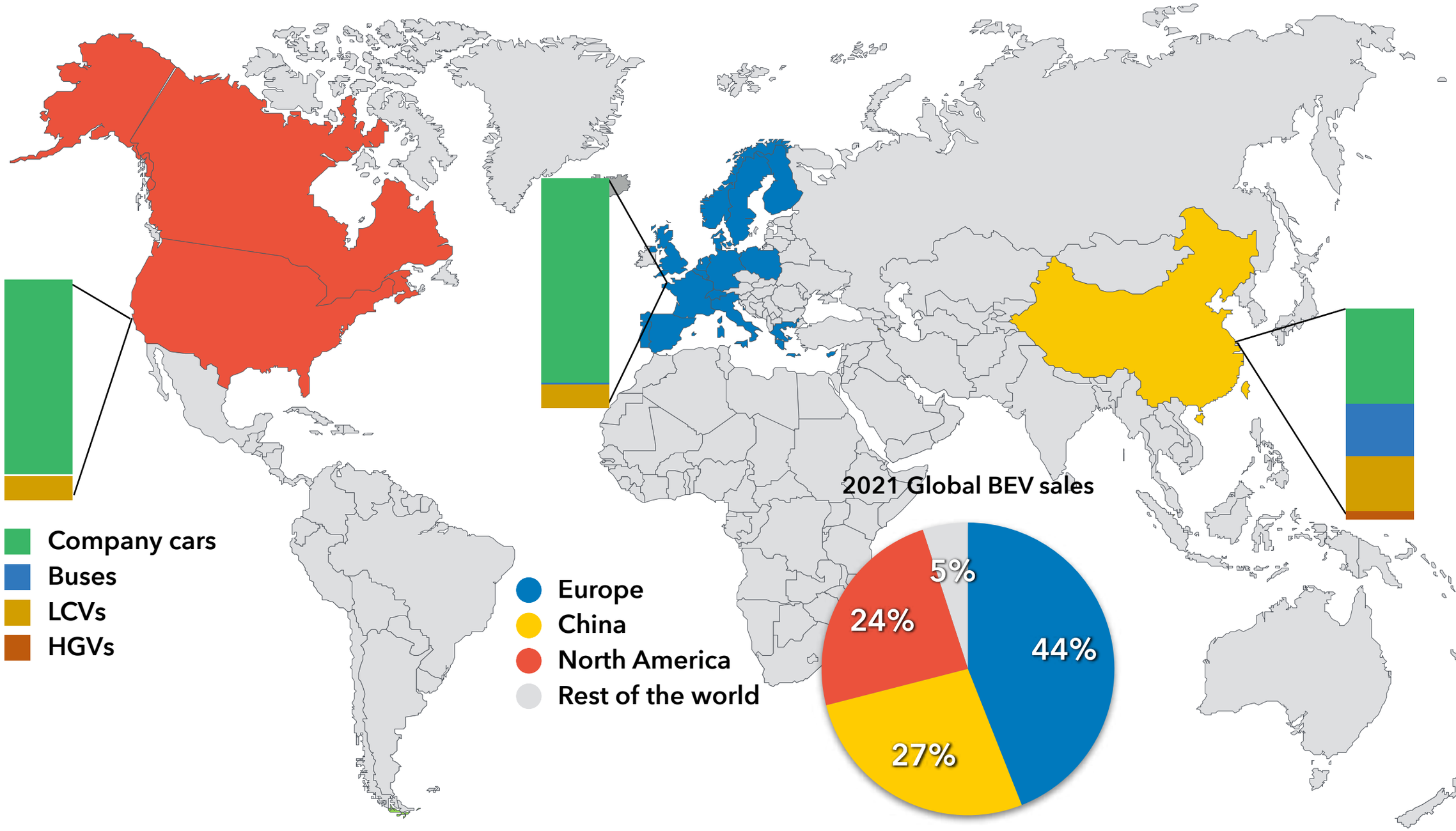
Key steps	Description	Key calculations
1 **Collect the historical data and evaluate the current practices for promoting EV in each country**	• We collected **historical data** of BEV sales and BEV in use from **2010 to 2021** in **27** countries in the world • Based on PTOLEMUS automotive forecast, we calculate the **share** of fleet BEV sales and share of fleet BEV in use from 2010 to 2021 • We also evaluated the **current incentives** promoting EV adoption in each of the 27 countries, (e.g. subsidies and tax benefits for EV purchase, charging infrastructure subsidies, etc)	• Share of BEVs in fleet vehicles new registrations from 2010 to 2021 • Share of BEVs in fleet vehicles in use from 2010 to 2021
2 **Develop models based on most advanced country and apply on other countries**	• For PCs, LCVs, and HGVs, we used the **Norwegian market's** rate of EV adoption as a benchmark, so that the point of inflexion, after the initial "early adoption" phase, could be realistically modelled for each country • For buses, we used the **Netherlands' as a prototype market**, as it is one of the most most advanced markets in terms of adoption in e-buses, in Europe	• Share of BEVs in fleet vehicle registrations from 2022 to 2030 • Number of fleet BEV registrations from 2010 to 2030
3 **Calculate the number of BEVs in use**	• We used historical data, detailing the number of BEVs in use, applied annual scrappage rates in each country and added the number of fleet BEV registration in current year	• Number of fleet BEVs in use from 2010 to 2030

Source: PTOLEMUS analysis

Fleet Electrification Global Study

PTOLEMUS

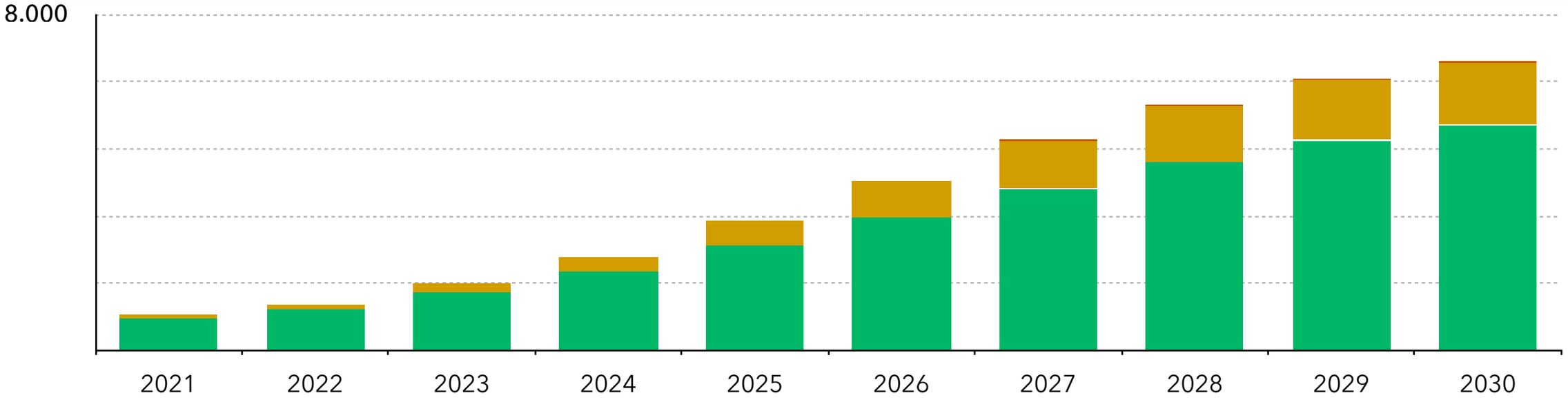
China, Europe and the North America account for 95% of total BEV sales in 2021



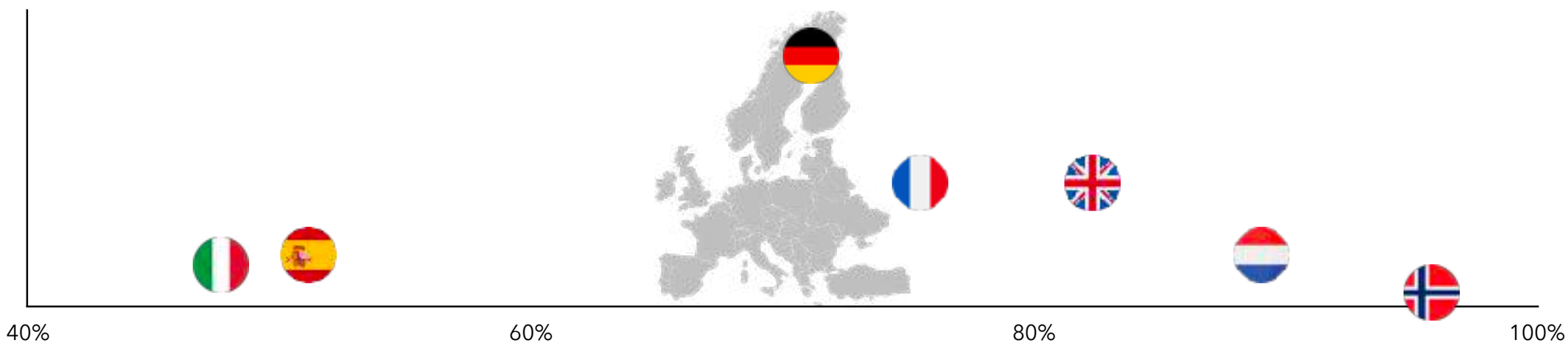
Source: PTOLEMUS analysis; IEA

Norway and Netherlands will be the leading countries in BEV adoption by 2030

Forecast volume of BEV registrations in Europe



BEV registrations and penetration rate in 2030 in key countries



Source: PTOLEMUS analysis; IEA; Norwegian Parliament

FLEET ELECTRIFICATION

Global Study

About PTOLEMUS

PTOLEMUS Consulting Group

The first strategy consulting & research firm entirely focused on augmented mobility & automation

Strategy consulting services

- **Strategy definition**
- **Investment assistance**
- **Procurement strategy**
- **Innovation management**
- **Business development**
- **Project management**

Market research services

- **Off-the-shelf reports**
- **Subscription services**
- **Custom market research**

Fields of expertise

Mobility services	Car pooling Car sharing MAAS	Micro-mobility Ride hailing Shared mobility	Smart parking Tax refund
Vehicle services	bCall eCall Fleet management	SVT / SVR Tracking VRM In-car Wi-Fi	Parking Navigation Speed cameras Traffic information
New energies	BEV EV charging Fuel cards	Fuel cells Hydrogen	PHEV Vehicle-to-grid
Usage-based charging	Car As A Service Electronic Toll Collection	Mobility-as-a-Service RUC	UBI / PAYD Vehicle rental Vehicle leasing
Vehicle data & analytics	AI CAN-bus Crowd-sourcing Data protection	Driver safety OBD Predictive analytics	Remote diagnostics xFCD
Vehicle automation	ADAS Autonomous cars	Autonomous trucks	Robo-taxis Shuttles
Enabling technologies	Positioning (GNSS / WiFi / cellular) M2M / connectivity	Smartphones Sensors	Telematics devices V2X

We serve over 350 clients across the mobility ecosystem

Analytics, maps & applications providers

Automotive manufacturers & suppliers

Mobile telecom players

Telematics solution providers

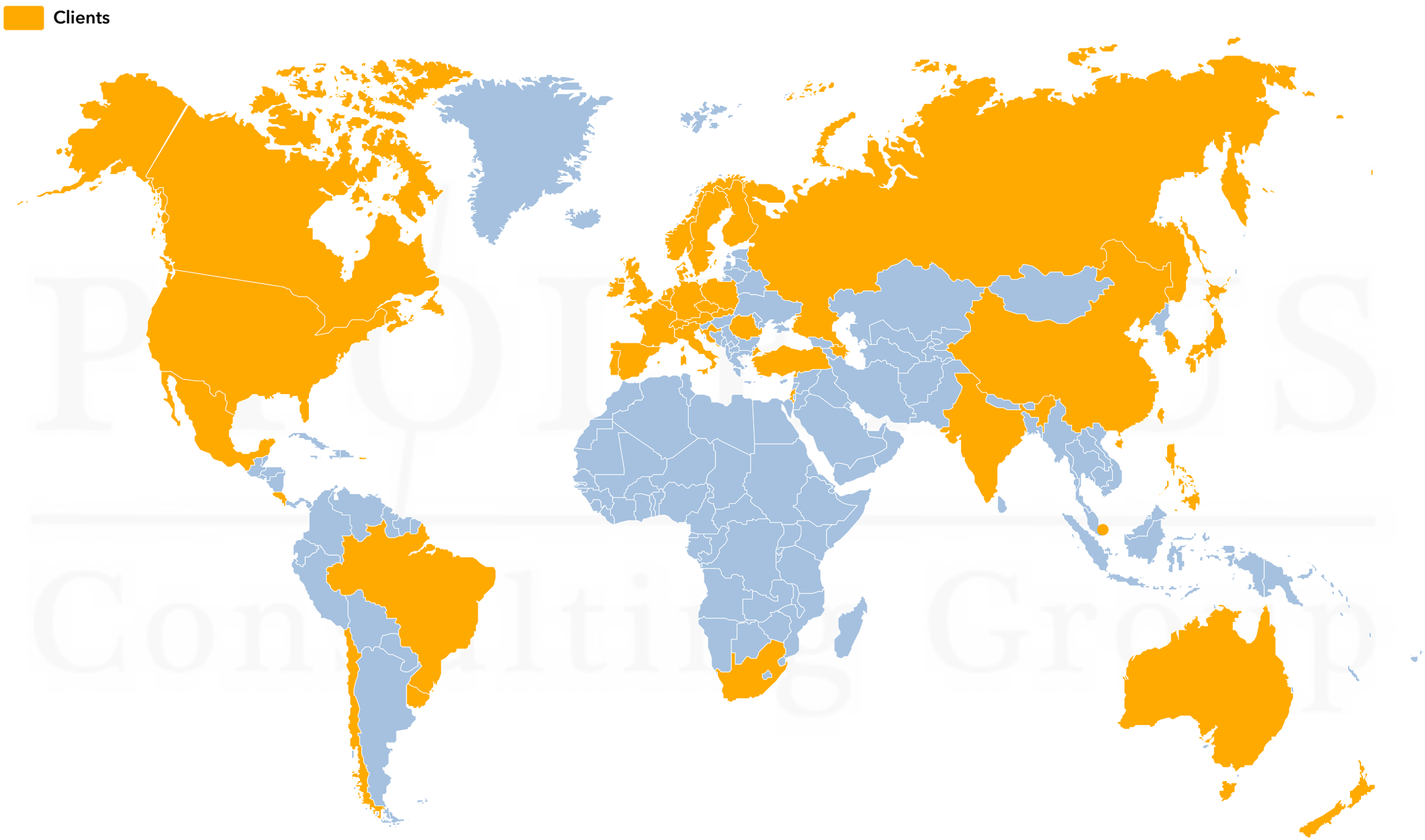
Fleet & fuel, ITS & regulators

Device & location suppliers

Insurers, aggregators & assistance providers

Banks & private equity investors

Our team of consultants, experts and analysts of 12 nationalities helps our clients in over 40 countries



PTOLEMUS can help your organisation define and achieve its fleet strategy in fast moving times

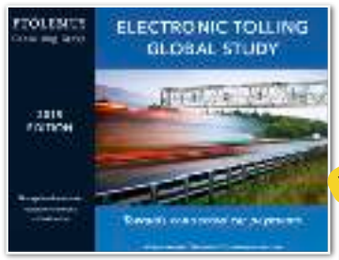
- **Strategy definition**
  - Strategic plan
  - Market entry assistance
  - Data strategy and analysis
  - Connected vehicle / telematics strategy
  - Decarbonisation strategy
  - Strategy orientation workshops
- **Innovation strategy**
  - Fleet services convergence strategy
  - Telematics product definition
  - Consent management
  - Data analytics & monetisation strategy
- **Innovation delivery**
  - Proof of concept design & launch
  - Architecture definition
  - Project management
- **M&A advisory**
  - M&A strategy
  - Commercial due diligence
  - Technology due diligence
  - Feasibility studies
  - Fleet services market sizing
  - Business case development
  - Cost benefit analyses
  - Post-merger integration
- **Procurement**
  - Definition of EV migration strategy
  - Assistance with tenders
  - Selection and sourcing of fleet telematics, software, data, platform, etc.
- **Business development**
  - Partnership strategy definition
  - Assistance to tender response
- **Project management**
  - Assistance in management of decarbonisation plan
  - Congestion charge project management

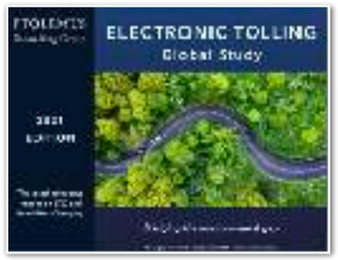
PTOLEMUS has published many landmark reports & market forecasts including on fleet management and electrification

AUTONOMOUS DRIVING

CONNECTED VEHICLE

TOLLING & ROAD USAGE CHARGING





ELECTRIFICATION

FLEET MANAGEMENT

INSURANCE

MOBILITY

PTOLEMUS

Notes:

1. Most of our reports come with bottom-up market forecasts for 18 regions for 10-year timeframe,
2. To receive all our reports & other research, a subscription model exists

FLEET ELECTRIFICATION

Global Study

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FREE
ABSTRACT

The reference report on the migration towards battery electric vehicles

FLEET ELECTRIFICATION

Global Study

Has the time come for fleets to embrace electric?