The Impact of Electric Vehicles on Italy's Motorway Infrastructure

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MOVYON
Tech the Future

About us

We are leaders in the development and integration of Intelligent Transport Systems Solutions and Autostrade per l'Italia's centre of excellence for research and innovation.

We are digital engineers for mobility: we design, integrate and implement innovative solutions to design the future, which for us is already intelligent, sustainable and powered by an invisible but ever-present technology.

Our solutions

General Framework

From climate emergency to the need to infrastructure the motorway network with recharging stations.

The goals of this work are:

- **Provide** an overview of the State-of-the-Art of Electric Vehicles (*EVs*) analysing their **historical market evolution**.
- **Forecast** the **expected number of EVs** in Italy by 2030
- Develop a methodology that **assesses** the **impacts** of EVs in terms of **demanded energy** and **power** on the **service areas** (***AdSs***) managed by **Autostrade per l'Italia** (*ASPI*).

Work's Outline

CLIMATE CHANGE

Carbon dioxide (CO_2) emissions from the transport sector account for about 23% of the global level of emissions. The most significant contribution comes from road transport, that accounts for just over 70%.

EVs MARKET

A detailed market analysis of the sales and development of EVs is made following a top-down approach that starts from the global market and arrives at the Italian one.

EVs FORECAST

A methodology for forecasting the number of EVs in Italy by 2030 has been developed.
This methodology allows also to understand which technological solution will prevail between Battery Electric Vehicles and Plug-In Hybrid Electric Vehicles.

ASPI TRAFFIC DATA

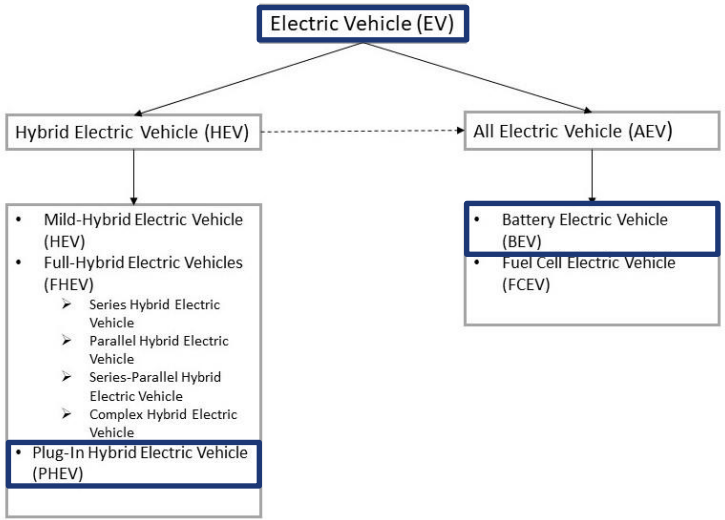
ASPI provided traffic data regarding the monthly passages of light vehicles in front of each service area of the network.

IMPACT EVALUATION

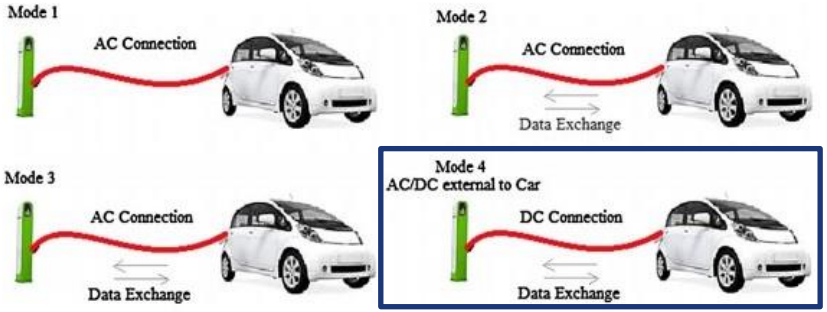
The impact of EVs is assessed for each of the 201 service areas of the ASPI. The daily, monthly and annual electricity consumption required to meet the recharging needs of EVs in service areas is estimated. The power of the charging station that will be needed to cope with the simultaneous recharging peaks is evaluated.

Electric Vehicles
State-of-the-Art

An **Electric Vehicle** is a vehicle that is powered, at least partially, by **electricity**. It is possible to distinguish between two macro-categories.



Charging process is divided into **4 mode/level** (based on IEC62196 standard). **Slow charging**: levels 1 and 2. **Fast or Ultra-Fast charging**: levels 3 and DC (level 4).



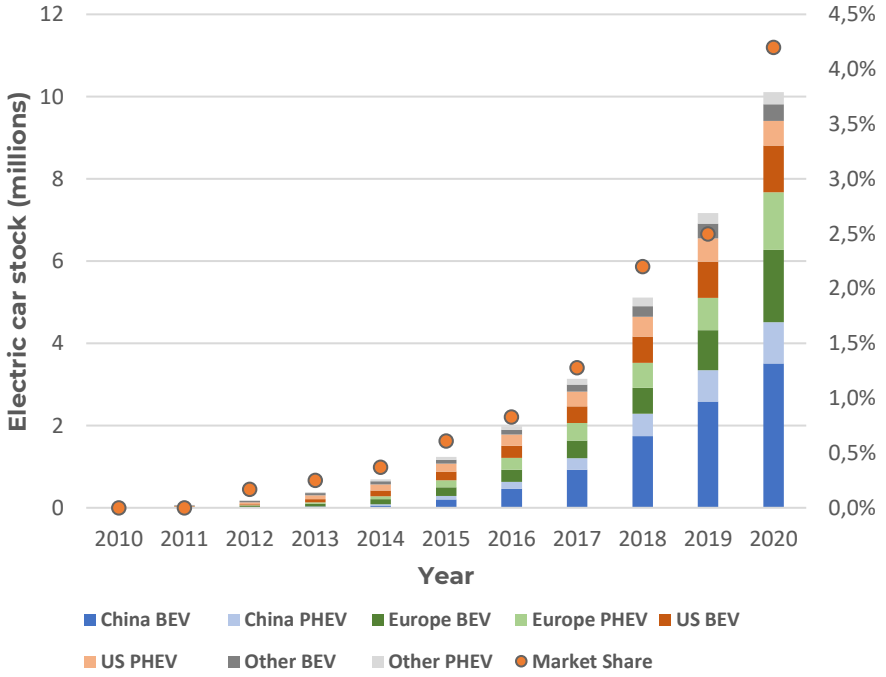
Standard	Source	Mode / Level	Voltage (V)	Phase	Current (A)
IEC62196	AC	1	120	Single	16
	AC	2	240	Single	32
	AC	3	250	Single	32-250
	DC	4	600	DC	400

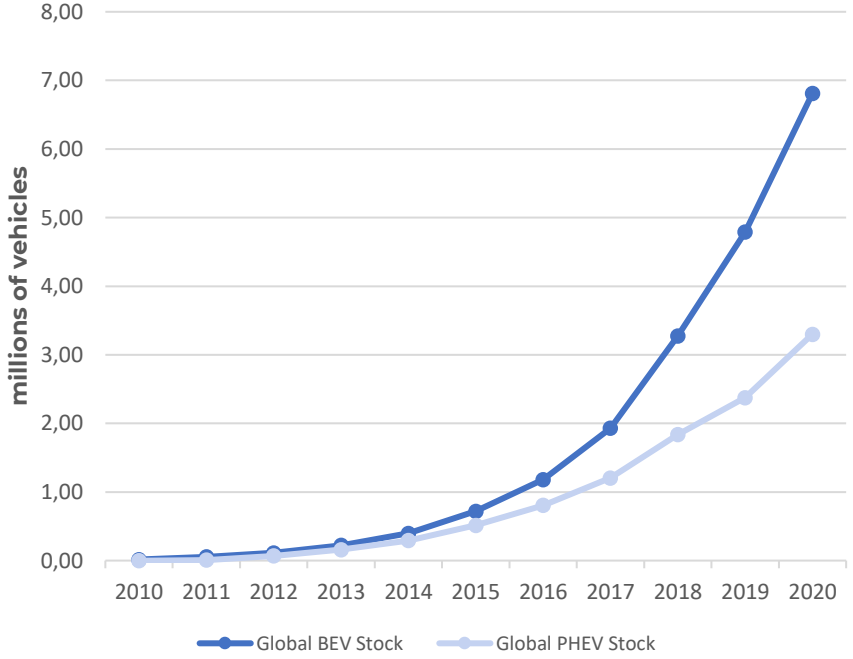
01.

Electric Vehicles Market Analysis and Expected Future Trends.

Electric Vehicles Market Analysis

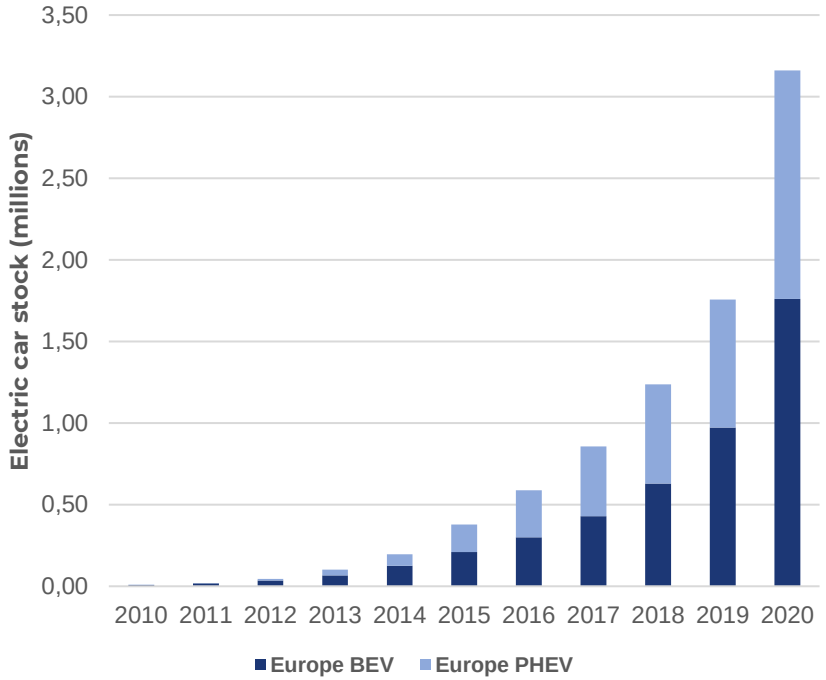
Global, European and Italian Focus

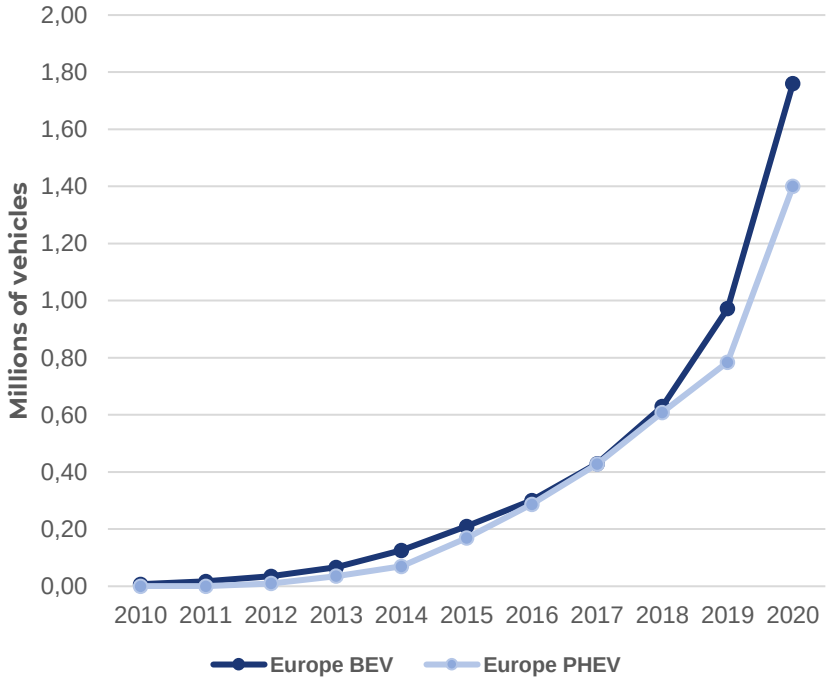




Electric Vehicles Market Analysis

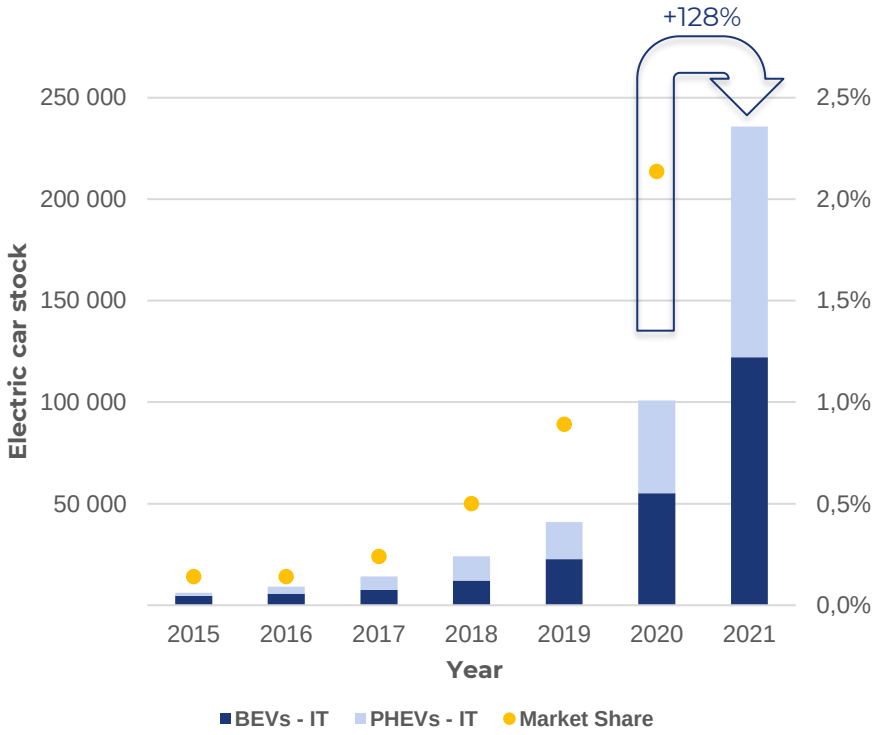
Global, **European** and Italian Focus

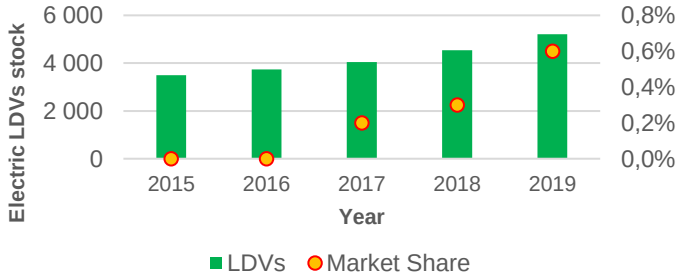


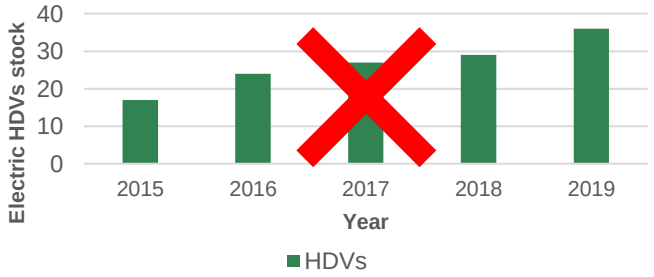


Electric Vehicles Market Analysis

Global, European and **Italian Focus**







Future Trends Scenarios

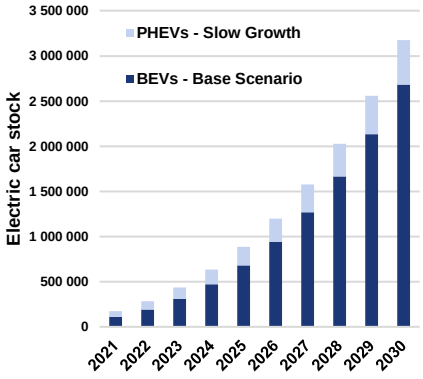
Expected number of BEVs and PHEVs in Italy by 2030

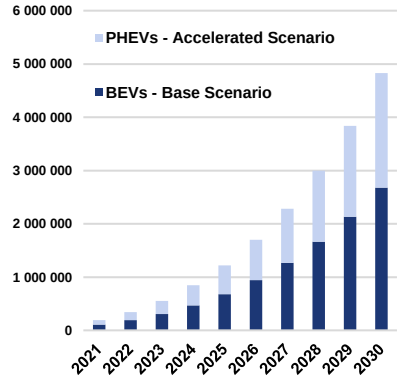
Two growth scenarios have been identified for both BEVs and PHEVs by interpolation, applying the **increasing and continuous function** that best approximates the historical data and that defines the growth trend for the coming years. A **polynomial function** of second or third degree was used.

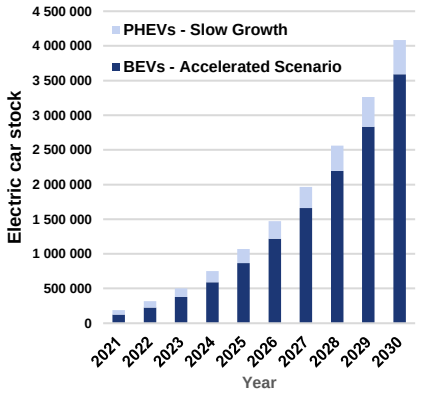
- **BEV:**
  1. **Base Scenario.**
  2. **Accelerated Scenario.**
- **PHEV:**
  1. **Slow Growth.**
  2. **Accelerated Scenario.**

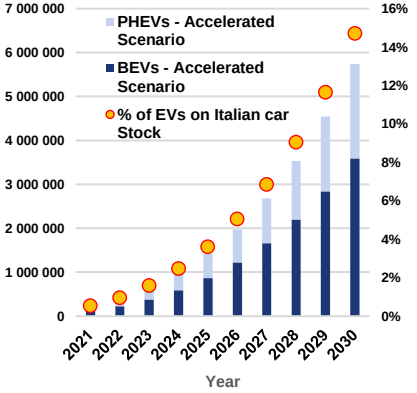
The last scenario, the most optimistic one, comes **closer to the targets** set by the Italian government in the PNIEC and then in the PNRR.

	Target EVs PNIEC 2030
BEVs	4 000 000
PHEVs	2 000 000
% EVs on entire stock	14%









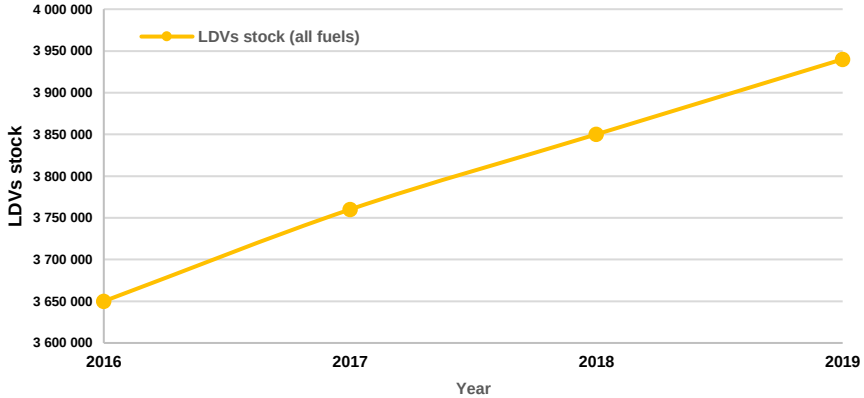
Future Trends Scenarios

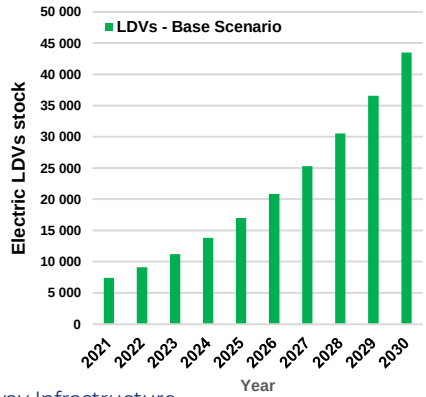
Expected number of LDVs in Italy by 2030

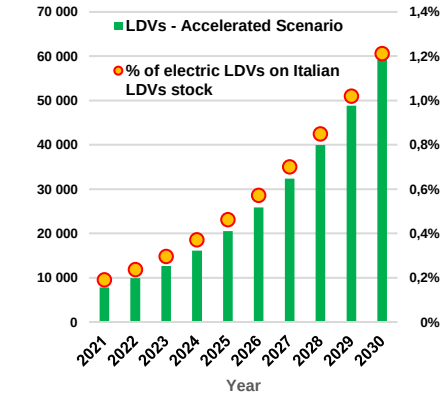
Similar calculations have been made based on the historical evolution of the fleet of electric light commercial vehicles in Italy. Two different growth scenarios were estimated.

- **LDV:**
  1. **Base Scenario.**
  2. **Accelerated Scenario.**

As a percentage of the total number of light commercial vehicles circulating in Italy, the stock of electric LDVs rises from **0.16% in 2020** to **1.21% in 2030** in the accelerated growth scenario.







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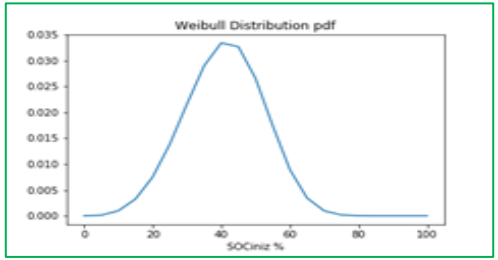
The Impact of Electric Vehicles on ASPI Motorway Network.

The Impact of EVs on ASPI Motorway Network

Forecasting energy Consumption in the Service Areas: **methodology**.

For each service area of the ASPI network, the developed algorithm is able to calculate the **expected energy consumption** on a **daily**, **monthly** and **annual basis**.

Daily light vehicle transit in front an AdS ***j*** (***TLG$_j$***). → Share of vehicles entering an AdS during a day (***F***). → Share of expected BEVs (***E***). → BEVs ***i*** stochastically redistributed and associated with a certain level of residual charge (***SOC***) and a certain battery capacity (***C$_{batt}$***).



From (kWh)	To (kWh)	Number of Vehicles in the Italian Electric Car Fleet in 2019	Probability
15	30	5176	26%
30	45	9434	48%
45	60	2395	12%
60	75	108	1%
75	90	264	1%
90	105	1974	10%

$$BEV_{in,j} = TLG_j \cdot F \cdot E$$

$$\Delta Eg, j = \sum_{1}^{n} \left(SOC_i^{fin} - SOC_i^{init} \right) \cdot C_{batt,i}$$

**Final SOC always equal to 80% of the battery capacity.*

The Impact of EVs on ASPI Motorway Network

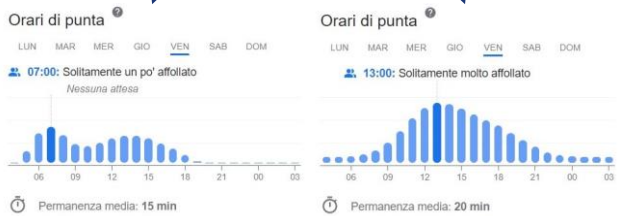
Forecasting the power to be Installed in the Service Areas: **methodology**.

In order to be able to recharge the battery to **80% of its capacity in just 20-30 minutes**, DC fast charging must guarantee each vehicle a charging power of at least 100 kW. The estimated number of EVs that may need to be **recharged at the same time** will serve as an indication of **how much power will need to be installed**.

Annual Average Daily Traffic in front an AdS ***j*** (***AADT***$_j$).

Hourly Peak Volume in front an AdS ***j*** (***HVP***$_j$). Function of the ***K-Factor***.

Factor	Urban AdS	Rural AdS
K	0.09	0.10



Share of vehicles entering an AdS (***F***) during the peak hour h.

Share of expected BEVs (***E***) during the peak hour h.

$$BEV_{in,j,h} = AADT_j \cdot K \cdot F \cdot E$$

Contemporary recharging (***RC***$_j$) in AdS. Function of the contemporary factor ***K***$_c$.

Power to be installed in AdS ***j*** (***P***$_{AdS,j}$). Function of the nominal power of a charging slot ***P***$_{nom}$.

$$P_{AdS,j} = BEV_{in,j,h} \cdot K_c \cdot P_{nom}$$

The Impact of EVs on ASPI Motorway Network

The choice of the **parameters**.

Parameters	From	To
Share of vehicles entering an AdS in respect to transits in front of it (***F***)	8%	12%
Time horizon*	2030	
Share of expected BEVs, including light passenger vehicles and light duty vehicles (full electric LDVs) in the Italian car fleet (*E*)*	10.1%	
State-Of-Charge distribution (***SOC***)	Weibull Distribution	
Battery capacity distribution (C_{batt})	Snapshot of the real Italian EVs fleet	
K-Factor to convert the total daily traffic into hourly peak traffic (***K***)	9% - 10%	
Contemporary Factor (K_c)	0.5	
Nominal power of a charging slot (P_{nom})	100 kW	

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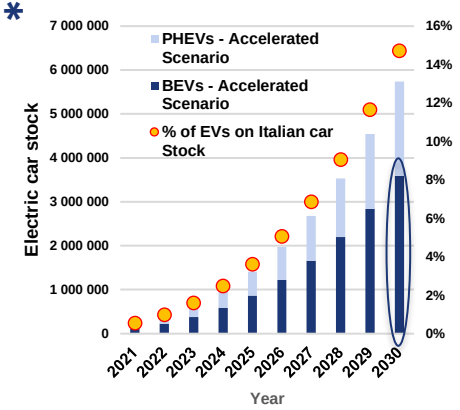
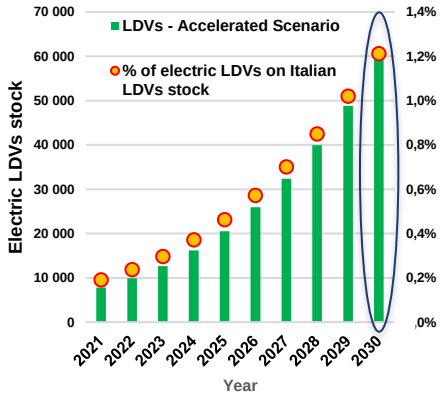
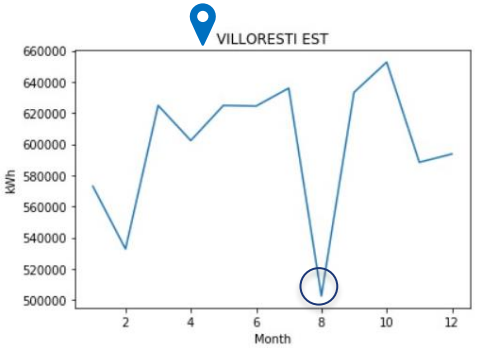
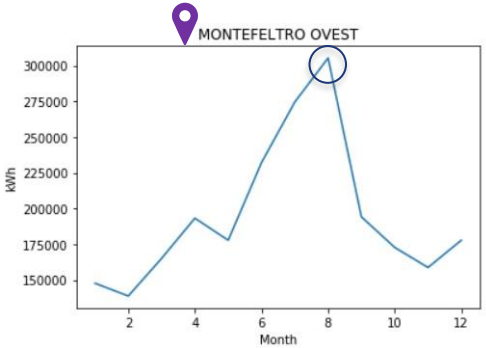




The Impact of EVs on ASPI Motorway Network

Forecasting energy Consumption in the Service Areas: **results**.



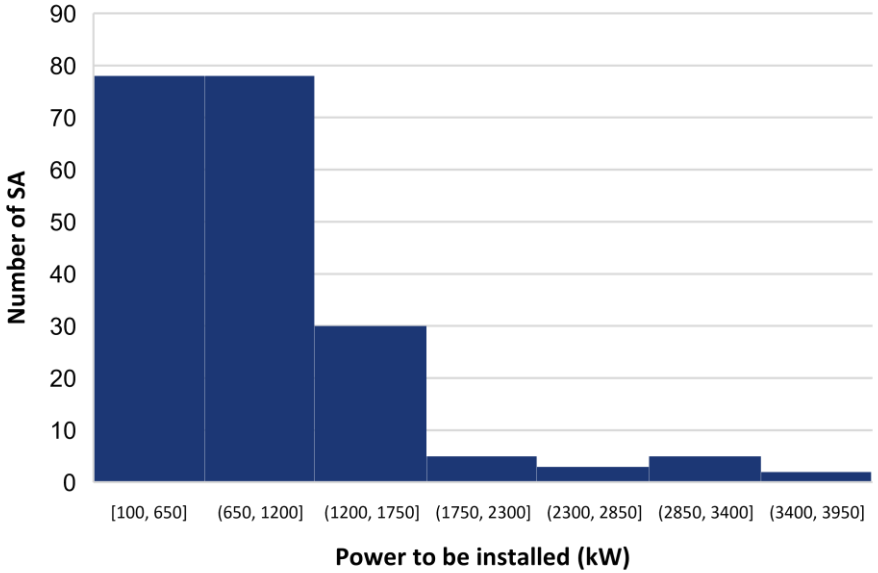


AdS	Year	Month	Daily BEVs Entries	Daily Electricity Consumption (kWh)	Monthly Electricity Consumption (kWh)
Adige Est	2019	1	110	1738	53864
Adige Est	2019	2	117	1849	51770
Adige Est	2019	3	128	1934	59950
Adige Est	2019	4	139	2131	63922
Adige Est	2019	5	129	1948	60386
Adige Est	2019	6	146	2217	66493
Adige Est	2019	7	157	2468	76504
Adige Est	2019	8	170	2693	83455
Adige Est	2019	9	151	2300	68996
Adige Est	2019	10	136	2073	64251
Adige Est	2019	11	123	1918	57538
Adige Est	2019	12	126	1934	59950

The Impact of EVs on ASPI Motorway Network

Forecasting the power to be Installed in the Service Areas: **results**.

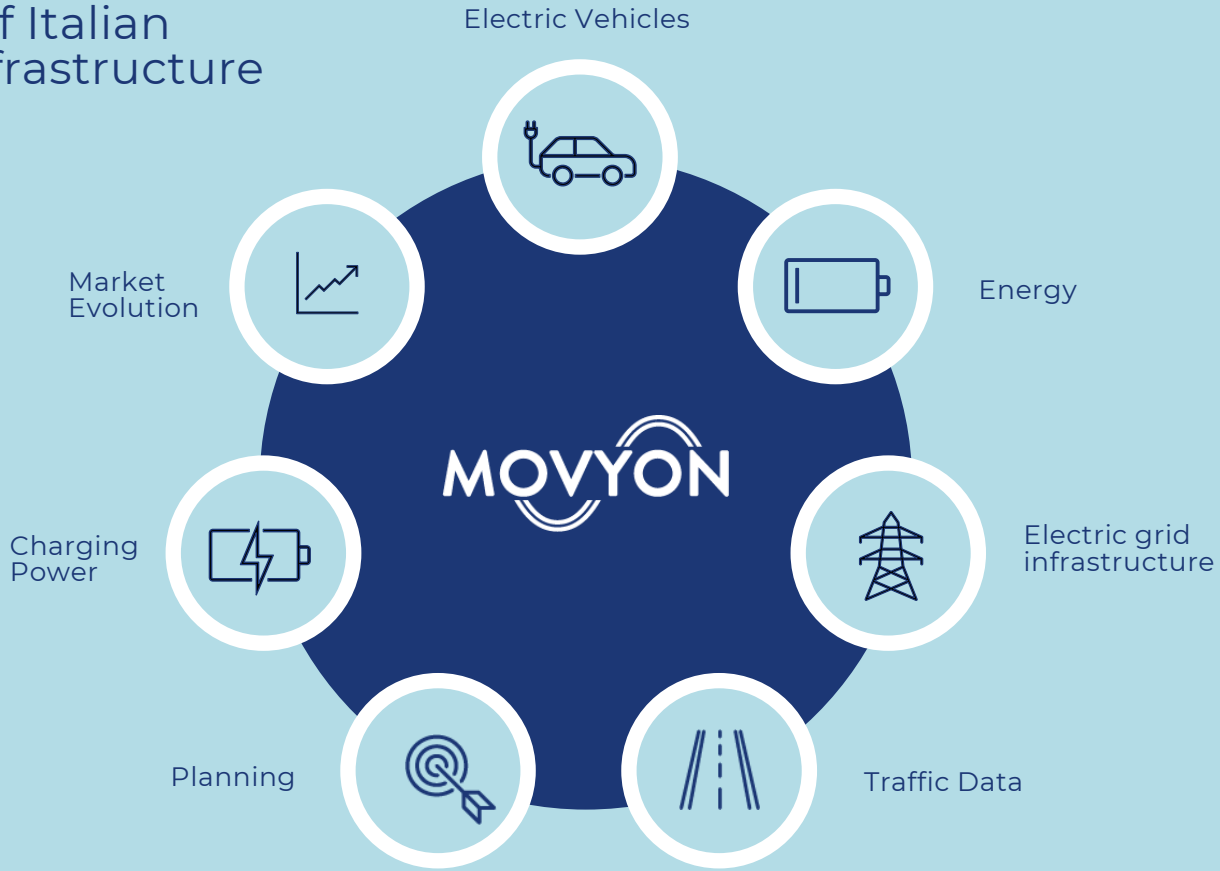
AdS	AADT	AdS Classification	Peak Hourlys BEVs Entries	Contemporary Recharges	Power Requirement (kW)
VILLORESI EST	75763	U	70	35	3500
MONTEFELTRO OVEST	25141	U	21	10	1000
TORRE ALEMANNA SUD	3776	R	3	1	100



Conclusion

Plan the development of Italian motorway's charging infrastructure

Starting from a collection of historical data related to the car market, even in the most cautious forecast, the number of **EVs in the Italian context can grow 30 times** from the current 100 000 to around 3 millions of units by 2030. In the busiest areas of the network, the needs of EVs both in terms of energy and in terms of the power that must be made available are onerous. **Charging stations capable of recharging 20 to 30 vehicles at the same time, with a capacity of 2-3 MW**, require significant investments, physical space and a particular attention to safety aspects. This is why this methodology can be extremely useful in planning the electrification of the motorway network over the next ten years.



Thank you.

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