European Copper Institute
Copper Alliance

E-mobility Vision Paper

June 2020

Context

In 2011, the European Commission concluded in its white paper "Roadmap to a Single European Transport Area" that the phase-out of fossil fuels driven cars by 2050 was necessary to achieve its energy and climate objectives. In 2019, as part of the European Green Deal, the Commission is proposing to revise the regulation on CO_2 standards for cars and vans, to ensure a clear pathway towards zero-emission mobility.

Greenhouse gas (GHG) emissions due to road transport have grown since 1990 by 20.5%, and now account for one-fifth of EU GHG emissions – and they keep growing. The picture is similar regarding final energy consumption. Road transport uses 24% of EU final energy, having grown by 28% since 1990.

The good news is that a zero-emission technology is ready today for market uptake: the battery electric vehicle. From day one this vehicle completely cuts local GHG and air pollutant emissions and emits three times less GHG emissions on a well-to-wheel basis. On a life cycle basis ("cradle to grave"), a battery electric vehicle also generates significantly less GHG emissions than cars using gasoline or diesel. Moreover, the full decarbonisation of the electricity system, which is foreseen well before 2050, will enable battery electric vehicles to make transport fully climate-neutral.

Electrifying road transport is also the fastest and most cost-effective way to achieve energy efficiency goals because it is the asset with the highest replacing rate (average car ownership period 5-7 years[1])and is currently at least 2.5 times more efficient than alternative technologies.

On 28 November 2019 the European Parliament declared a climate emergency and its Members asked for immediate and ambitious action to limit the effects of climate change[2]. Battery electric vehicles are ready to contribute to addressing this challenge. What is needed now is to accelerate the deployment of full electric vehicles.

Copper is one of the main materials that makes this transition possible. On average a battery electric vehicle requires three times more copper than a vehicle driven by a combustion engine. Half of it is in the battery system, mainly as foil in the anode of the cell working as current collector and heat dissipator. About one quarter is in the drive motors and their control system, and the other quarter is in wire harness, connectors and electronics. In addition, copper plays a role in the charging infrastructure and in the generation of renewable electricity to power the vehicles.

1 https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/2nd_hand_cars_en.pdf

2 https://www.europarl.europa.eu/news/en/press-room/20191121IPR67110/the-european-parliament-declares-climate-emergency

Benefits

A battery electric vehicle (BEV)

- emits **3 times less CO_2** than an equivalent vehicle driven by a combustion engine, and this factor will increase to more than 4 times by 2030 (well-to-wheel emissions, based on EU average energy mix, details in Annex I). This will significantly contribute to reducing the growing share of road transport in CO_2 emissions in the EU[3] (currently 20%, since it increased by 20.5% over the period 1990-2015[4]).
- emits no NOx or particulate matter ($PM_{2.5}$), two drivers of **air pollution** that cause 5.4% of deaths in Europe[5]. If the city of Rome would electrify its fleet of public and light-duty goods vehicles, emissions of NO_x and particulate matter would decrease by 34% and 22%[6] respectively.

- at speeds below 30 km/h, **emits significantly less noise** than internal combustion engine vehicles[7]. For people aged over 65, the cardiovascular and respiratory mortality due to urban diurnal noise could be even bigger than that due to $PM_{2.5}$[8].

Electromobility improves also energy security. The EU imports 87% of its oil demand, of which 47% is used for road transport[9].

In addition to decarbonisation, health and energy security, what really makes the BEV the **best zero emission technology currently available** are two further elements:

- A battery electric vehicle is **2.5 times more energy efficient** than a vehicle powered by a combustion engine. This will increase to 3.3 times by 2030 (well-to-wheel, based on EU average electricity mix, details in Annex I). Road transport consumes 24.4% of final energy in EU[10], with a 28% increase in 2015 compared to 1990, and it continues to increase[11].
- **BEVs perfectly match renewable electricity generation**. In an "always connected while parked" scenario, a BEV will be able to use or supply electricity from/to the grid as required. Through an aggregated operation of many vehicle connections, it will be possible to provide balancing services and intraday storage for electricity markets, thus BEVs will also enable greater integration of renewables.

3 https://www.eea.europa.eu/publications/analysis-of-key-trends-and/

4 https://ec.europa.eu/clima/policies/transport/vehicles_en

5 http://documents.worldbank.org/curated/en/781521473177013155/The-cost-of-air-pollution-strengthening-the-economic-case-for-action

6 http://www.aria.fr/PDFs/25ans/05_Vehicule%20Electrique.pdf

7 http://www.compett.org/documents/Conferencepapers/Noise_from_electric_vehicls_state_of_the_art_literature_survey.pdf

8 https://www.sciencedirect.com/science/article/pii/S0013935114004629?via%3Dihub

9 http://ec.europa.eu/eurostat/statistics-explained/index.php/Oil_and_petroleum_products_-_a_statistical_overview#Imports_of_crude_oil

10 http://ec.europa.eu/eurostat/statistics-explained/index.php/Consumption_of_energy 2015 Transport account for 33.1% final energy https://www.eea.europa.eu/data-and-maps/indicators/transport-final-energy-consumption-by-mode/assessment-8 Road transport represents 74% of final energy in transport.

11 https://www.eea.europa.eu/data-and-maps/indicators/transport-final-energy-consumption-by-mode/assessment-8

Vision for light-duty vehicles

The latest BEV models launched on the market offer **a real range of around 400 km.**[12].

Many BEVs already achieve a **lower total cost of ownership** than their equivalent conventional ones[13]. On top of that, BEVs provide grid services that will bring additional revenues for both charging operators and vehicle owners.

For the average passenger car, **a 3.7 kW charger suffices** to replenish the energy consumed during the day in less than 3 hours overnight[14]. For heavy users and light commercial vehicles, a 7.4 kW charger will be sufficient. Low power chargers are also convenient to reduce the stress of the distribution grid and building installations, while overnight charging makes better use of infrastructure already in place.

Many consumers are concerned about making a longer journey than 400 km with a BEV because of the possible unavailability of chargers or a lengthy waiting time while charging. Our proposal is to set European targets and national supporting schemes to deploy **150 kW chargers every 60 km along the TEN-T Core Network** (with a BEV efficiency of 15 kWh/100 km, it will take 6 minutes to add a 100 km range). At final destinations (hotels, residentials buildings, public areas, etc.), the more efficient alternative is to charge at 3.7 kW.

To decarbonise road transport, it is necessary to convince consumers to shift to BEVs. For this to happen, BEVs should be at least as convenient as conventional vehicles. Regarding urban charging, the most convenient way is wireless charging, also known as **Park & Forget**. Once parked, the vehicle will manage the charging session without driver intervention, following the criteria predefined by the user (price range, state of charge range, etc.). Artificial intelligence and authorised access to calendar applications will provide a better consumer experience through improved management of the energy requirements.

The reduction of the cost of batteries will enable the use of stationary batteries to offer higher charging power while lowering the power of the connection to the grid. This technology change, combined with a bigger fleet of electric vehicles on the roads, will facilitate the business case to charge at **350 kW** or higher and improve the user experience.

As the share of renewable electricity generation grows, the more efficient charging pattern will be to shift from overnight charging to an "**always connected while parked**" scenario in which the vehicle will be available at any moment to offer services to the

12 https://www.fueleconomy.gov/feg/findacar.shtml

13 https://neo.ubs.com/shared/d1wkuDlEbYPjF/ page 10 based on 3-year lease, 14,400 km/year and 50% residual value after 3 years. https://www.leaseplan.com/en-ix/global-fleet-insights/tco-ev/ 56% BEVs with lower TCO than ICEVs without doing smart charging (cost of electricity only 54% lower than fuel cost for equivalent use)

14 http://www.trt.it/wp/wp-content/uploads/2012/12/driving-and-parking-patterns-final_online.pdf page 62 average daily driven distance 60 km, with a BEV efficiency of 15 kWh/100 km it's possible to replenish the energy consumed in less than 3 hours of overnight charging.

grid. This implies that many parking spaces will need to be equipped with a low power wireless charger (7.4 kW). This charging technology will also be convenient for autonomous vehicles.

Vision for heavy-duty vehicles

Battery-driven road freight transport (trailer trucks) will be commercially available from 2021.

> These trucks will require a 500-700 kWh battery for a 400 km range (with a 45 minute stop every 400 km according to the EU regulation).
>
> There is a need for 1 MW charging points along roads complemented by 100 kW charging points at overnight facilities.

Regarding battery-driven road public transport (buses), a number of models are already available with overnight charging at the depot.

> **The total cost of ownership of full electric buses is already lower than the equivalent diesel models**[15].
>
> **12 large cities have already committed** to only operate zero-emission buses from 2025 onwards[16].

Other aspects

Life cycle CO_2 emissions:

> **BEV vs Diesel: 88 vs 216 gCO_2-eq/km** (with EU 2015 grid electricity mix)[17].
>
> **BEV vs Gasoline: 280 vs 580 gCO_2/mile** (for a 265-mile battery electric vehicle and a full-size gasoline car)[18].

Around 260,000 net jobs could be generated in the EU by 2030[19].

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[15] https://data.bloomberglp.com/bnef/sites/14/2018/05/Electric-Buses-in-Cities-Report-BNEF-C40-Citi.pdf
[16] http://www.c40.org/press_releases/mayors-of-12-pioneering-cities-commit-to-create-green-and-healthy-streets
[17] https://www.transportenvironment.org/sites/te/files/publications/TE%20-%20draft%20report%20v04.pdf
[18] https://www.ucsusa.org/sites/default/files/attach/2015/11/Cleaner-Cars-from-Cradle-to-Grave-exec-summary.pdf
[19] https://europeanclimate.org/wp-content/uploads/2018/02/Fuelling-Europes-Future-2018-v1.0.pdf

With a market share of electric vehicles of 35% by 2030, 90% of electric vehicles sold in the EU should be produced locally in order to maintain employment within the automotive sector at the current level[20].

Main policy asks

To accelerate the adoption of full electric vehicles it is necessary to convince consumers to choose them. For this to happen, electric vehicles must be at least as convenient as conventional vehicles. This can be achieved by deploying the right infrastructure:

- **deploying 150 kW chargers on the TEN-T Core Network every 60 km** to enable long journeys (Annex II);
- making it easier to install a charging point for consumers with off-street parking: **Right to plug** (Annex III);
- relieving consumers of the annoying task of charging the vehicle, especially for those without off-street parking: **Predictive urban public wireless 7.4 kW charging infrastructure** (Annex IV);
- simplifying consumer information to more easily know if a vehicle can access the city centre: **Low emission zones with CO_2 thresholds** (Annex V).

Additional policy asks

- **establishing e-roaming across the EU (data interoperability of user authentication and payment)** in all charging points with public access (Annex VI).
- implementing smart charging from day one. **Mode 3 only for AC charging** (Annex VII).
- **developing a price comparison methodology. Considerations for BEVs,** as around 90% of electricity is recharged at private charging points (Annex VIII).
- **introducing a battery ID Code**. A unique code on battery system, pack and module to allow automatic dismantling and specific battery cell processing (Annex IX).
- **developing an integrated network of national vehicle registration systems**. In 2014 4.66 million vehicles – 39% of total End of Life Vehicles (ELV) – were at 'unknown whereabouts'. Improving this situation would have a significant impact on the availability of critical raw materials for new EVs (Annex X).

20 https://www.transportenvironment.org/sites/te/files/publications/Briefing%20-%20How%20will%20electric%20vehicle%20transition%20impact%20EU%20jobs.pdf

ANNEX I
Greenhouse gas emissions and energy efficiency comparison

Year	Primary Energy Factor (entire supply chain)[21]	CO_2 at power plant level per unit of net generation	CO_2 from well at LV level	CO_2 from well at LV level
		gCO_2eq/kWh	gCO_2eq/kWh	gCO_2eq/MJ
2015	1.9	326	429	119
2030	1.35	226	298	83

Glossary:

- LV: low voltage

Notes:

- 2015 GHG emissions from European Commission and Eurostat data, made available through EUenergyApp[22].
- 2030 GHG emissions from Commission Staff Working Document Impact Assessment accompanying the document Proposal for a Directive of the European Parliament and of the Council amending Directive 2012/27/EU on Energy Efficiency[23].
- To obtain CO_2eq emissions from well at low voltage, we have used the conversion factor of 1.315 for all the years. This is the 2013 value, that should be much lower in the 2030 scenario due to a higher penetration of renewables[24].

	Code	Year data	WTT energy	TTW energy	WTW energy	ratio ICEV/BEV	WTW GHG	ratio ICEV/BEV
			MJ/ 100km	MJ/ 100km	MJ/ 100km		gCO_2eq / km	
Conventional gasoline	COG1 2020+ DISI	2009	26	142	168		125	
BEV EU-mix low voltage	EMEL3 2020+	2009	86	38	124	1.4	57	2.2
BEV EU-mix low voltage	EMEL3 2020+	2015	34	38	72	2.3	45	2.8
BEV EU-mix low voltage	EMEL3 2020+	2030	13	38	51	3.3	31	4

21 https://ec.europa.eu/energy/sites/ener/files/documents/final_report_pef_eed.pdf page 5

22 http://energypost.eu/eu-energy/

23 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016SC0405R(01) tables 8 to 17

24 https://www.sciencedirect.com/science/article/pii/S1361920916307933 Table 2 CI at LV / CI gross electricity production

Glossary:

- WTT: well to tank
- TTW: tank to wheel
- ICEV: internal combustion engine vehicle
- BEV: battery electric vehicle
- WTW: well to wheel
- GHG: greenhouse gas

Notes:

- Figures for 2009[25].
- WTW energy for BEV calculated as TTW x PEF.
- WTW GHG emissions for BEV calculated as TTW energy x CO_2 from well at LV level / 100 km.
- Glossary: WTT (Well-to-Tank), TTW (Tank-to-Wheel), WTW (Well-to-Wheel), GHG (Greenhouse Gas) ICEV (Internal Combustion Engine Vehicle), BEV (Battery Electric Vehicle), MJ (million Joules)

ANNEX II
To deploy 150 kW chargers on the TEN-T Core Network every 60 km

Rationale

- In order to make full electric vehicles convenient for long journeys too, infrastructure deployment across Europe (TEN-T Core Network) is crucial. Two equally important elements in this infrastructure: charging power (to limit charging time) and even deployment (to remove range anxiety).
- With the current (limited) penetration of EVs, profitability of such infrastructure is unsatisfactory (very long payback period). Therefore, private operators have been reluctant to invest in 150 kW along major roads. Public financial support is thus required.
- As part of the Green Deal, the EU Commission will support the deployment of public recharging and refuelling points where persistent gaps exist, notably for long-distance travel and in less densely populated areas, and will launch as quickly as possible a new funding call to support this deployment.[26]

Policy ask

- Directive of Alternative Fuels Infrastructure
  - Replacing the Directive by a Regulation. As a Regulation is directly applicable, it ensures homogeneity and a shorter implementation time, as no transposition into national law is required.
  - Binding target: To have 150 kW stations with at least two chargers every 60 km or less along the TEN-T Core Network operational within 18 months after the publication of the revised Regulation.
- National support schemes where required:

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25 https://iet.jrc.ec.europa.eu/about-jec/sites/iet.jrc.ec.europa.eu.about-jec/files/documents/wtw_app_1_v4a_march_2014_final.pdf
26 https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf

  - Tender for locations on service or rest areas on Core Network, or on eligible locations near Core Network with/without capex subsidies.
  - At least in Spain, Poland, Portugal, Romania, Bulgaria and Greece.

Description of concept

- A national authority will define the locations, service or rest areas to be eligible for public support. On the TEN-T Core Network, such locations should be installed every 60 km[27], with access from both ways when possible and near cities when applicable.
- Recommended configuration:
  - At least two 150 kW chargers by location (upgradeable to four) to supply that electric power simultaneously, to reduce the impact on customers if one of the charging points is out of service.
  - A 700 kWh stationary battery for every two chargers, to reduce the grid access fees (main opex item), and eventually to implement another revenue stream from grid services
  - 200 kW feeding line, 50 kW for every charger.
- Quality of service:
  - To set a maximum annual percentage of time out of service.
  - To establish a mechanism (QR code and phone number) for users to inform when they cannot use the charging point.
- Available financial support by the European Commission with a rolling call under the Connecting Europe Facility (CEF) Blending Facility[28].
- References of tenders for service or rest areas: Switzerland[29], The Netherlands[30]
- References of subsidy schemes: The Netherlands[31], Germany[32], Czech Republic[33], Ireland[34], Canada[35], California[36], Norway[37]

ANNEX III
Right to plug

Rationale

- The aim is to make it easier to install a charging point for consumers with off-street parking in existing residential buildings.

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27 https://publications.europa.eu/en/publication-detail/-/publication/1533ba56-094e-11e7-8a35-01aa75ed71a1

28 https://ec.europa.eu/inea/en/news-events/newsroom/eu-launches-blending-facility-to-support-sustainable-transport-projects

29 https://www.electrive.com/2019/03/07/swiss-government-fedro-awards-fast-charging-network-contracts/
https://www.astra.admin.ch/astra/de/home/dokumentation/medienmitteilungen/anzeige-meldungen.msg-id-74223.html

30 https://zoek.officielebekendmakingen.nl/stcrt-2011-23149.html
https://english.rijksvastgoedbedrijf.nl/binaries/central-government-real-estate-agency/documents/publication/2019/04/01/auction-of-tenancy-rights-to-petrol-stations-on-national-highways-in-the-netherlands-2019/Brochure+Veiling+Huurrechten+Benzinestations+2019.pdf

31 http://ec.europa.eu/competition/state_aid/cases/258489/258489_1710979_137_2.pdf

32 http://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=3_SA_46574

33 http://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=3_SA_45182

34 https://www.dccae.gov.ie/documents/Fast%20Chargers%20for%20Electric%20Vehicles%20in%20Ireland.pdf

35 https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation/electric-vehicle-alternative-fuels-infrastructure-deployment-initiative/18352

36 California https://calevip.org/incentive-project/southern-california

37 https://www.enova.no/bedrift/landtransport/stotte-til-infrastruktur/hurtiglading/

- As considered in the Commission Recommendation (EU) 2019/1019 Annex, section 3.4.3.3[38]:
    - Lengthy and complex approval procedures can be a major barrier to owners and tenants installing recharging points in existing multi-tenant residential and non-residential buildings. Obtaining the necessary approvals can create delays or prevent installation.
    - 'Right to plug' requirements ensure that any co-owner is able to install a recharging point for an electric vehicle without having to obtain the (potentially difficult) consent from the other co-owners.
    - As reference, the Spanish legislation (Ley Propiedad Horizontal article 17.5[39]) allows a co-owner to install a recharging point for private use when located in an individual parking place and when the association of co-owners has been informed in advance. The co-owners cannot block the installation. The cost of the installation and of the subsequent electricity consumption is assumed by the individual who has installed the recharging point.

Policy ask

- To include the "Right to Plug" in national legislation, at least in: Germany, UK, Italy, Poland and Sweden.

Description of concept

- For most passenger cars, a 3.7 kW charger will suffice to replenish the average energy used during the day in less than three hours (7.4 kW for heavy users).
- The charger should be connected to the home meter whenever possible, to reduce grid access fees and facilitate the implementation of demand response services. In older installations, an extension of the meter and an inspection of the electrical installation may be required.
- At least one connector of type 2 (Mennekes) in mode 3 (remotely controlled), and a Schuko for category L vehicles.

ANNEX IV
Predictive urban public wireless 7.4 kW charging infrastructure

Rationale

- The aim is to relieve consumers from the cumbersome task of charging the vehicle, especially for those without off-street parking.
- Two-thirds of EU cars park overnight on the street or in public car parks[40].
- Benefits:
    - For cities: an invisible charging infrastructure without space requirements.
    - For users, to forget about charging and having to deal with cables, apps or tokens. This is especially convenient for disabled and elderly people.

Policy ask

- Directive of Alternative Fuels Infrastructure: introducing binding targets for cities (and regional governments grouping several towns) to have awarded tenders

[38] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019H1019&from=EN

[39] https://www.boe.es/buscar/act.php?id=BOE-A-1960-10906

[40] https://publications.jrc.ec.europa.eu/repository/bitstream/JRC77079/driving%20and%20parking%20patterns%20-%20final_online.pdf

before 2025 to deploy charging points on at least 20% of public parking spaces (on-street and car parks)[41], within no more than 300 metres from any residential building.

- To promote wireless pilots among reference cities in order to include wireless charging as a requirement for future tenders.

Description of concept

- The way wireless charging works is called Park & Forget (about charging), and these are the basic steps:
  - The driver parks and aligns the pads of the vehicle with the one in the street. Depending on the model, the vehicle could do this by itself.
  - Vehicle and charging point start authentication and data transfer.
  - If authentication is confirmed, the charging session starts.
  - The charging session finishes when planned or when the driver unlocks the vehicle.
    The charging process stops in case of detection of a living object (LOD) or of a foreign object (FOD) and a warning message is sent to the user's mobile phone.
- Up to 7.4 kW for passenger cars and light commercial vehicles (gross vehicle weight < 2,500 kg).
- Predictive versus on demand, because above a certain number of daily requests of new chargers, it will not be feasible to deliver them on demand. Two examples of algorithms:
  - Optimal allocation of electric vehicle charging infrastructure in cities and regions[42] by JRC.
  - Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite[43] by NREL.
- Wireless charging can reach an efficiency of 95%[44] (the battery receives 95% of the electricity supplied to the charging point), same actual efficiency as charging with cables[45].
- The capital cost, under the hypothesis of mass production, of the additional equipment to implement wireless charging is around 500€ for the vehicle, and 2,000€ for the charging point[46].
- Vehicle to Grid (V2G) capabilities, also available for wireless charging, could reduce the cost of the electricity by up to 42%[47].
- Major car manufacturers have already included wireless charging in their car platforms (for example VW[48], Toyota[49], Daimler[50]).
- A retrofit is available to add wireless to vehicles[51] and charging points[52].
- All related standards and protocols will be ready in middle 2021:

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41 https://www.nic.org.uk/wp-content/uploads/CCS001_CCS0618917350-001_NIC-NIA_Accessible.pdf page 90
42 http://publications.jrc.ec.europa.eu/repository/bitstream/JRC101040/allocatechargingpoints_sciencepolreport_eurreport_online.pdf
43 https://afdc.energy.gov/evi-pro-lite
44 https://www.magment.de/en-downloads-blog/2019/9/03-magment-wireless-charging-broschure-iaa-edition
45 https://www.adac.de/rund-ums-fahrzeug/tests/elektromobilitaet/stromverbrauch-elektroautos-adac-test/
46 Information collected from wireless equipment manufacturers
47 https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Innovation_Outlook_EV_smart_charging_2019.pdf page 93
48 http://newsroom.vw.com/vehicles/meet-the-volkswagen-platform-designed-to-spawn-10-million-electric-vehicles/
49 https://www.lexus.com/documents/concept/LF-30-Electrified/2019-TMS-Lexus-LF-30_Press_Release.pdf
50 https://www.daimler.com/innovation/case/electric/concept-eq-2.html
51 https://www.theverge.com/2019/3/21/18276541/norway-oslo-wireless-charging-electric-taxis-car-zero-emissions-induction, https://eandt.theiet.org/content/articles/2019/07/ev-wireless-charging-set-to-benefit-from-37m-government-funding/, http://www.volterio.com/, http://www.intis.de/wireless-power-transfer.html
52 https://www.magment.de/en-downloads-blog/2018/8/16/magment-inductive-wireless-charging-upgrade-kit

Theme	Topic	Code	Description	Available
Wireless power transfer	Vehicle side	ISO/DIS 19363	Electrically propelled road vehicles - Magnetic field wireless power transfer - Safety and interoperability requirements	2020-03
	Ground side	IEC 61980-1:2015 Edition 1	Electric vehicle wireless power transfer (WPT) systems - Part 1: General requirements	Yes
		IEC TS 61980-2:2019 Edition 1	Electric vehicle wireless power transfer (WPT) systems - Part 2: Specific requirements for communication between electric road vehicle (EV) and infrastructure	Yes
		IEC TS 61980-3:2019 Edition 1	Electric vehicle wireless power transfer (WPT) systems - Part 3: Specific requirements for the magnetic field wireless power transfer systems	Yes
	Vehicle and ground side	SAE J2954	Wireless Power Transfer for Light-Duty Plug-in/Electric Vehicles and Alignment Methodology	2020-12
Wireless data transfer		ISO 15118-1: 2019	Road vehicles - Vehicle to grid communication interface - Part 1: General information and use-case definition	Yes
		ISO 15118-2:2016	Road vehicles - Vehicle-to-grid communication Interface - Part 2: Network and application protocol requirements	Yes
		ISO 15118-8:2018	Road vehicles - Vehicle to grid communication interface - Part 8: Physical layer and data link layer requirements for wireless communication	Yes
		ISO 15118-9 ED1	Road vehicles - Vehicle to grid communication interface - Part 9: Physical and data link layer conformance test for wireless communication	2021-07
Data interoperability (authentication & payment)		ISO/DIS 15118-20	Road vehicles - Vehicle to grid communication interface - Part 20: 2nd Generation network and application protocol requirements	2020-06
		OCPP	Open Charge Point Protocol	Yes
		OCPI (P2P)	Open Charge Point Interface Protocol	Yes
		OCPI (Hub)	Open Charge Point Interface Protocol	Yes
		OSCP	Open Smart Charging Protocol	Yes

ANNEX V

Low emission zones (LEZ) with CO_2 thresholds

Rationale

- The aim is to stimulate consumers to shift to cleaner vehicles when planning to travel to city centres.
- It is also a way to set a common framework for cities and governments, linking air quality efforts (local focus) with climate change efforts (national focus).
- Local governments will improve air quality not only because of the direct effect of the lower emissions from vehicles within LEZ but also because it will be a permanent reminder to citizens that there are other vehicle technologies that are cleaner and more convenient.

Policy ask

- Applicable to cities above 50,000 inhabitants.
- Central area, at least 1% of the city surface with a trajectory to increase it in future.
- On duty 365 days/year, 24 hours/day.
- Automatic Number Plate Recognition. Stationary cameras on main access and random controls with portable ones.
- Daily toll for access except for vehicles complying with LEZ standards:
    - Light-duty vehicles (gross vehicle weight <=3,500 kg), <50 gCO_2/km
    - Heavy-duty vehicles:
        - GVW <= 7,500 kg, class Euro 6.
        - GVW >7,500 kg, <350 gCO_2/km, or class Euro 6 if the vehicle model was available before 1 January 2019.

Description of concept

- 50,000 inhabitants or more because of the budget requirements to implement the LEZ.
- CO_2 threshold instead of air quality classes because:
    - There is a strong correlation between CO_2 and air pollutant emissions. Three technologies emit below 50 gCO_2: BEV, fuel cell electric vehicle (FCEV) and most plug-in hybrid electric vehicles (PHEV) (page 38-39[53]). And most PHEVs made after Sept 2014, Euro 6 effective date (page 69).
    - Easy for drivers: just two parameters; gross vehicle weight and CO_2 emissions.
    - Easy for local authorities: with the national database of registration numbers, CO_2.
    - It would be an exercise of coherence between road tolls and urban tolls, as included by the European Commission in its proposal for the new Eurovignette Directive: shift of road charging of heavy duty vehicles (HDV)from EURO classes to CO_2 emissions (supported by the Council in September 2019[54]).
- 50 gCO_2/km for light duty vehicles (LDV) from the revised CO_2 for Cars Regulation.
- 350 gCO_2/km for HDV from the revised CO_2 for Trucks Regulation.

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[53] https://www.theicct.org/sites/default/files/publications/ICCT_Pocketbook_2018_Final_20181205.pdf

[54] https://www.consilium.europa.eu/register/en/content/out?&typ=ENTRY&i=ADV&DOC_ID=ST-12008-2019-INIT

- As a reference, 4x2 Rigid 7.5-10t truck consumes 16.9 l/100km. Assuming that all the carbon contained in the fuel is oxidized into CO_2, that means 443 gCO_2/km[55].
- The Monitoring and Reporting Regulation requires that, as of 1 January 2019, truck manufacturers monitor and report annually to the Commission the CO_2 emissions and fuel consumption of each new truck above 7.5 tonnes[56]. The scope is set to be amended in the future to also cover smaller trucks as well as buses and coaches.

ANNEX VI
e-roaming across EU (data interoperability of user authentication and payment)

Rationale

- Charging interoperability is key for electric vehicle adoption. It has two parts: the plug and, if required, to provide the recharging service on behalf of another service provider. The current AFID establishes plug types by default. Now is the time to extend interoperability to data (user authentication and payment).

Policy ask

- Directive of Alternative Fuels Infrastructure. The proposal is to change AFID article 4.8 from
  "Member States shall ensure that operators of recharging points accessible to the public are free to purchase electricity from any Union electricity supplier, subject to the supplier's agreement. The operators of recharging points shall be allowed to provide electric vehicle recharging services to customers on a contractual basis, including in the name and on behalf of other service providers."
  to
  "Member States shall ensure that operators of recharging points accessible to the public are free to purchase electricity from any Union electricity supplier, subject to the supplier's agreement. The operators of recharging points shall provide electric vehicle recharging services to customers on a contractual basis, when provided through new points after the publication of the revised Directive, including in the name and on behalf of any other service provider operating in the European Union, for interoperability purposes."

Description of concept

- Precedents:
  - In the Netherlands. e-roaming in its basic form – allowing EV drivers to charge at every charging station – has been possible since 2011. In that year, the Central Interoperability Register (CIR) was established, containing all cards/tokens for public charge stations issued by all service providers active in the Netherlands. This register, created with the support of the Dutch government, was transferred to eViolin in 2012. In March 2018, the role of the register was taken over by roaming services.[57]

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55 https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/heavy/docs/hdv_2011_01_09_en.pdf page 173

56 https://ec.europa.eu/clima/policies/transport/vehicles/heavy_en

57 https://www.mdpi.com/2032-6653/9/4/50/htm

- In France, the ADVENIR programme offers a subsidy for public charging point installations. It covers 40% of the cost per charging point. One of the conditions for receiving financial aid is to be a part of the platform Gireve[58].
- In the UK, major charging point operators reached an agreement to implement e-roaming before the end of 2019[59].
- In the USA, the California Air Resources Board approved a similar measure, into force from July 2020[60]: *'By one year after [insert the effective date of the regulation], the EVSP shall meet, at a minimum, and maintain the "California Open Charge Point Interface Interim Test Procedures for Networked Electric Vehicle Supply Equipment for Level 2 and Direct Current Fast Charge Classes'.*
- Report on the convenience to implement e-roaming (starting from section 18.6 on page 33)[61].

ANNEX VII
Mode 3 only for AC charging

Rationale

- While the energy demand increase due to EVs will not be a challenge, power demand will make a big impact on low voltage grids and on buildings' electrical infrastructure, as evidenced in the following studies:
  - Imperial College London. Electrification of transport: Challenges and opportunities[62].
  - EDSO for Smart Grids. Smart charging: integrating a large widespread of electric cars in electricity distribution grids[63].
  - 50Hertz & Elia Grid International. E-Mobility and its future effect on demand and flexibility[64].
  - IRENA. Innovation Outlook: Smart charging for electric vehicles[65].
  - Element Energy. Batteries on wheels[66].
- To avoid that impact, it is recommended to implement smart charging as soon as possible, to control time and power of charging. One precondition is the

58 http://advenir.mobi/labellisation/les-offres-eligibles/
59 https://news.evbox.com/en-WW/182404-leading-charge-point-operators-plan-roaming-agreement-in-the-uk
60 https://ww2.arb.ca.gov/rulemaking/2019/evse2019
61 https://live.r-e-a.net/wp-content/uploads/2019/10/HI-RESInteroperability-report.pdf
62 https://www.iea.org/media/workshops/2015/esapworkshopvi/StrbacPapadaskaplopoulos.pdf
63 https://www.edsoforsmartgrids.eu/wp-content/uploads/EDSO-paper-on-electro-mobility-2.pdf
64 http://mobilityintegrationsymposium.org/wp-content/uploads/sites/7/2017/11/1_3_EMob17_190_paper_Roland_Bauer.pdf
65 https://www.irena.org/publications/2019/May/Innovation-Outlook-Smart-Charging
66 https://www.transportenvironment.org/publications/batteries-wheels-role-battery-electric-cars-eu-power-system-and-beyond

mode of charging. There are three modes of charging in Alternating Current (AC)[67], but only Mode 3 remotely controlled allows smart charging.

Policy ask

- Directive of Alternative Fuels Infrastructure. All new public AC charging points have to operate in mode 3.

Reference

- The UK only subsidises home chargers that are Mode 3 compliant[68].

ANNEX VIII
Price comparison methodology. Considerations for BEVs.

Rationale

- Article 7.3 of AFID[69] says:
    - Where appropriate, and in particular for natural gas and hydrogen, when fuel prices are displayed at a fuel station, a comparison between the relevant unit prices shall be displayed for information purposes. The display of this information shall not mislead or confuse the user.
    - In order to increase consumer awareness and provide for fuel price transparency in a consistent way across the EU, the Commission shall be empowered to adopt, by means of implementing acts, a common methodology for a comparison of the unit prices of alternative fuels.
- The Commission approved this common methodology with the Implementing Regulation (EU) 2018/732[70], which shall apply from June 2020.
- Unlike other alternative fuels, battery electric vehicles recharge at low power charging points in 90% of the cases; most of them at private facilities (home or place of work) instead of at fuel stations[71].
- The difference in the unit price of electricity between those low power urban points when used overnight and the high-power chargers could easily reach a factor 10.
- On the other hand, the range of performance (kWh/100 km) between electric passenger cars is quite wide, even within the same class.

Policy ask

- For the type of vehicle, only use class B and for the performance, the weighted average by sales of WLTP performance (kWh/100 km) corresponding to all the electric models offered in that Member State.
- And, in order to calculate the cost of electricity, to make the weighted average of prices in a specific Member State, with a weight of 85% for the electricity supplied at low power at private facilities during overnight (1-7AM) as the period most convenient for consumers.

ANNEX IX
Battery ID Code

67 https://nederlandelektrisch.nl/u/files/2018-11-ev-charging.pdf

68 https://www.electrive.com/2019/06/25/uk-new-requirements-for-chargepoints/

69 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0094&from=en

70 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R0732&from=EN

71 https://www.toi.no/getfile.php/1343167/Publikasjoner/T%C3%98I%20rapporter/2016/1492-2016/Summary.pdf; https://www.edsoforsmartgrids.eu/wp-content/uploads/EDSO-paper-on-electro-mobility-2.pdf

Rationale

- The Batteries Directive is the only piece of EU legislation that is entirely dedicated to batteries. One of its two primary objectives is to minimise the negative impact of batteries on the environment, including at their end of life. And to ensure that targets for collection rates and recycling efficiencies are in place.
- In the coming years a new battery application will account for the majority of the battery capacity in use: traction batteries for electric vehicles. According to the Task 7 Draft Report of the Preparatory Study on Ecodesign of Rechargeable Electrochemical Batteries[72], the forecast for battery capacity stock in mobile applications in the medium sales scenario for Europe in 2030 is 2.1 TWh.
- More effective than targets is to establish the conditions for making the recycling process profitable for all the participants. Also, to include in the recycling process the collection of the battery systems (typically from the Authorised Treatment Facilities), their dismantling, and battery cell processing.
- For EV batteries, if it was possible to automate the dismantling, it would save 80-95% of dismantling costs and significantly facilitate making the full battery recycling process profitable for all participants in the value chain. In addition, knowing in advance the composition (chemistry) of the battery cells would allow the recycling efficiency to be improved and, consequently, the profitability of such recycling.

Policy ask

- The new Battery Directive should require, at least for EV batteries, a unique Battery ID Code at all levels (pack, module and cell) for all the batteries manufactured or introduced in Europe. This code will provide data on a server, which the manufacturer or supplier will bear the responsibility of updating, and which will be available to third-party accredited professionals in regard to the:
    - composition in standardised categories (NMC, LFP, etc.), that will facilitate identification of the main chemistry of the battery and the substances it contains;
    - dismantling information for recyclers in the form of safety instructions, tools list, and a time-lapse video to show how a product can be dismantled and allow recyclers to automate the process.

Reference

- In August 2018 China approved an initiative very similar to the Battery ID Code: “Recovery and Use of Batteries for New Electric Vehicles”[73].

ANNEX X
Integrated network of national vehicle registration systems

[72] https://ecodesignbatteries.eu/sites/ecodesignbatteries.eu/files/attachments/ED_Battery_Task%207_V17clean.pdf

[73] http://www.tai-sen.cn/Industry_News/52.html

Rationale

- In 2014, 4.66 million end-of-life vehicles (ELV), representing 39% of the total vehicles being decommissioned, were at 'unknown whereabouts'[74], i.e. they were deregistered but without a Certificate of Destruction (CoD) issued or available to the authorities, also with no information that the vehicle has been treated in an Authorized Treatment Facility (ATF) or has been exported.
- From 2007 at least, the 'unknown whereabouts' share has remained at a constant level[75]. This situation needs to be improved because:
    - such ELVs with 'unknown whereabouts' can potentially cause significant environmental and human health harm without proper treatment;
    - the situation distorts the legal market through illegal activities;
    - the materials contained in these ELVs are valuable, in particular the raw materials that have become critical as consequence of the growing share of electric vehicles (e.g. need to make new EV batteries).
- The two main elements that explain most of the issue with ELVs at 'unknown whereabouts' are vehicle dismantling at illegal sites, and exporting of ELVs outside of Europe as used cars. Our proposal for the former element is to replicate the current Dutch system, with several improvements, in all Member States in order to implement economic incentives to take ELVs to ATFs. For the latter element, we propose to make the roadworthiness test a requirement for a vehicle to be exported as used car, similar to the current situation in Italy and Ireland.
- In 2008, around 20% (3.3 million of 16.3 million vehicles) of new registrations in EU27 were used vehicles coming from other Member States[76].

Policy ask

- To establish in the ELV Directive that all Member States should implement a registration system similar to the Dutch one.
- Vehicle holders will annually pay the vehicle insurance and the cost of technical inspection. The road tax has not been included to simplify the implementation.
- Five possible conditions (non-cumulative) for the holder to stop paying:
    - The Authorised Treatment Facility (ATF) issues a Certificate of Destruction (CoD) in the registration system.
    - In case of sale in the same Member State, the agent with access to the registration system will update the name of the holder of the vehicle.
    - In case of export to another Member State, the vehicle will not be deregistered until it has been registered in the new Member State.
    - In case of export outside the EU, the export agent with access to the registration system will deregister the vehicle and enter the data of the buyer.
    - In case of stolen vehicles, the police will introduce this element and deregister the vehicle in the registration system.
- To have the vehicle pass a roadworthiness test no earlier than 12 months prior to the export operation outside the EU as a requirement for a vehicle to be exported as used car.

Description of the concept

74 https://ec.europa.eu/environment/waste/elv/pdf/ELV_report.pdf

75 http://ec.europa.eu/environment/waste/pdf/target_review/Final Report Ex-Post.pdf

76 https://www.oeko.de/oekodoc/1114/2011-005-en.pdf

- The main elements of the Dutch system (more details in the report by ADEME[77]):
  - Annually, 470,000 vehicles are deregistered: 220,000 ELVs and 250,000 exported as used vehicles.
  - Less than 2.3% of ELVs are dismantled at illegal sites (1,000 – 5,000 vehicles). There are concerns on 30,000 exported used cars (12%)[78].
  - The 'holdership' concept is applied, which means the vehicle obligations in terms of taxation, inspection and insurance are related to holding the vehicle, not to its use.
  - One software platform run by the Department of Transport (RDW) tracks any change of the vehicle status (unique relation VIN-license plate-owner) since it first enters the market until it leaves it (export, destruction or theft).
  - Only authorised operators can update the vehicle status in the system (dealers, ATFs, export agents, insurers, etc.). The involvement of the automotive sector facilitates acceptance and crossed controls of the shared data.
  - Annually, the vehicle holder has to pay the road tax, vehicle insurance and the roadworthiness test, until the vehicle is deregistered or sold to another holder.
  - The main area of improvement concerns import/exports as the system does not keep track of buyer or seller outside of the Netherlands. A mechanism to share data between Member States and collecting additional data for exports outside EU should overcome this limitation.

77 https://partage.ademe.fr/public/e9e42c

78 https://elv.whereabouts.oeko.info/fileadmin/images/Consultation1_Docs/_3.3__Flashlights_NL_ELV_workshop.pdf