CIRCE
Centro de Investigación de Recursos y Consumos Energéticos

Huesca

2021

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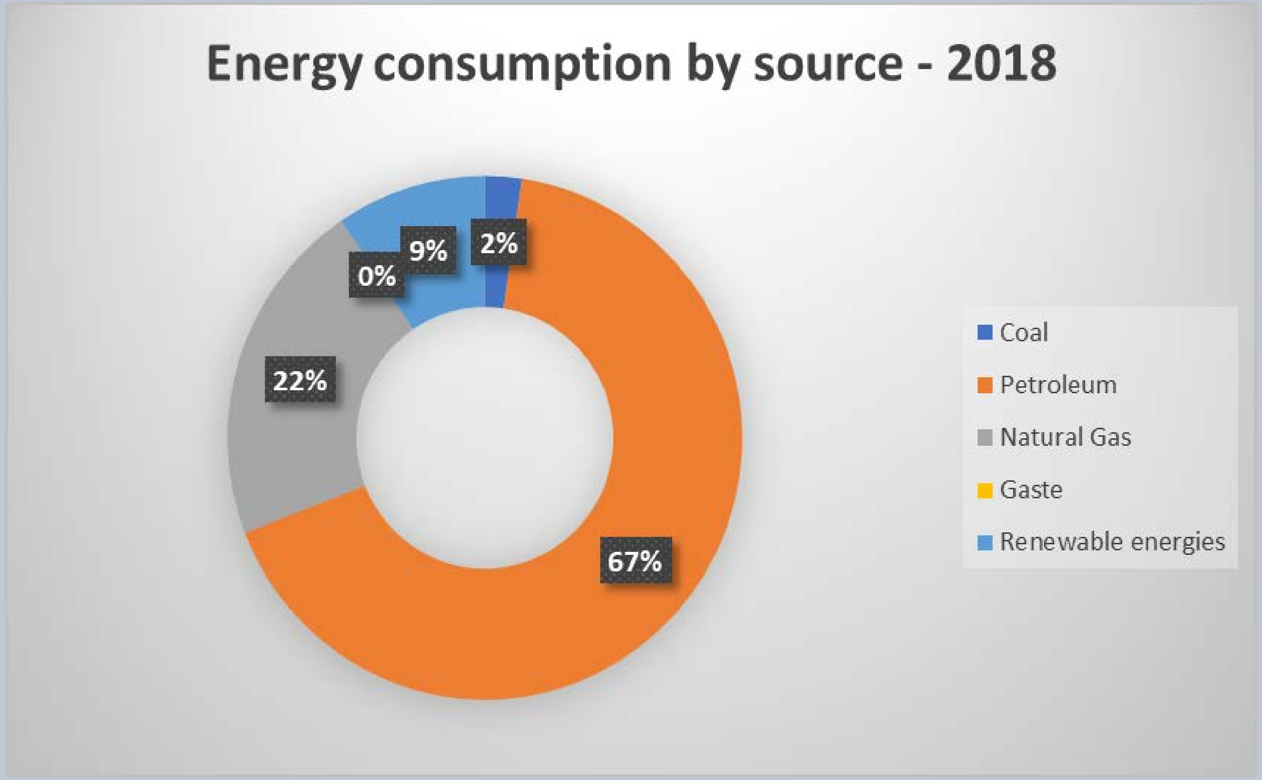
Electric vehicles: General approach

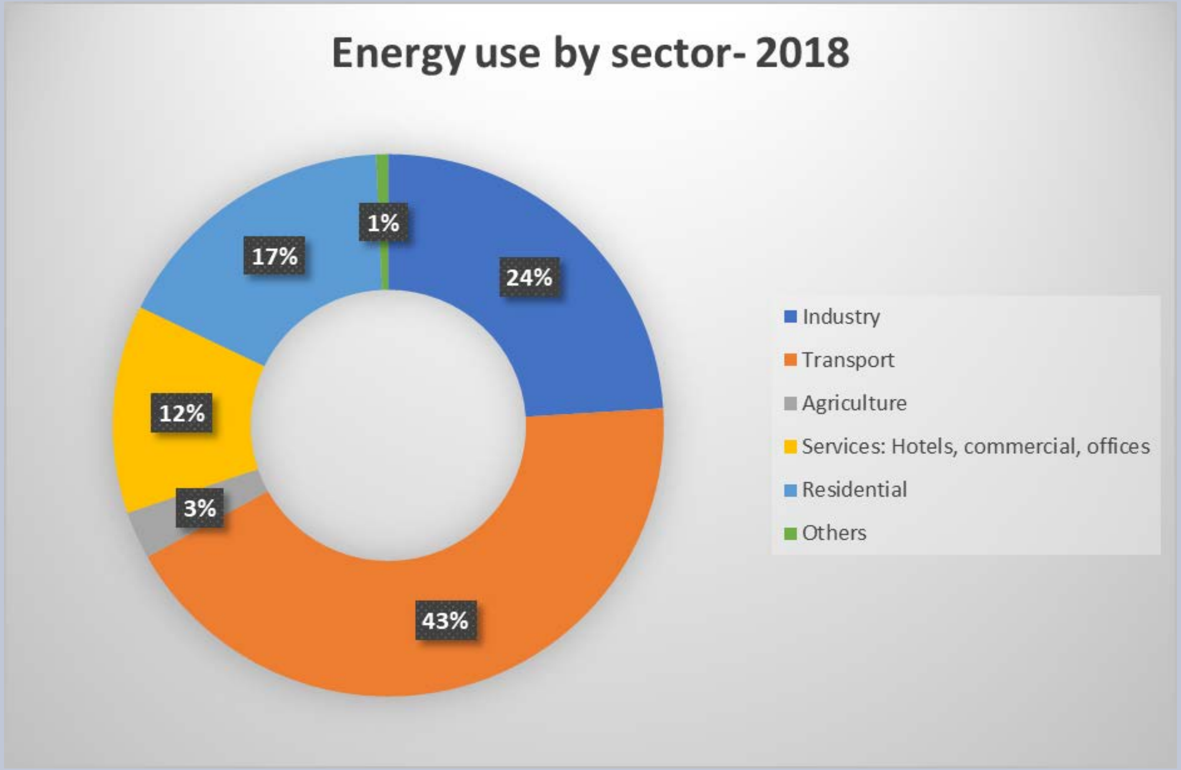
1 CURRENT ENERGY SITUATION

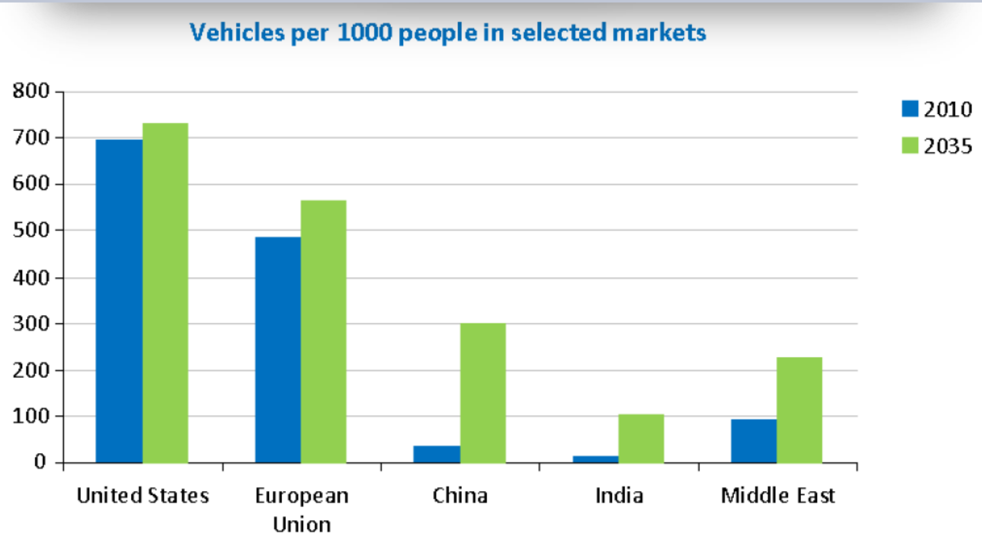


Globally the message of energy transition is clear. There is a need of reduction of the carbon emissions and replacement of fossil fuels by renewable sources of energy

1 CURRENT ENERGY SITUATION

It is also important to know the sector that uses the energy





Global growth forecast for vehicle use continues to grow

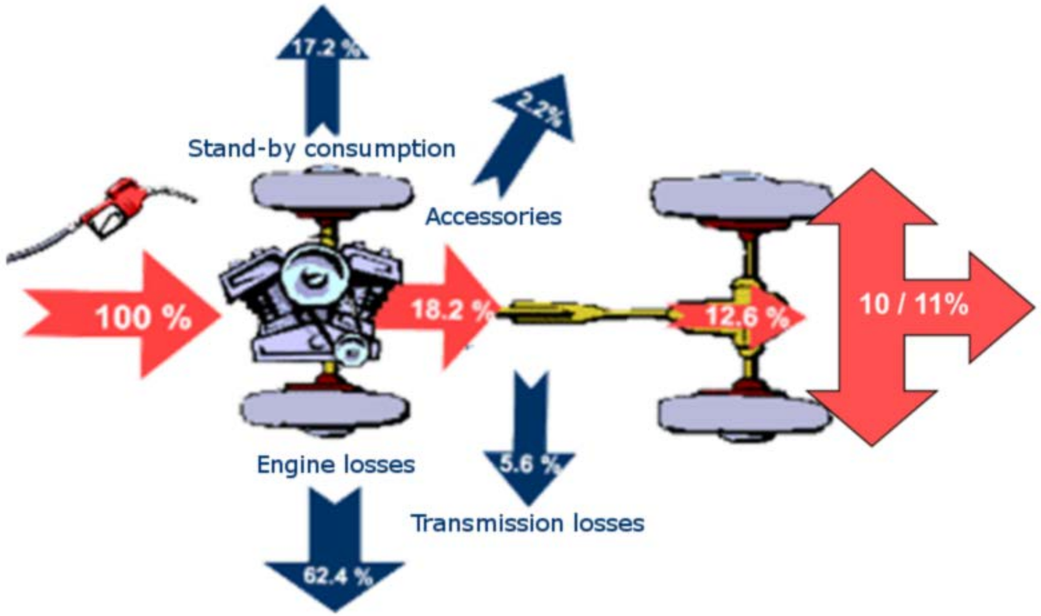
2 EFFICIENCY IN THE TRANSPORT SECTOR

Internal combustión vehicle, ICE

- Maximum obtainable efficiency from source to wheels is around 16%, meaning that more of 80% of the energy content of their fuel is wasted

Electric vehicle, EV

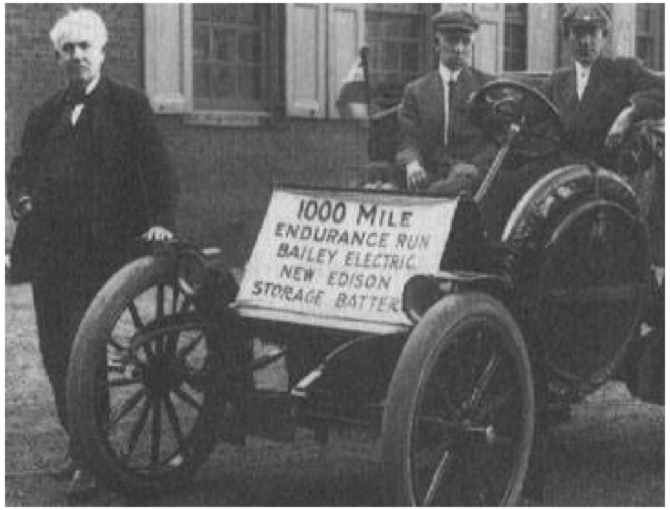
- Minimum of 60% of their input energy into turning the wheels directly



3 SHORT HISTORY OF THE ELECTRIC VEHICLE

More than 100 years ago the dispute between different technology vehicles

- most important innovations:
- 1828 First small scale electric cars
- 1880 First electrical installations with distributed generation.
- 1881 First commercially- successful electric tram line.
- 1878 First Commercial Pb Acid Batteries
- 1890 First practical electric vehicles



3 SHORT HISTORY OF THE ELECTRIC VEHICLE

EV - Good option:

- Simplicity
- Reliability
- smooth running
- no gear shifting or crank
- they were not noisy
- they were fast
- the range was reasonable
- the maintenance was minimal
- its cost was bearable

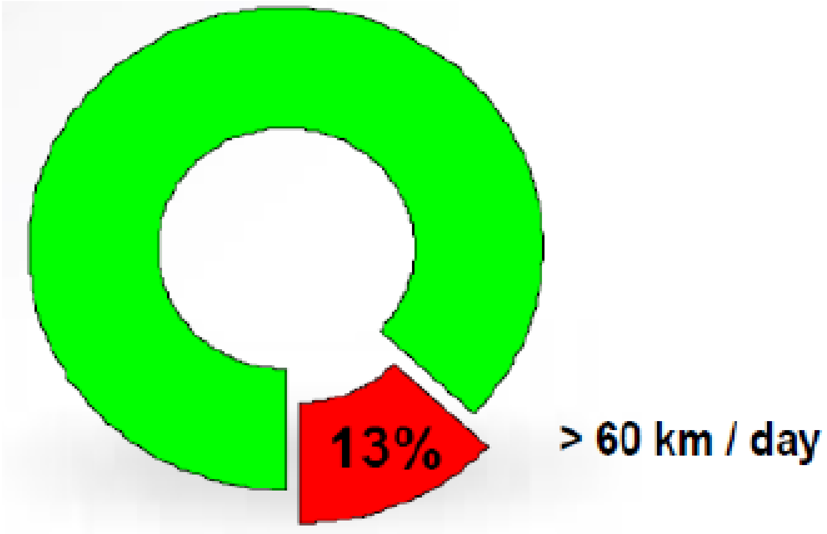
ICE, prevailed in time

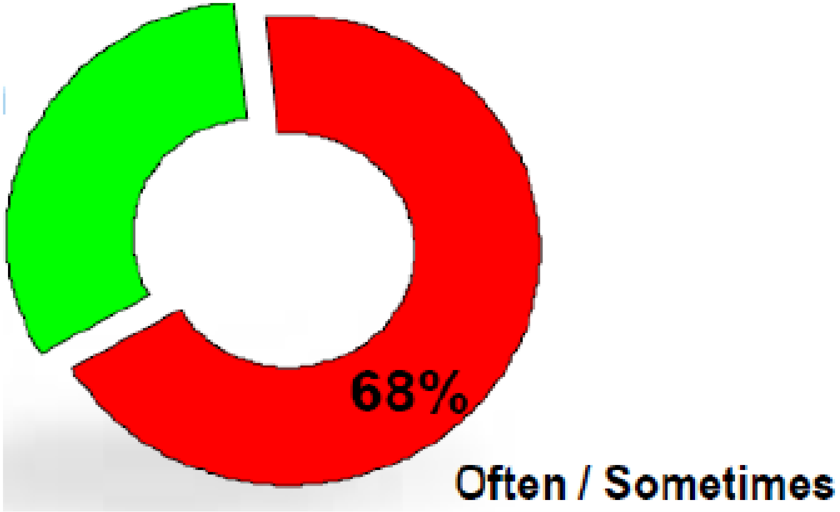
- First the immense availability of oil discovered and its reduction in cost
- And second, gasoline cars were in that moment able to travel farther and faster than equivalent electric ones.

4 ELECTRIC VEHICLE USAGE HABITS

87% of daily trips are shorter than 60km

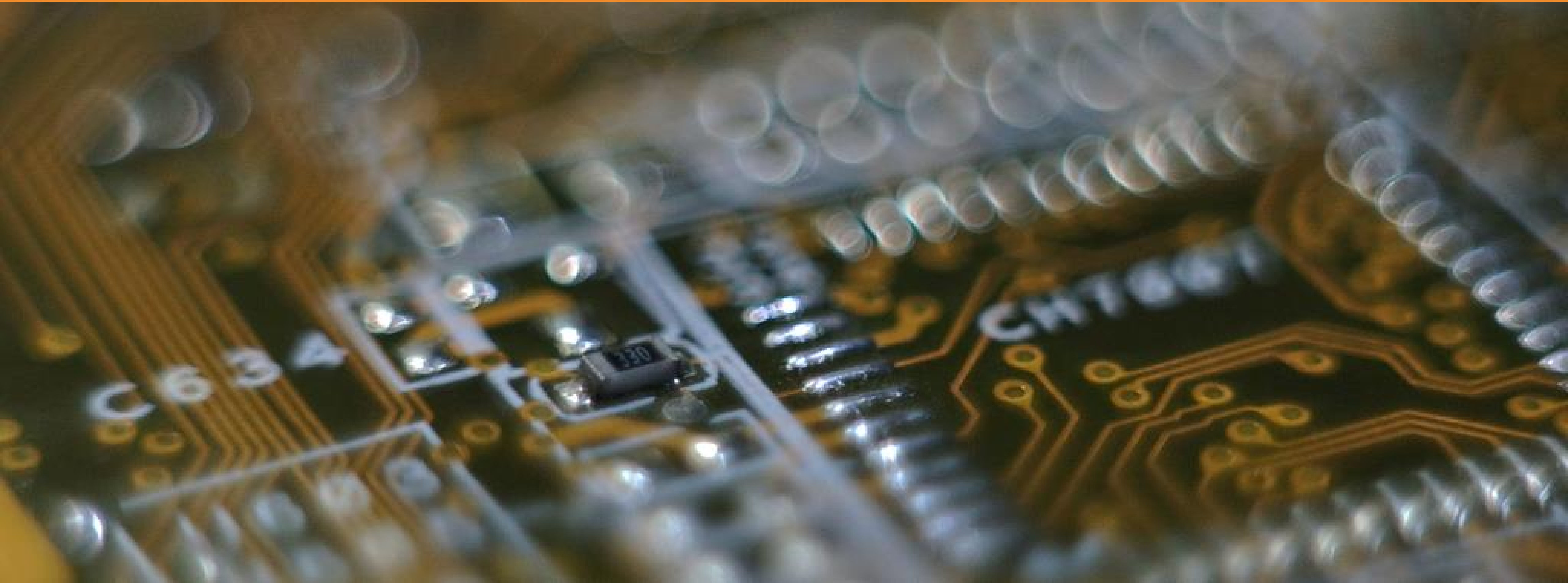
32% of inter-urban trips are shorter than 150km



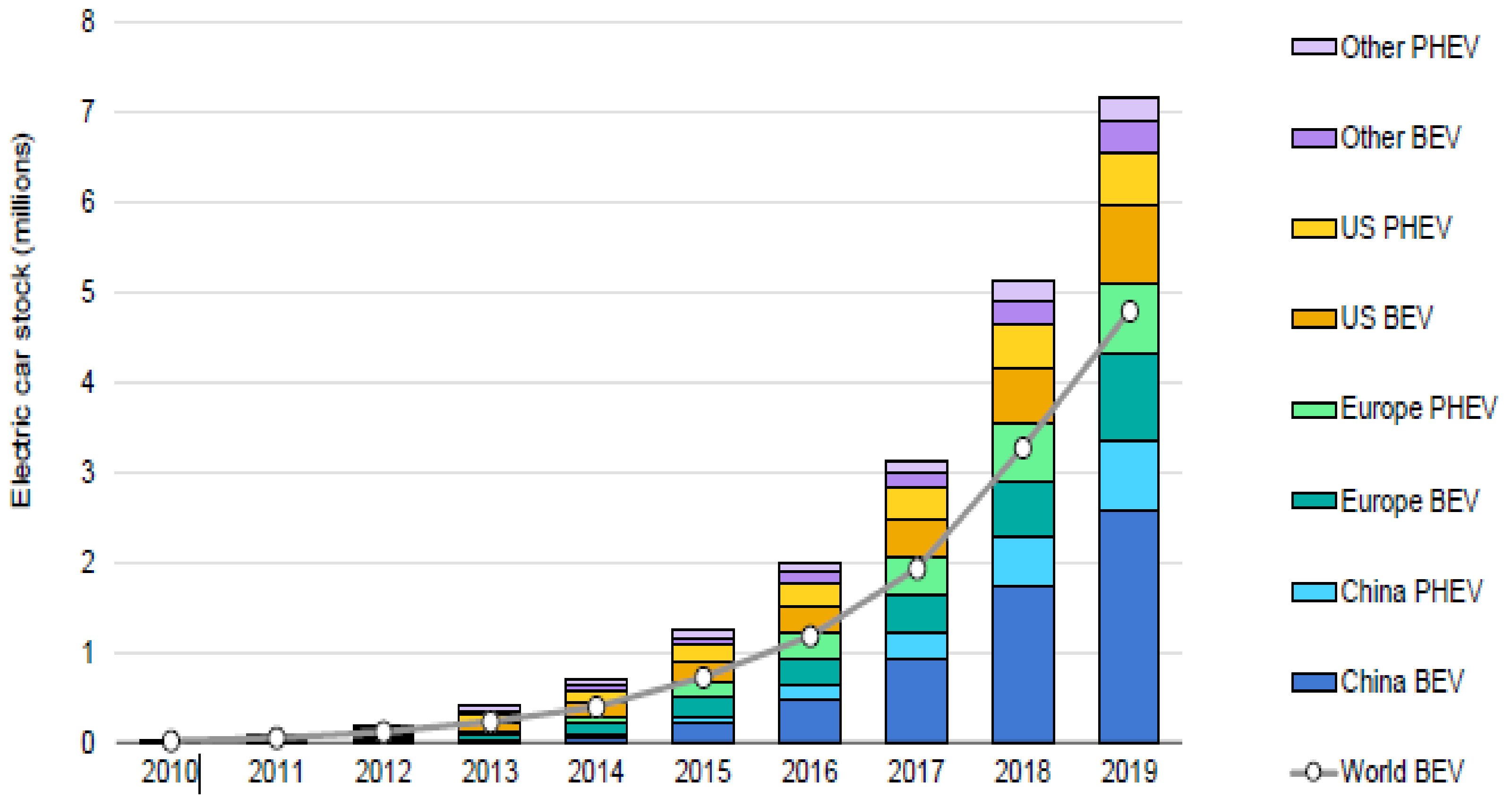


A 200 KM RANGE IS ENOUGH FOR THE MOST OF THE USERS

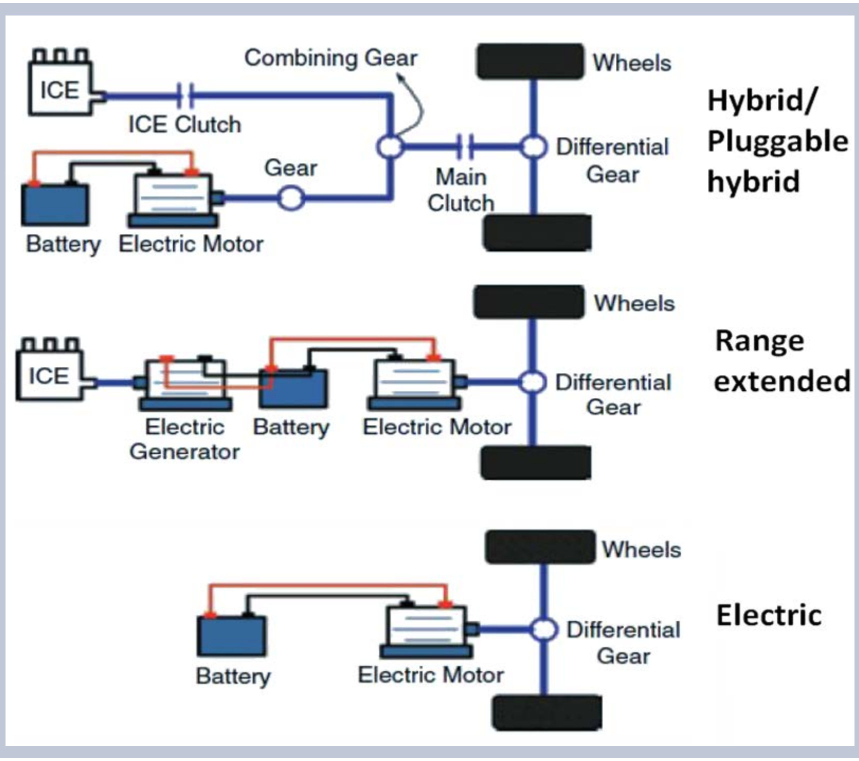
CURRENT EV MARKET



Global EV distribution, 2010 - 2019



Different types of EVs



Type	Components	Range	Battery capacity	Direct emissions
Hybrid/Pluggable	Combustion and electric engines	700km	Low/Medium	Low
Range extended	Combustion and electric engines	700km	Medium	Very low
Electric	Electric engine	200km	High	None

Private EVs

Type	Battery capacity	Range	Power EV (cv/kW)
Hyunday KONA	64 kWh	484 km	204/150
Nissan Leaf e+	62 kWh	385 km	217/160
RENAULT Twingo	22 kWh	270 km	81/60
OPEL Corsa	16 kWh	337 km	150/111
PEUGEOT ION	16 kWh	150	66/49


Hyunday KONA

Nissan Leaf e+

RENAULT Twingo


Opel Corsa - e

Peugeot ION

Commercial and industrial EVs

Type	Battery capacity	Range	Power EV (cv/kW)
IVECO Daily 65C Electric Van	84.5 kWh	130 km	30.0/40.5
Goupil B3–C Caja Basculante	15.36 kWh	100 km	5.4/7.3
KANGOO ZE	15.3 kWh	170 km	44/59

Electric motorbikes

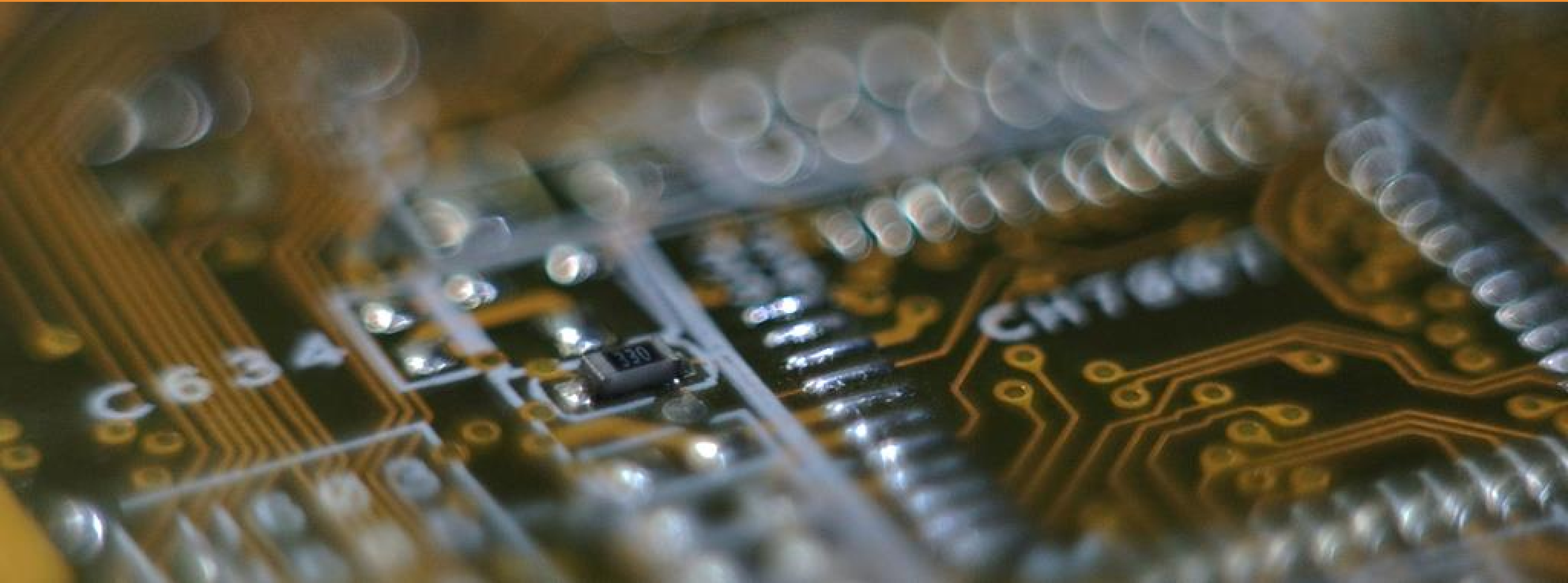
Type	Battery capacity	Range	Power EV (cv/kW)
NIU M series	1.5 kWh	65 km	2.05/1.2
Silence S01	2.4 kWh	80 km	5.00/6.75
Zero Motorcycles S	14.4 kWh	200 km	22.00/29.92

NIU M series

Silence S01

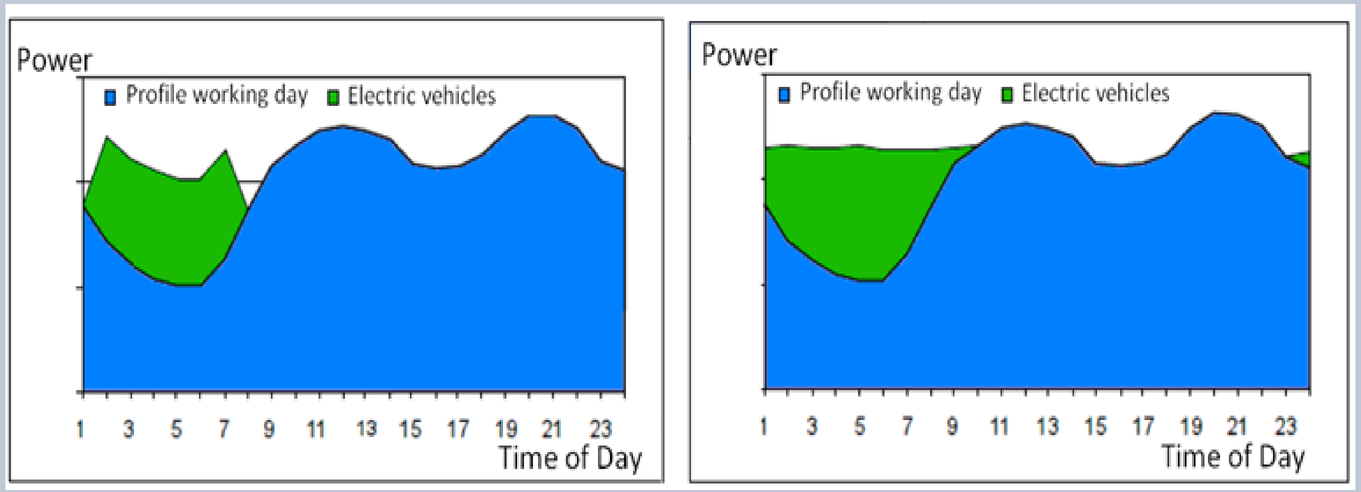
Zero Motorcycles

EV CHARGING

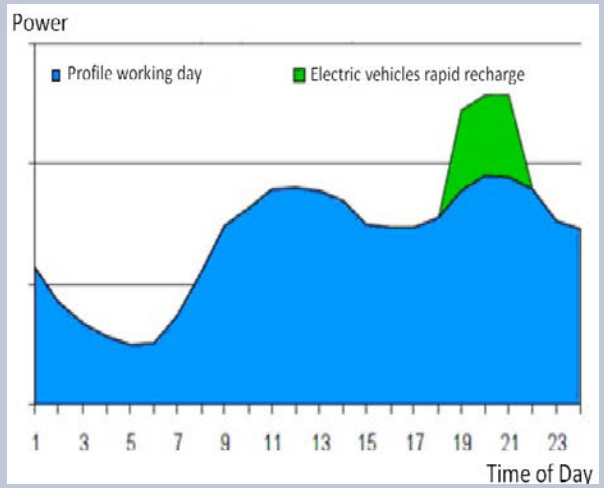


Integration of charging systems with the electrical grid

Night-time slow charge

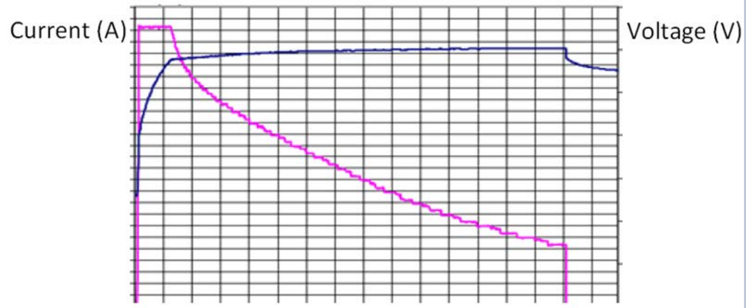


Day-time charge

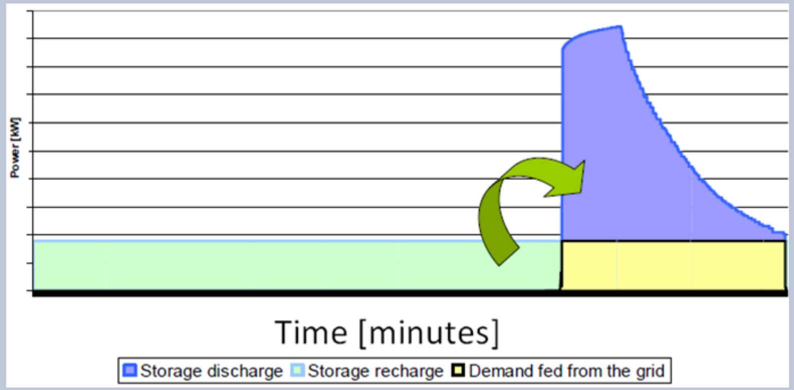


Integration of charging systems with the electrical grid

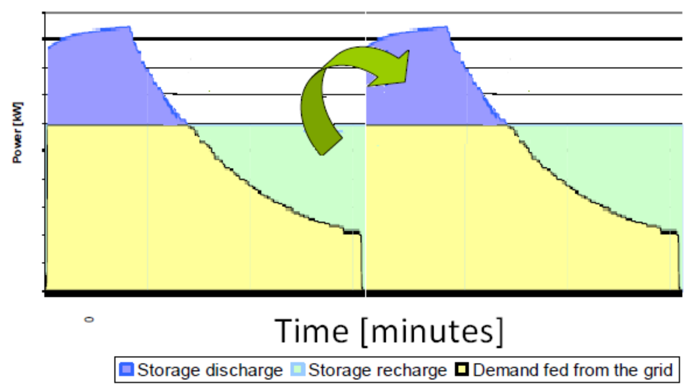
Energy requirements for fast charge



Demand balance strategies of EV charging



One charge



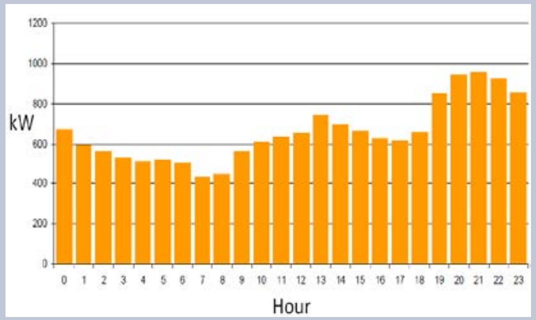
Continuous charging

Demand from electric vehicles fast charge stations could be shifted to low demand periods by storing that electricity at night

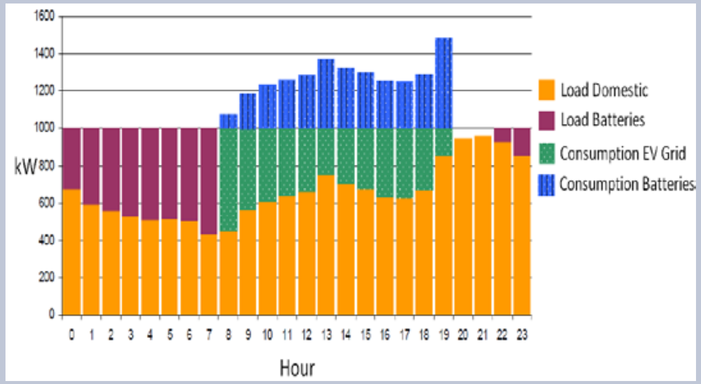
Integration of charging systems with the electrical grid

Practical example

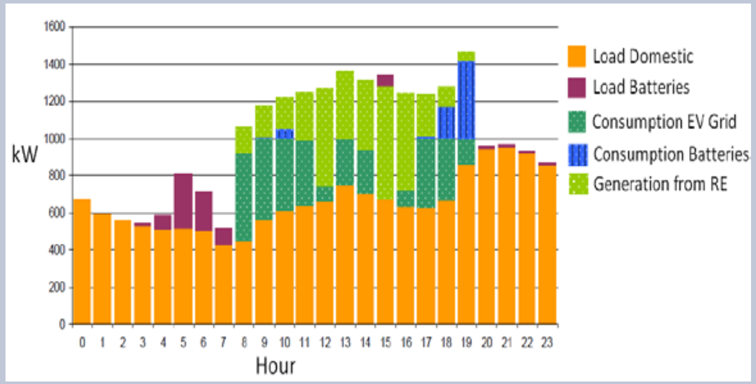
Electricity demand without EVs



Electric vehicle charging with load batteries



Overall system with renewable energy generation and a small storage system

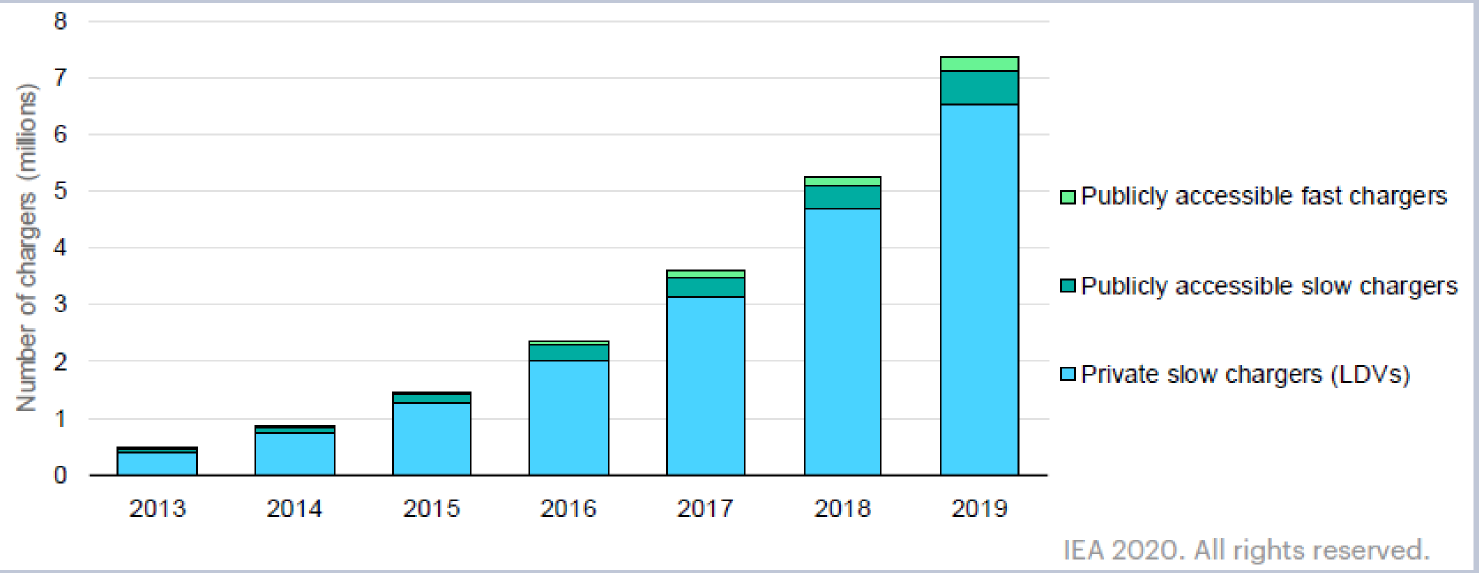


Renewable energy generation

This network has the following characteristics:

- 1 Transformer with a power of 1000 kVA
- 500 households
- 600 vehicles

Global stock of electric Light Duty Vehicles (LDV) chargers



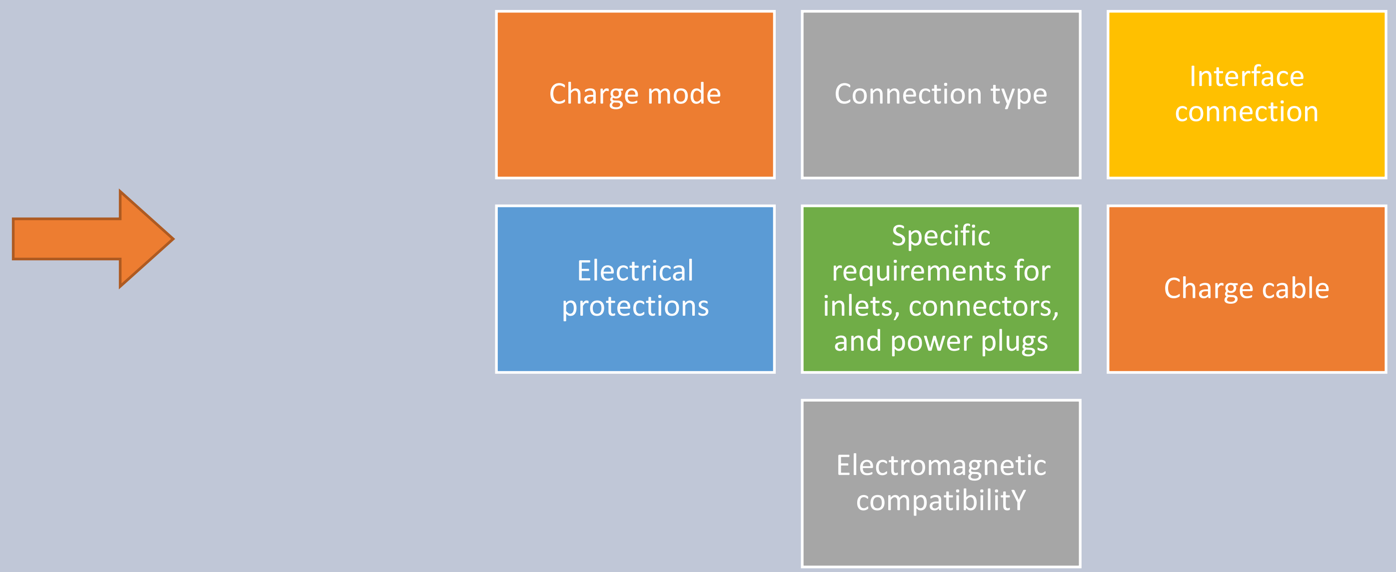
Source: Global EV Outlook 2020

Harmonized charging standard is the key for the massive deployment of electric mobility

- Level: The power output range of the charger.
- Type: it refers to the connector and socket used by the charger.
- Mode: referring to the communication protocols between the charger and the vehicle.

IEC 61851 - International standard for EV conductive charging systems

This standard includes



IEC 61851 - International standard for EV conductive charging systems

Creating together

Modes for charging electric vehicles

	Mode 1		Mode 2		Mode 3		Mode 4	
Grid connection	16 A plug (Type A)		Standardized outlet (Type B)		EV connected directly to the grid by means of a Charging Post (Type B)		EV connected indirectly to the grid by means of a Charging Post (Type C)	
Device for regulating the charging	EV on board		EV on board		EV on board		EV off board (Charge post has regulation)	
Recharging system permanently connected to the grid	---		No		Yes		Yes	
Communication	Not required		Pilot control wire compulsory		Communication between vehicle and post compulsory		Communication between vehicle and post compulsory	
Phases	1	3	1	3	1	3	1	3
Max power (kW)	3.7	11	7.4	22	7.4	33	240	210

EV Charging

Operation and parts of the EV | Zaragoza

Miguel Zarzuela / Laura Gimenez / Maria Gabriela Cañete

CIRCE Foundation

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 847038

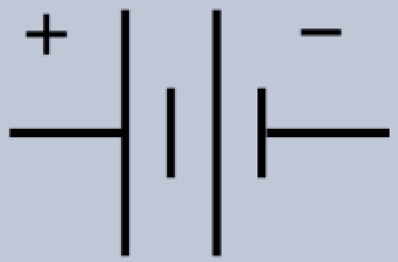
Electric vehicles: Operation and parts

Content

1 Batteries

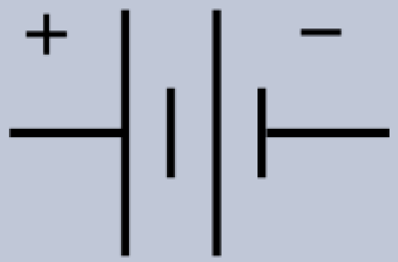
¿What is a Battery?

One or more electrochemical cells capable of either generating electrical energy from chemical reactions or using electrical energy to cause chemical reactions.



1 Batteries

¿What is a Battery?

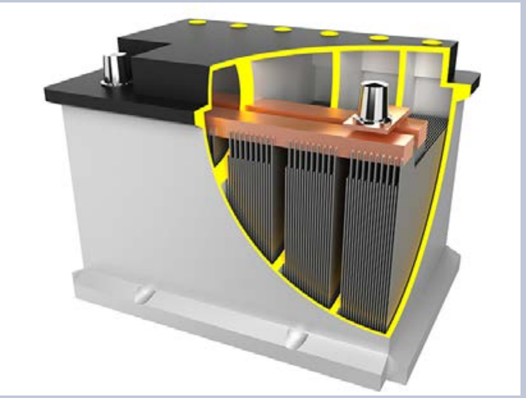


One or more electrochemical cells capable of either generating electrical energy from chemical reactions or using electrical energy to cause chemical reactions.

Automotive Battery

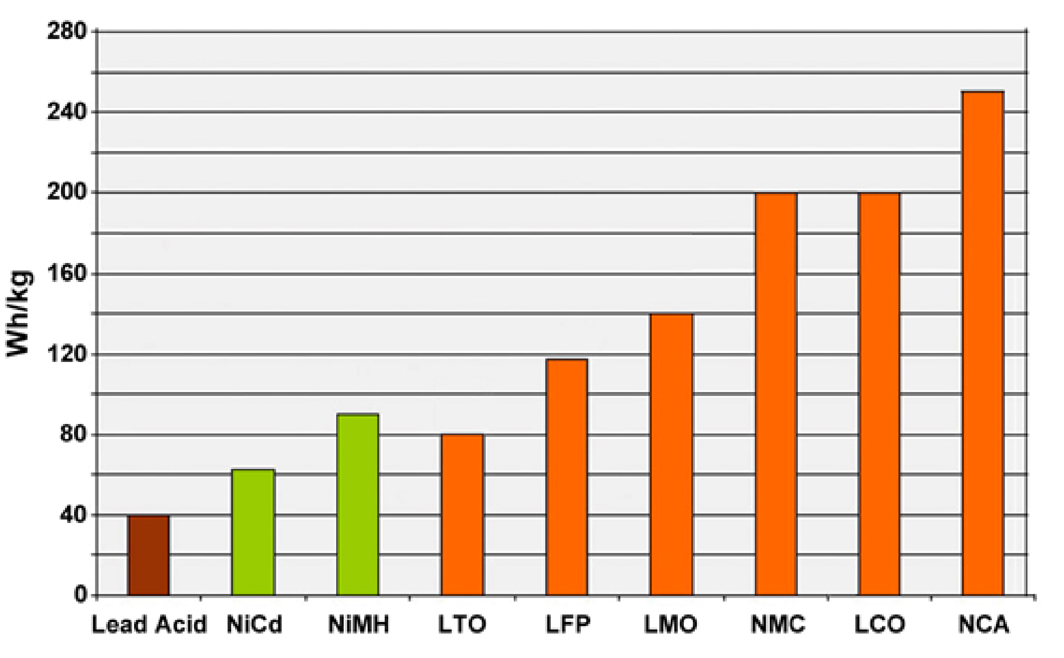
Energy source of an Electric Vehicle (EV) to move the wheels

1 Batteries Chemistry



Classical Batteries
Lead Acid

Li-ion revolution



- Nominal Voltage
- Specific Energy
- Charge / Discharge rate
- Cycle life

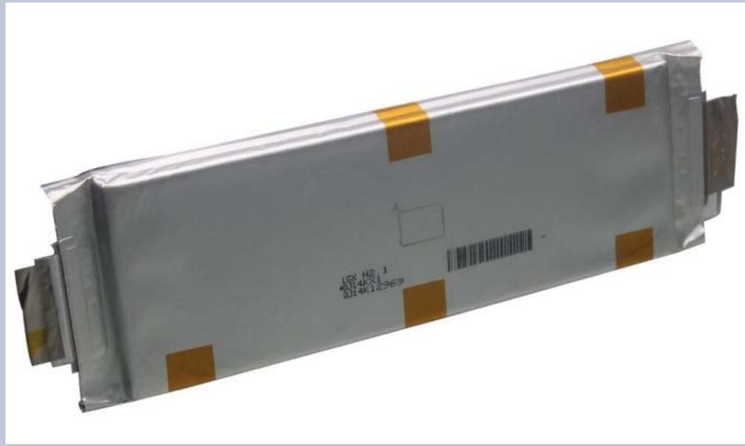
1 Batteries

Automotive Battery

Consist of an arrangement of series and parallels of individual cells

12 x  = Battery module (12s) 

Cylindrical Cell



Pouch (prismatic) cell

1 Batteries

Automotive Battery

Consist of an arrangement of series and parallel of individual cells

12 x  = Battery module (12s) 

36 x 

= Audi e-tron battery (108s4p cells)

= Audi e-tron battery (9s4p modules)

1 Batteries

Automotive Battery Example

Consist of an arrangement of series and parallel of individual cells

12 x  = Battery module (12s) 

36 x  = Audi e-tron battery (108s4p cells)

= Audi e-tron battery (9s4p modules)

V = 108 cells in series = 3,66 x 108 = **396 V**

Ah = 60 Ah/cell x 4 parallels = **240 Ah**

Wh = 240 Ah x 396 V = 95 040 Wh = **95 kWh**

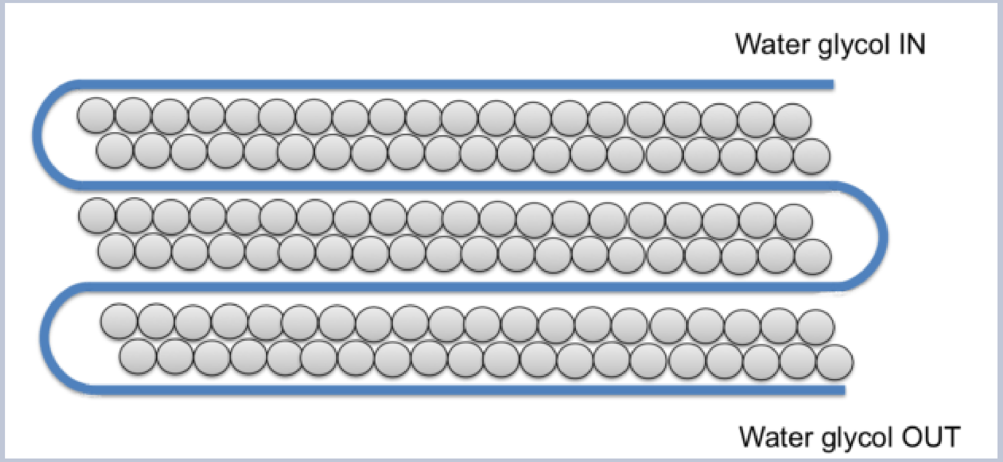
1 Batteries Systems

BMS: Battery Management System

- Monitors cell voltage and temperatures
- Control intensity, power, and energy
- Protect cells from discharger or overvoltage
- Balance cells to avoid voltage differences

Battery Thermal Management System

- Monitors temperatures
- Maintain performance and longevity



Steeep: Support & training for an Escellent Energy Efficiency Performance

2 Electric vehicle engine

Since the mid-19th century, different technology vehicles appeared, and electric and internal combustion engines coexisted. The electric engine was a good option for its:

- simplicity,
- reliability,
- smooth running,
- no gear shifting or crank,
- they were not noisy,
- they were fast,
- the range was reasonable,
- the maintenance was minimal,
- and its cost was bearable

Although, due to the immense availability of oil and its reduction in cost, the oil era prevailed. And now, internal combustion engines power most cars around the world

2 Electric vehicle engine

Figure: View of EV drivetrain. Engine placement between two wheels

Various types of EV can be found: DC series, Brushless DC, Permanent magnet synchronous, Three phase AC induction and Switched Reluctance motors.
For high power applications like performance two-wheelers, cars, buses, trucks the ideal motor choice would be **Permanent magnet synchronous or Three phase AC induction motors**

2 Electric vehicle engine

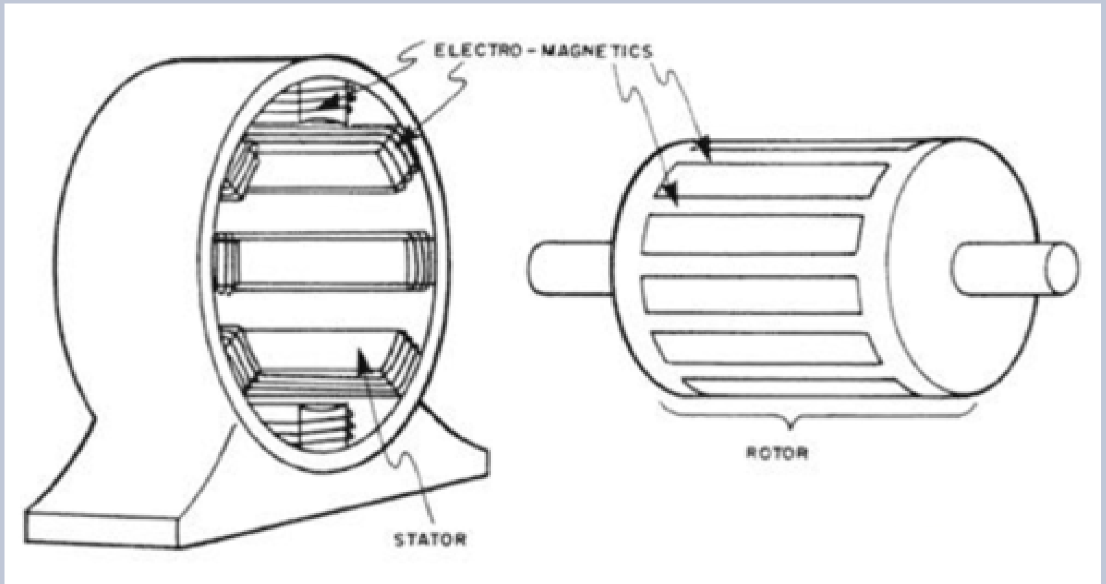
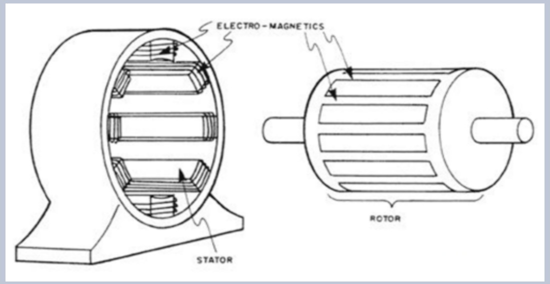


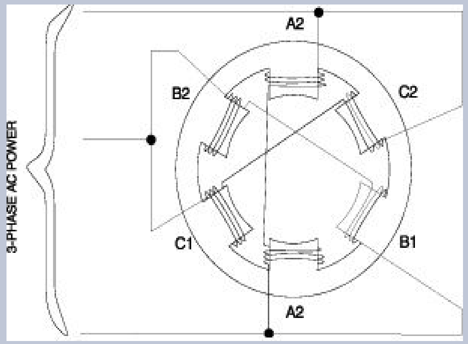
Figure: Electric engine - Stator & Rotor

In both cases two major parts of the motor can be distinguish, the **stator,** where the stationary windings are; and the **rotor**, with the magnets that rotate and move the axis, converting the electric energy in mechanical.

2 Electric vehicle engine

The stator



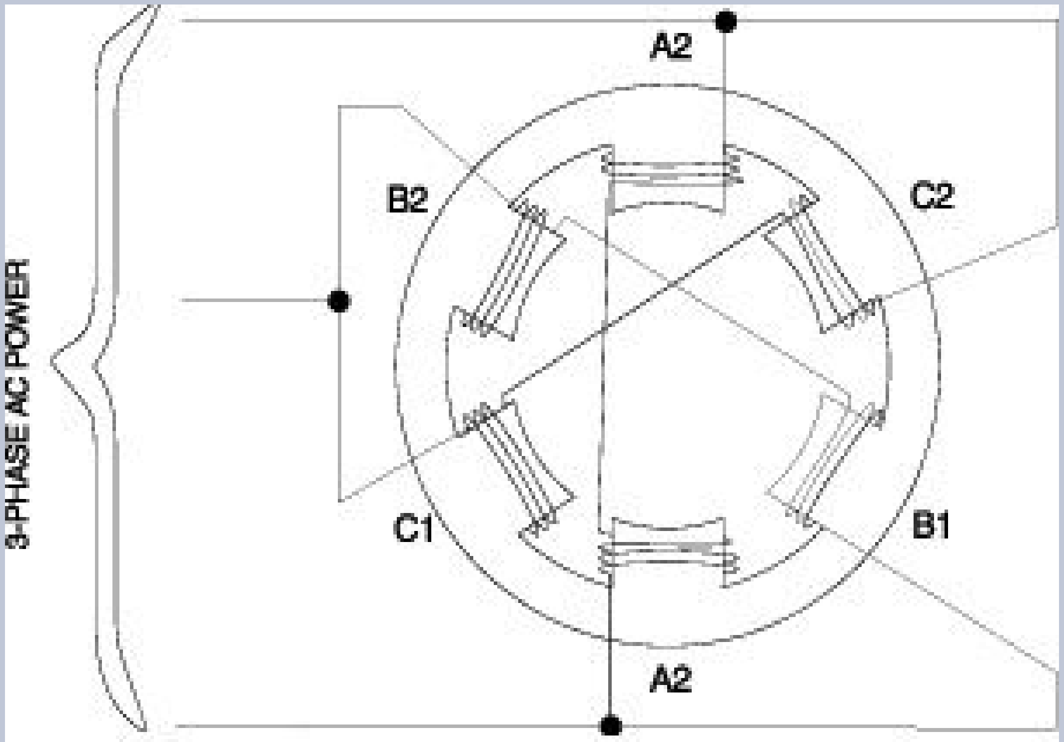


The stator is made up of stacked steel laminations with axially cut slots for winding.

Windings consist of a number of similar coils placed in sequential slots in the stator surface and connected in series. Each coil contains a number of insulated turns of conductor

2 Electric vehicle engine

The stator



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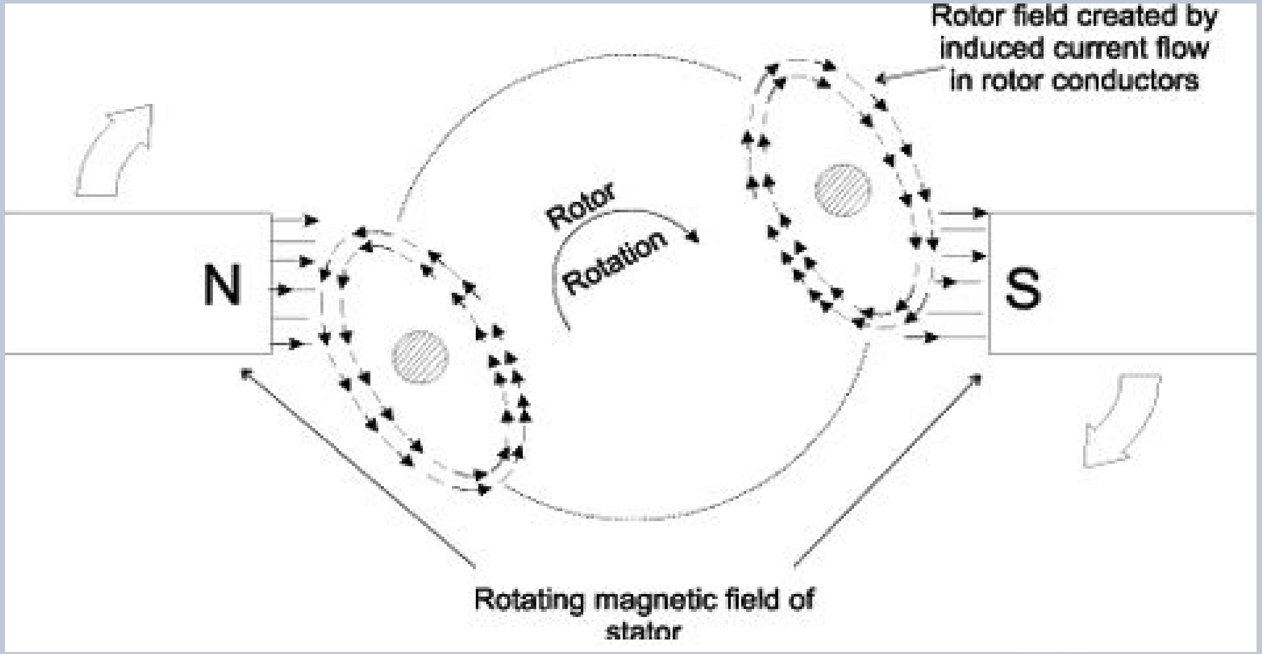
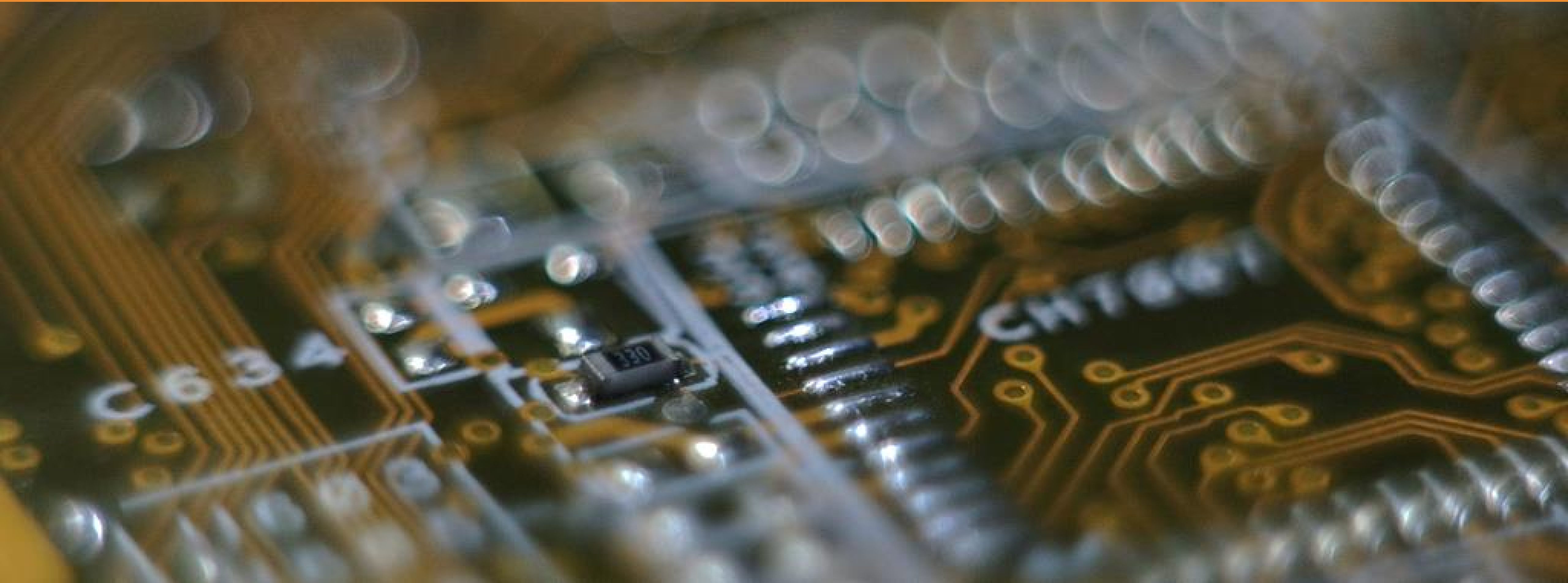


When a 3-phase induction motor is connected to utility type 3-phase power, torque is produced at the outset; the motor has the ability to start under load. No inverter is needed.

In contrast, a brushless DC motor produces no starting torque when directly connected to fixed frequency utility power. They really need the aid of an inverter whose “phase” is maintained in step with the angular position of the rotor.

ELECTRIC VEHICLE CHARGER



IEC 61851 - International standard for EV conductive charging systems

This standard includes

- Charge mode
- Connection type
- Interface connection
- Electrical protections
- Specific requirements for inlets, connectors, and power plugs
- Charge cable
- Electromagnetic compatibilitY

IEC 61851 - International standard for EV conductive charging systems

Modes for charging electric vehicles

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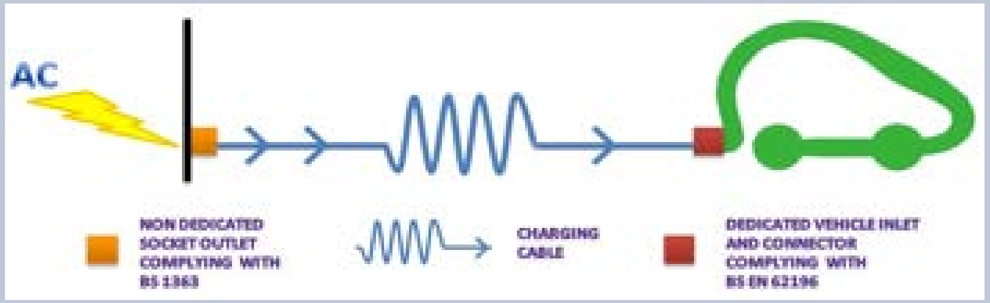
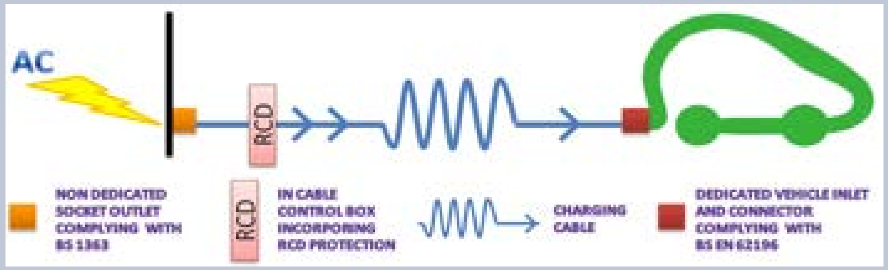
MODE 1



- The Charger is in the EV
- The EV controls the charger process
- Threephasic or monophasic connection

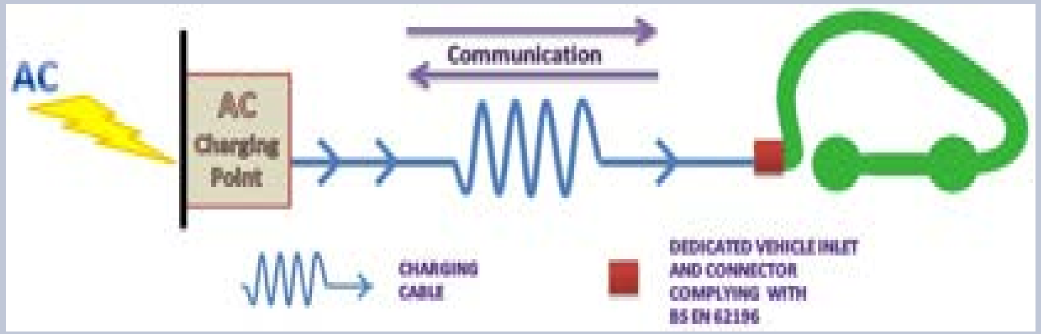
MODE 2



- The Charger is in the EV
- Includes a pilot control connection
- The pilot manage the process parameters

Mode 3 Fast AC Charging

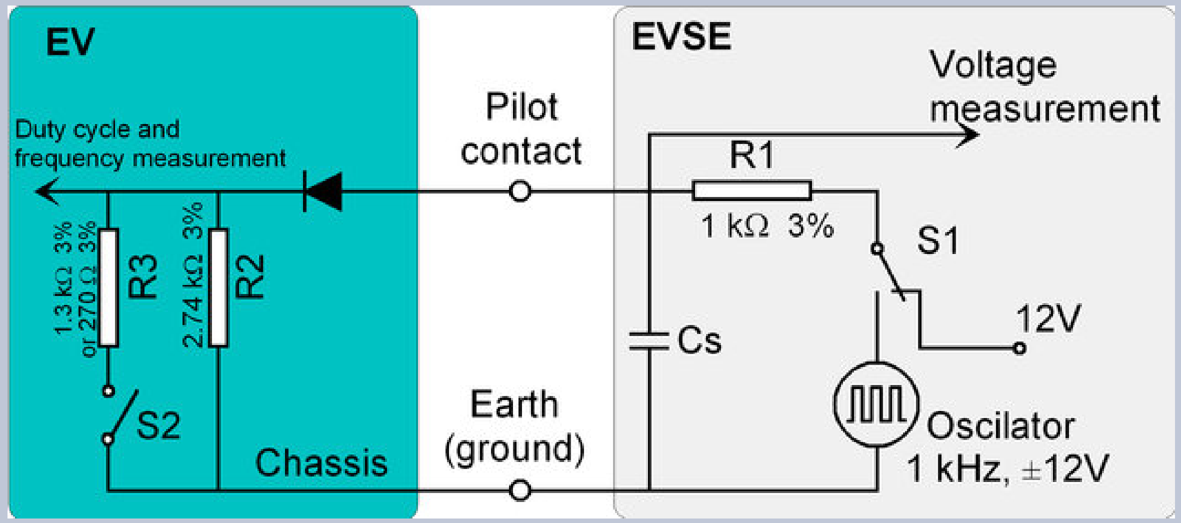
MODE 3



- ➢The Charger is in the EV
- ➢The recharger socket is permanently connected to the grid
- ➢Like mode 2, includes a control pilot

Mode 3 Fast AC Charging

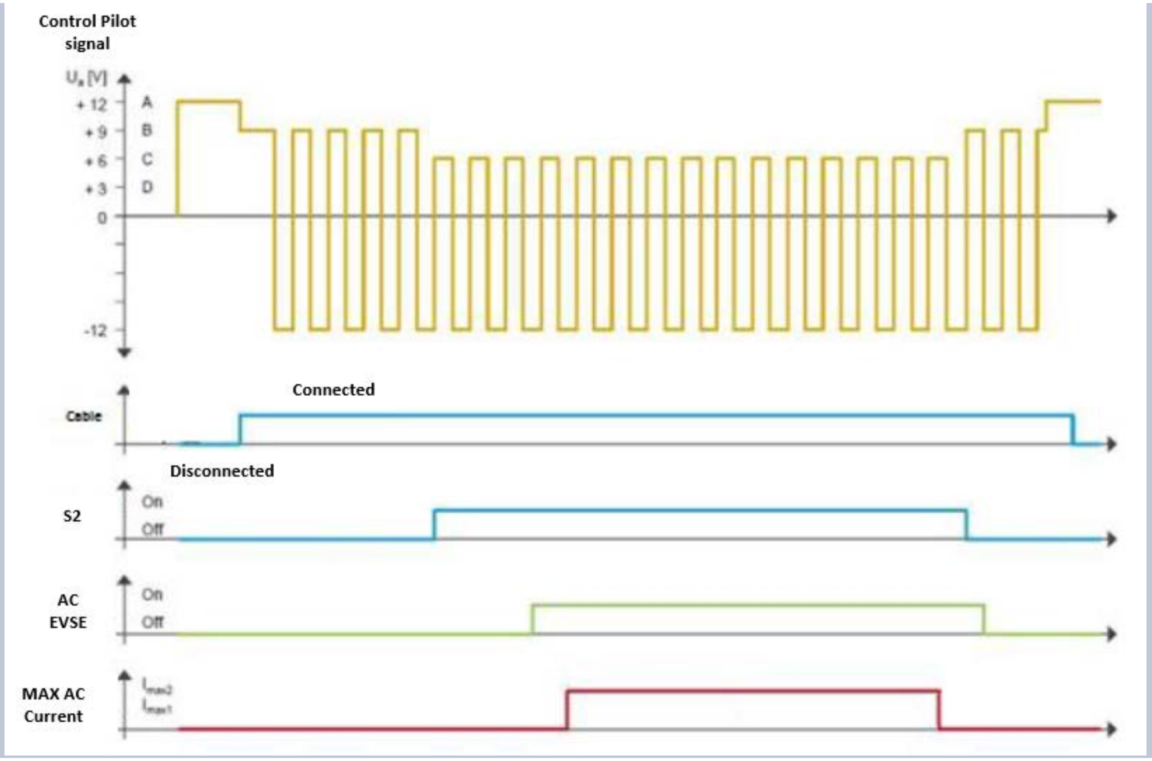
➢Control pilot circuit



Mode 3 Fast AC Charging

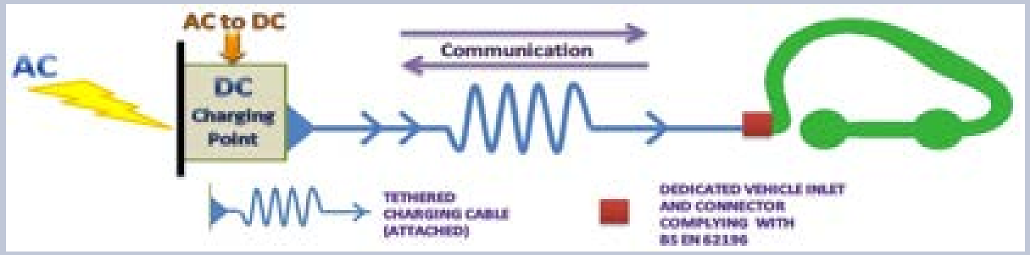
MODE 3

- ➢The Charging process comprise 9 steps



Mode 4 Fast DC Charging

MODE 4



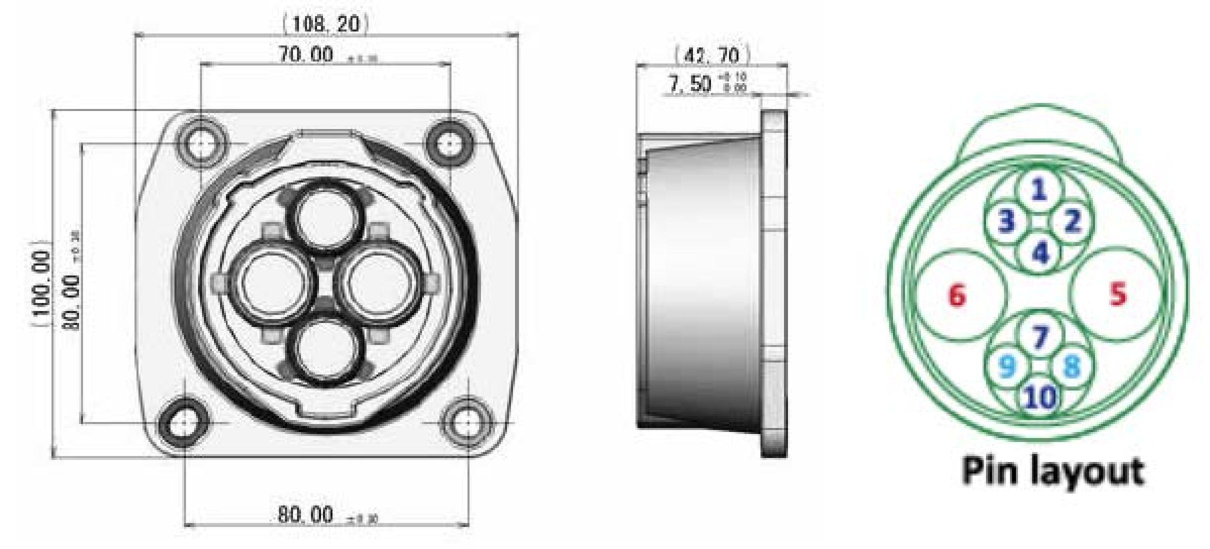
- The Charger is outside the EV
- The EV has a DC input socket
- CHAdeMO and CCS2 (Combined Charger System)

Mode 4 Fast DC Charging CHAdeMO

- Use CAN bus

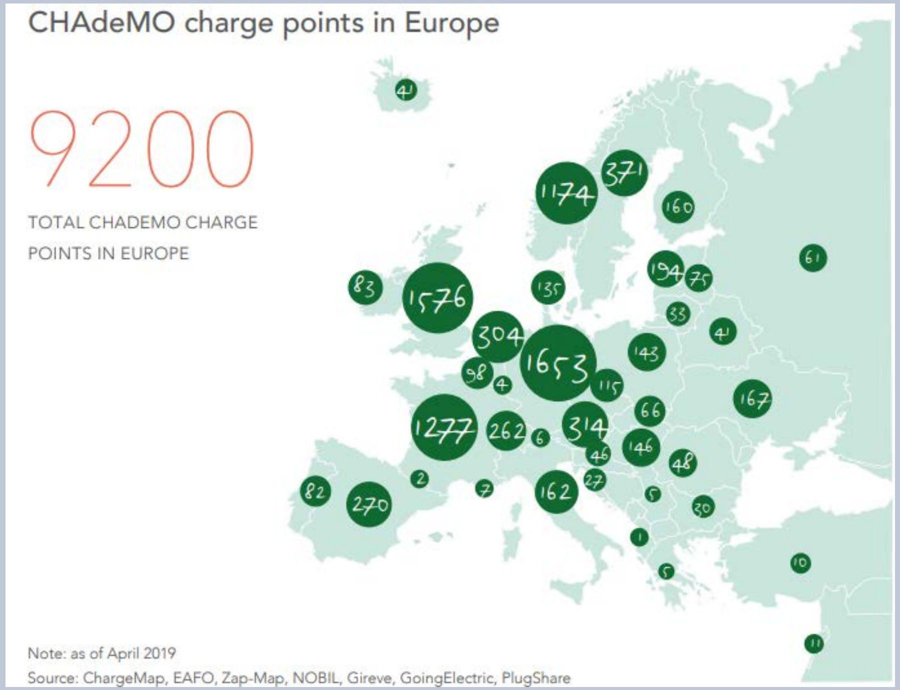
- The CHAdeMO protocol stablishes a dialogue between the EV and the external charger

    - The EV request the necessary energy to recharge the battery



CHAdeMO Connector

Mode 4 Fast DC Charging CHAdeMO



Mode 4 Fast DC Charging CHAdeMO

In 2018 CHAdeMO release the 2.0 protocol which covers until 400 kW and 1 kV

The CHAdeMO protocol support the V2G charging

Mode 4 Combined Charging System (CCS2)

The recharging of the vehicle both in AC (slow/medium charging) and DC (quick charging) using two types of charger connectors and only one charging inlet in the vehicle

CCS is a combined system that chargers EV with both AC current and DC current via the vehicle inlet meaning that only one interface or connector is required in the vehicle

CCS connector for Europe and North America (Source articles.sae.org)

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Muchas gracias por su atención

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