Mobilità elettrica e sostenibilità

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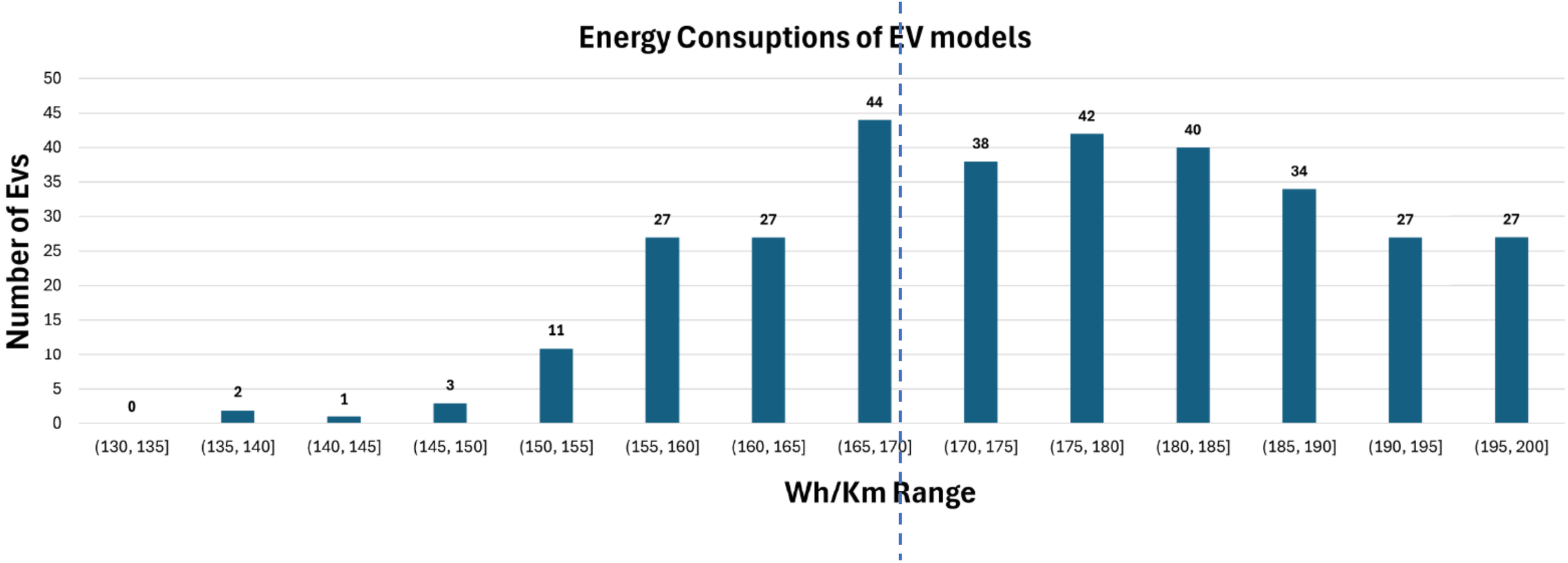
0. EV energetics

model	Wh/km	model	Wh/km	model	Wh/km	model	Wh/km
Lightyear One	104	Mercedes EQS 450+	168	Hyundai IONIQ 5 Standard Range 2WD	187	Ford Mustang Mach-E SR AWD	206
Tesla Model 3 Standard Range Plus	147	Fiat 500e Hatchback 42 kWh	170	Mercedes EQA 250	187	Porsche Taycan 4S Cross Turismo	207
Tesla Model 3 Standard Range Plus LFP	149	Fiat 500e 3+1	170	Volkswagen ID.4 Pro Performance	188	Porsche Taycan 4 Cross Turismo	207
Tesla Model 3 Long Range Dual Motor	152	Fiat 500e Cabrio	170	Audi Q4 e-tron 40	188	Nissan Ariya e-4ORCE 87kWh	207
Hyundai IONIQ Electric	153	MG MG5 Electric	170	Volkswagen ID.4 1st	188	Porsche Taycan Turbo	209
Sono Sion	156	Kia e-Soul 39 kWh	170	Nissan Ariya 63kWh	188	Ford Mustang Mach-E ER AWD	210
Mini Cooper SE	156	Lucid Air Dream Edition	171	Aiways U5	188	Audi e-tron GT RS	210
Hyundai Kona Electric 39 kWh	157	Tesla Model Y Long Range Dual Motor	171	Hyundai IONIQ 5 Long Range 2WD	189	Porsche Taycan Turbo S	215
Hyundai Kona Electric 39 kWh	157	Volkswagen ID.3 Pro S	171	Kia EV6 Long Range AWD	189	Ford Mustang Mach-E GT	215
Lucid Air Pure	157	CUPRA Born 170 kW - 82 kWh	171	Porsche Taycan 4S	189	Mercedes EQC 400 4MATIC	216
SEAT Mii Electric	158	Tesla Model S Plaid+	172	Tesla Model X Long Range	189	Volvo C40 Recharge	217
Dacia Spring Electric	158	Nissan Leaf e+	172	Polestar 2 Long Range Dual Motor	190	Porsche Taycan Turbo Cross Turismo	217
Lucid Air Touring	160	Kia e-Soul 64 kWh	173	Mercedes EQA 300 4MATIC	190	Audi e-tron Sportback 50 quattro	219
Renault Zoe ZE40 R110	161	Kia e-Niro 64 kWh	173	Mercedes EQA 350 4MATIC	190	Porsche Taycan Turbo S Cross Turismo	220
BMW i3 120 Ah	161	Kia e-Soul 64 kWh	173	Skoda Enyaq iV 80X	190	Byton M-Byte 72 kWh 2WD	222
Hyundai Kona Electric 64 kWh	162	Opel Ampera-e	173	Audi Q4 Sportback e-tron 50 quattro	190	Volvo XC40 P8 AWD Recharge	224
Hyundai Kona Electric 64 kWh	162	JAC iEV7s	173	Hyundai IONIQ 5 Standard Range AWD	190	Nissan Ariya e-4ORCE 87kWh Performance	226
Tesla Model S Long Range	162	Polestar 2 Standard Range Single Motor	174	Lexus UX 300e	192	Audi e-tron Sportback 55 quattro	231
Nissan Leaf	164	Skoda Enyaq iV 60	176	Porsche Taycan 4S Plus	192	Audi e-tron Sportback 55 quattro	231
Volkswagen ID.3 Pure Performance	164	Smart EQ fortwo cabrio	176	Seres 3	193	Audi e-tron 50 quattro	231
Peugeot e-208	164	Smart EQ forfour	176	MG ZS EV	193	Jaguar I-Pace EV400	232
CUPRA Born 110 kW - 55 kWh	164	Audi Q4 Sportback e-tron 35	176	Hyundai IONIQ 5 Long Range AWD	194	Jaguar I-Pace EV320	232
Opel Corsa-e	164	Skoda Enyaq iV 50	176	Renault Kangoo Maxi ZE 33	194	Audi e-tron 55 quattro	237
Renault Twingo Electric	164	Polestar 2 Long Range Single Motor	176	Nissan Ariya e-4ORCE 63kWh	194	Audi e-tron 55 quattro	237
Fiat 500e Hatchback 24 kWh	164	Mazda MX-30	176	MG Marvel R	194	Byton M-Byte 95 kWh 2WD	238
BMW i3s 120 Ah	165	Opel Mokka-e	176	Skoda Enyaq iV RS	195	Citroen e-SpaceTourer XS 50 kWh	243
Renault Zoe ZE50 R110	165	Mercedes EQS 580 4MATIC	177	Nissan Ariya 87kWh	196	Citroen e-SpaceTourer M 50 kWh	243
Tesla Model 3 Performance	165	Tesla Model Y Performance	177	Mercedes EQB 350 4MATIC	196	Opel Zafira-e Life S 50 kWh	243
MG MG5 EV	165	BMW i4 *	178	Kia EV6 GT	196	Opel Zafira-e Life M 50 kWh	243
Volkswagen ID.3 Pro Performance	166	Porsche Taycan	180	Hyundai IONIQ 5 Project 45	196	Peugeot e-Traveller Compact 50 kWh	243
Volkswagen ID.3 Pro	166	Citroen e-C4	180	Ford Mustang Mach-E SR RWD	197	Peugeot e-Traveller Standard 50 kWh	243
CUPRA Born 150 kW - 62 kWh	166	DS 3 Crossback E-Tense	180	Audi Q4 e-tron 50 quattro	197	Peugeot e-Traveller Long 50 kWh	243
Lucid Air Grand Touring	167	Peugeot e-2008 SUV	180	Tesla Model X Plaid	198	Byton M-Byte 95 kWh 4WD	244
Kia e-Niro 39 kWh	167	Kia EV6 Standard Range 2WD	181	Nissan e-NV200 Evalia	200	Citroen e-SpaceTourer XL 50 kWh	250
Smart EQ fortwo coupe	167	Porsche Taycan Plus	182	BMW iX xDrive 40	200	Opel Zafira-e Life L 50 kWh	250
Honda e	168	Volkswagen ID.4 Pure Performance	182	Volkswagen ID.4 GTX	200	Citroen e-SpaceTourer M 75 kWh	252
Honda e Advance	168	Audi Q4 e-tron 35	182	Ford Mustang Mach-E ER RWD	200	Citroen e-SpaceTourer XL 75 kWh	252
Renault Zoe ZE50 R135	168	Volkswagen ID.4 Pure	182	Audi e-tron GT quattro	202	Opel Zafira-e Life M 75 kWh	252
CUPRA Born 170 kW - 62 kWh	168	Skoda Enyaq iV 80	183	BMW iX3	206	Opel Zafira-e Life L 75 kWh	252
Tesla Model S Plaid	168	Kia EV6 Long Range 2WD	184	BMW iX xDrive 50	206	Peugeot e-Traveller Standard 75 kWh	252

ENERGY CONSUMPTION. REAL-WORLD VALUES 2021

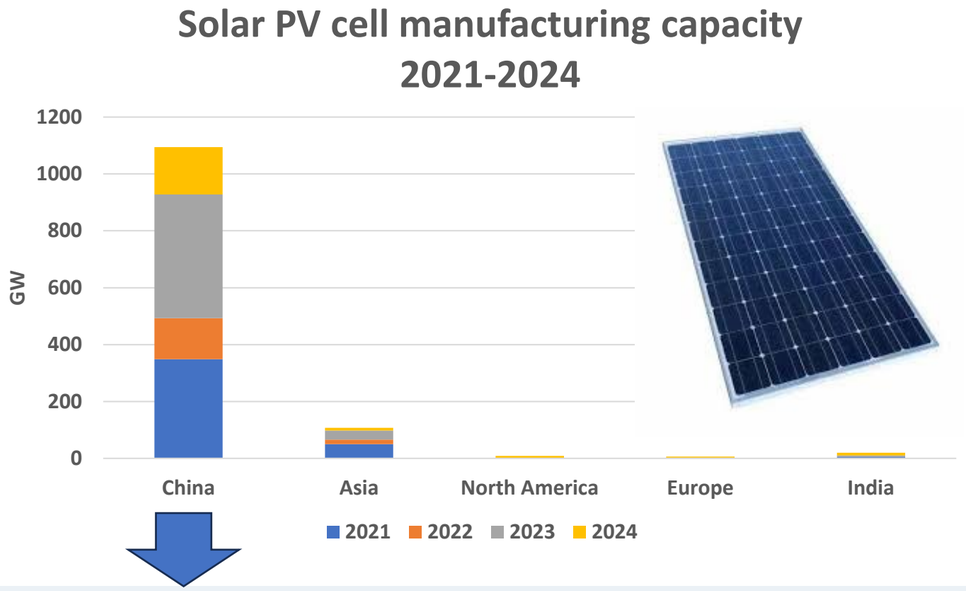
Electric Vehicle database https://ev-database.org/

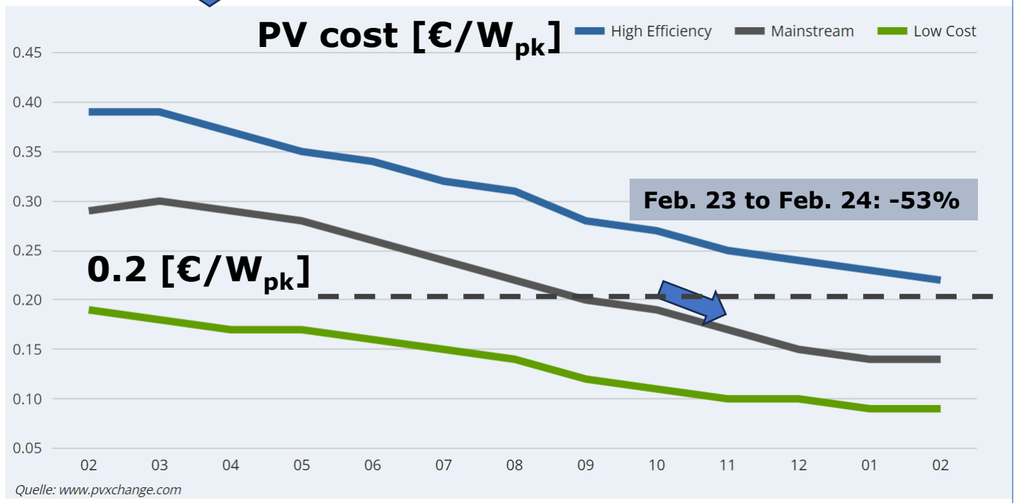
0. EV energetics



Average: 170 [Wh/km]

0. Electric cars and renewables





Two panels: 2x 500Wpk =1kWpk. **Size 2x 2mx1m≈4m²**

Panels cost

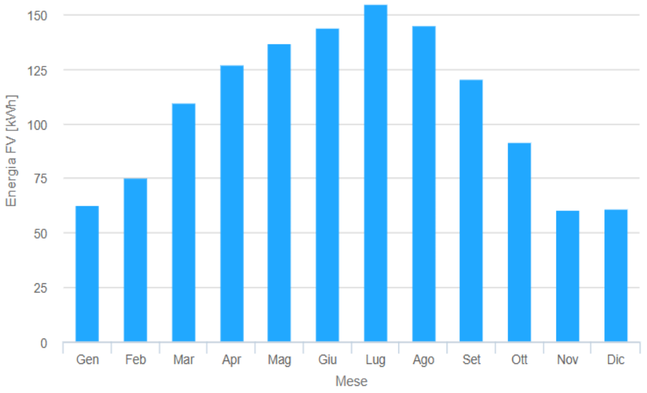
$$1000[W_{pk}] \cdot 0.2\left[\frac{€}{W_{pk}}\right] = 200\left[\frac{€}{kW_{pk}}\right]$$

Installation

$$200\left[\frac{€}{kW_{pk}}\right]$$

total

$$400\left[\frac{€}{kW_{pk}}\right]$$



Location: Forlì

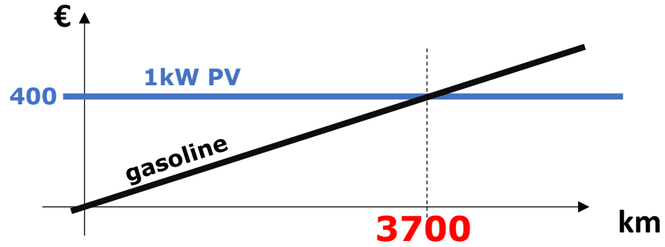
$$3.52\left[\frac{kWh}{day}\right] \rightarrow \frac{3.52\left[\frac{kWh}{day}\right]}{0.170\left[\frac{kWh}{km}\right]} = 20.7\left[\frac{km}{day}\right]$$

$$1287\left[\frac{kWh}{year}\right] \rightarrow \frac{1287\left[\frac{kWh}{year}\right]}{0.170\left[\frac{kWh}{km}\right]} = 7555\left[\frac{km}{year}\right]$$

Average energy consumption of electric car

Gasoline vs. PV

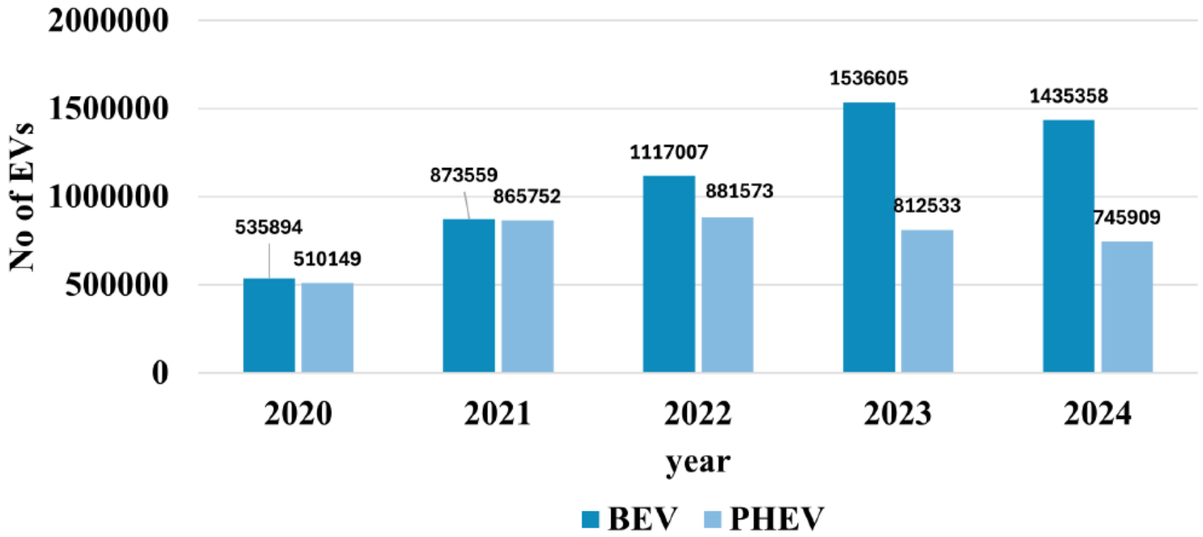
$$\frac{1.8\left[\frac{€}{l}\right]}{16.6\left[\frac{km}{l}\right]} = 0,108\left[\frac{€}{km}\right]$$



2. EV MARKET

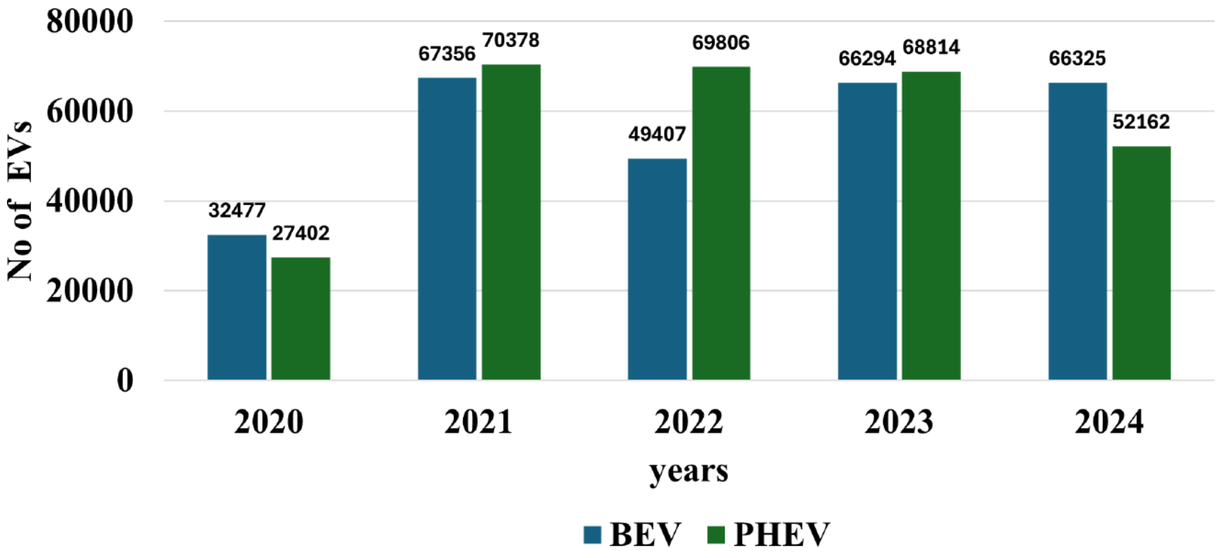
European Union

BEV market share: approx 13%

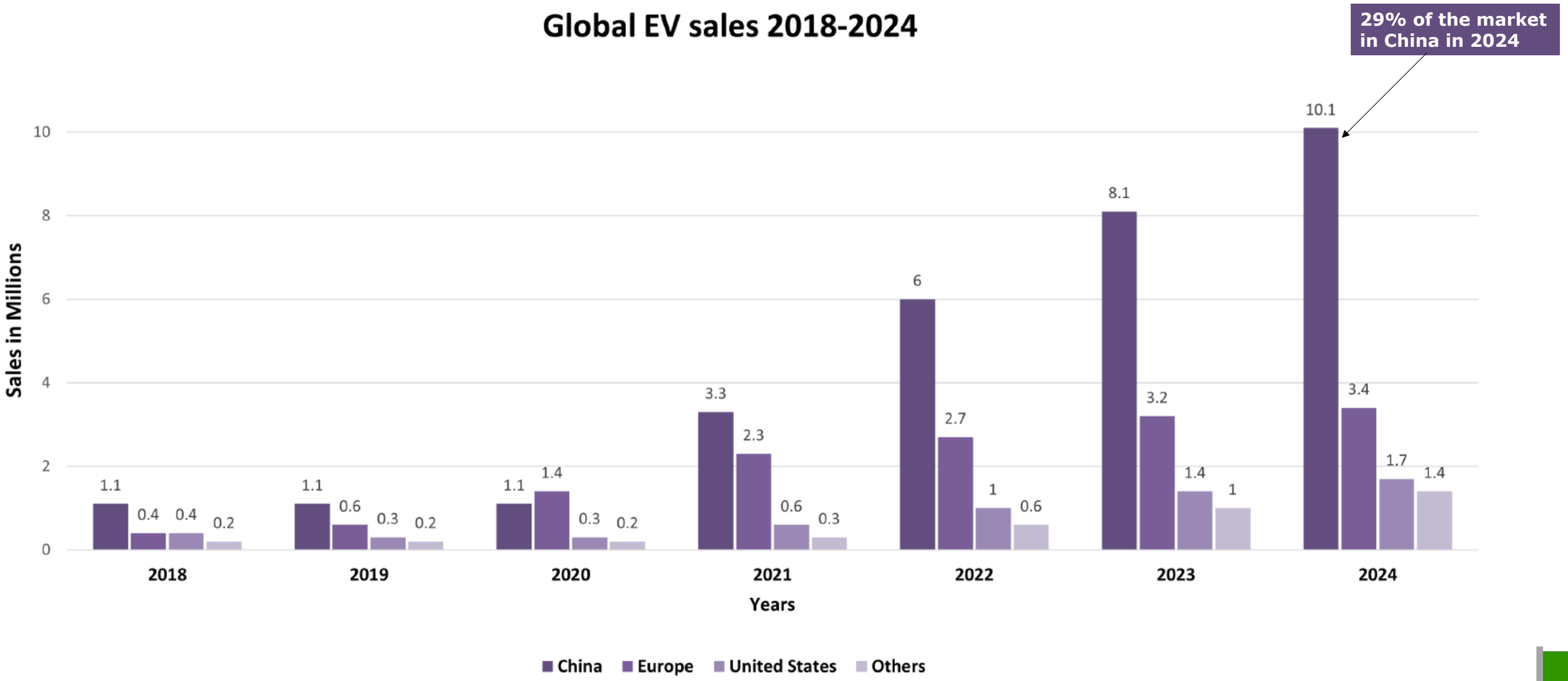


ITALY

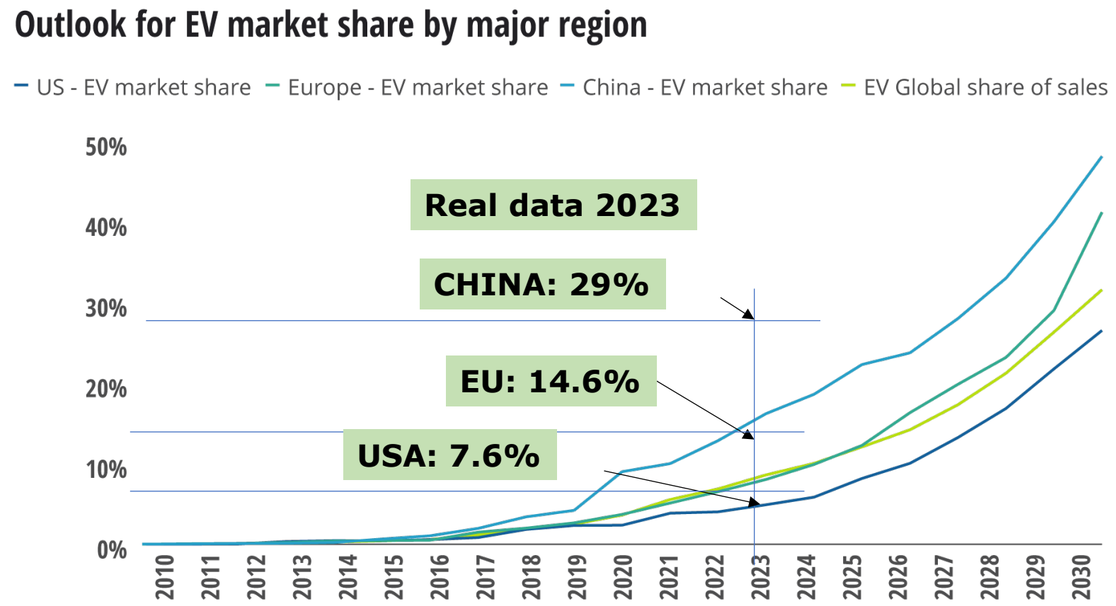
BEV market share: approx 4.4%



2. MARKET

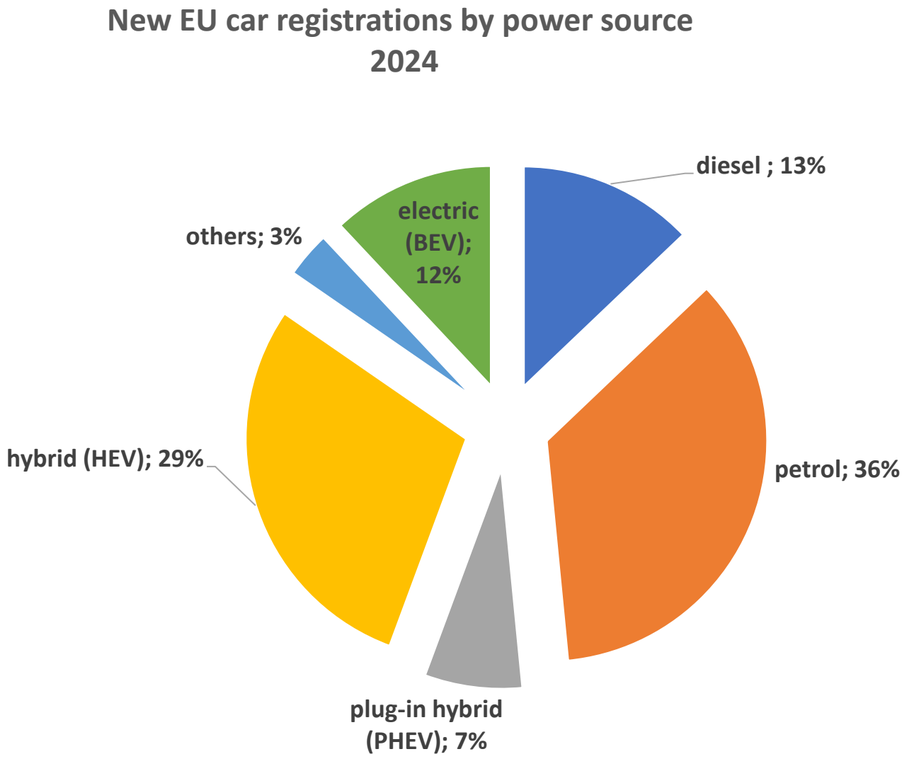

Global EV sales 2018-2024
29% of the market in China in 2024
Sales in Millions
0
2
4
6
8
10
1.1
0.4
0.4
0.2
1.1
0.6
0.3
0.2
1.1
1.4
0.3
0.2
3.3
2.3
0.6
0.3
6
2.7
1
0.6
8.1
3.2
1.4
1
10.1
3.4
1.7
1.4
2018
2019
2020
2021
2022
2023
2024
Years
China
Europe
United States
Others

2. EV MARKET

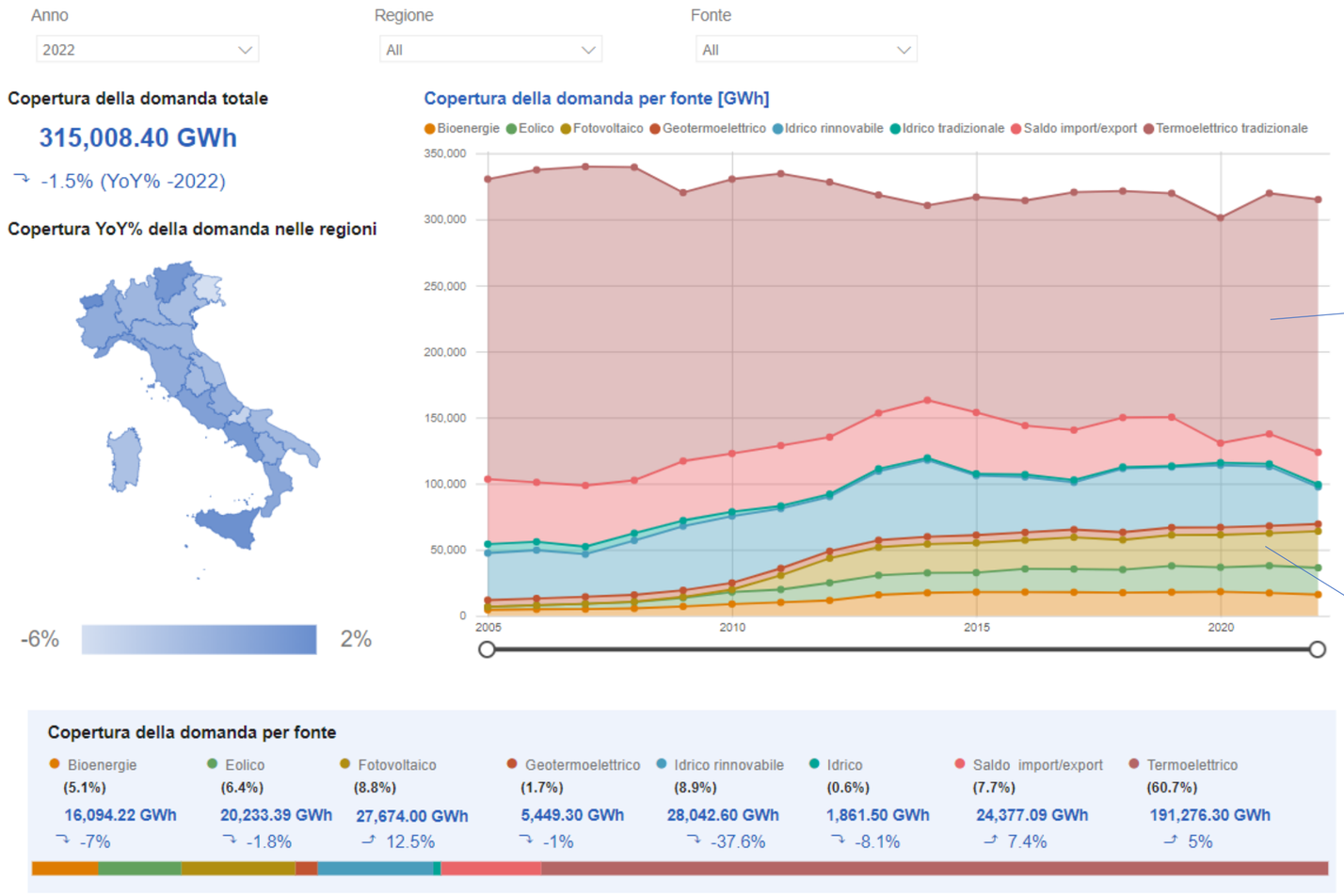


Source: Deloitte analysis. Year 2020

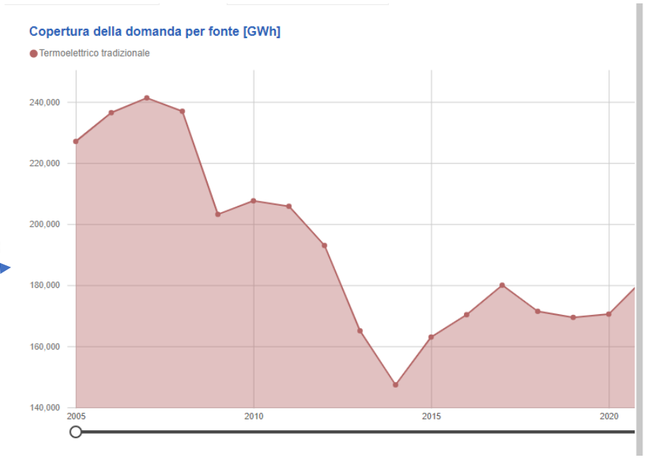
2. EV MARKET


New EU car registrations by power source
2024
diesel ; 13%
petrol; 36%
plug-in hybrid (PHEV); 7%
hybrid (HEV); 29%
others; 3%
electric (BEV); 12%

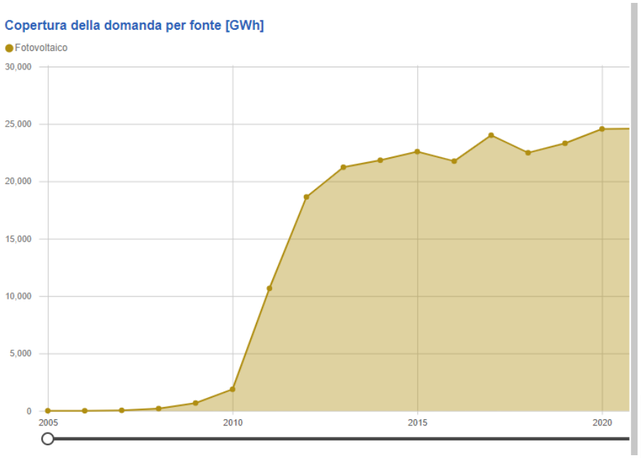
4. Electric energy production



Thermal (NG, coal)



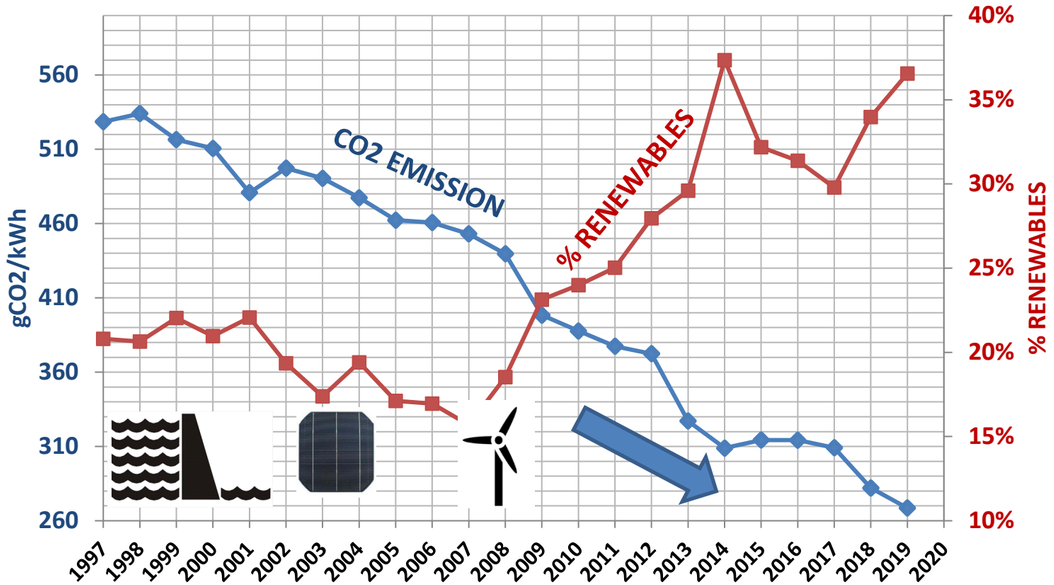
Photovoltaic

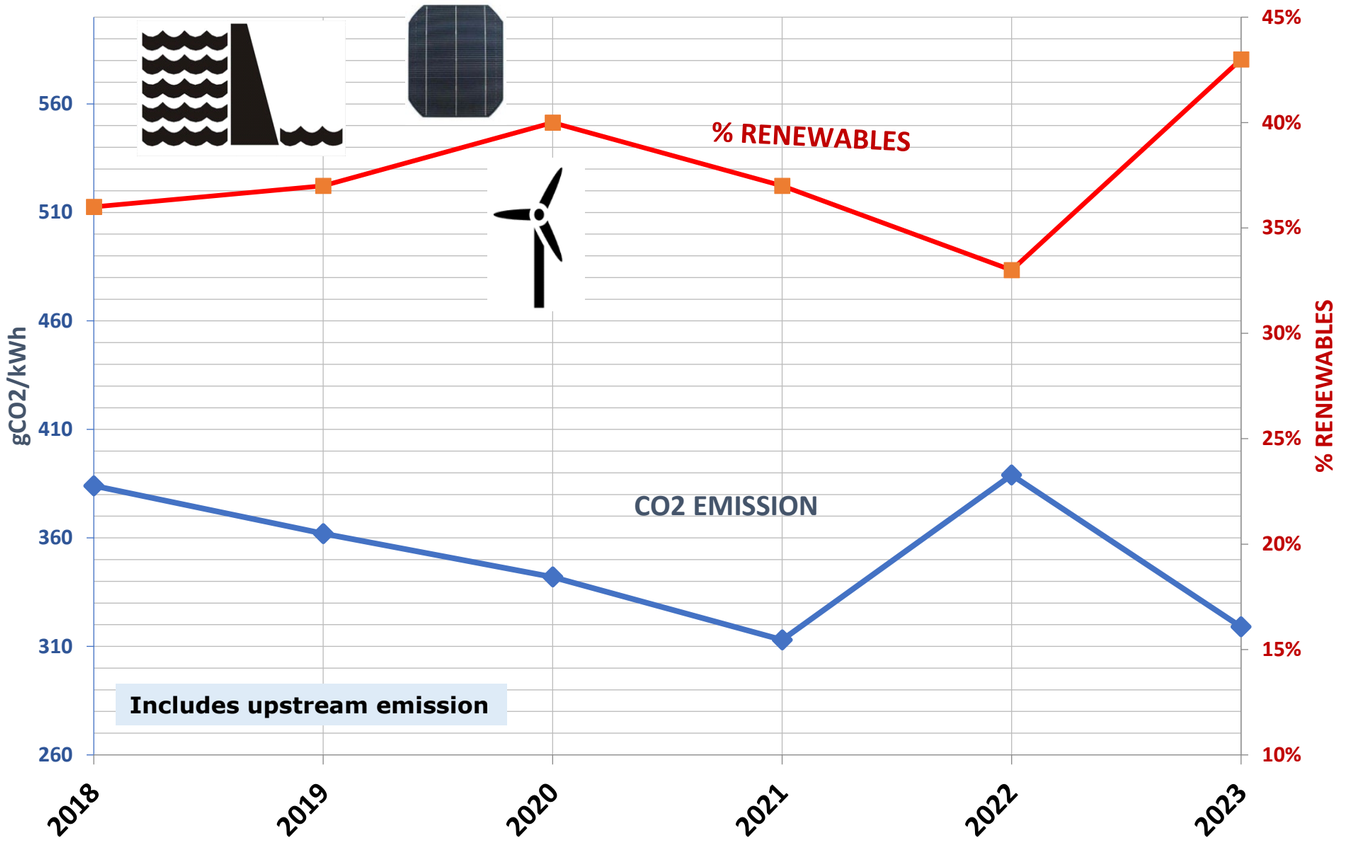


TERNA. Pubblicazioni statistiche https://www.terna.it/it/sistema-elettrico/statistiche/evoluzione-mercato-elettrico/domanda-copertura-fonte

4. Electric energy production

Share of renewable electric energy (TERNA) and global emission factor of consumed energy in ITALY (ISPRA).



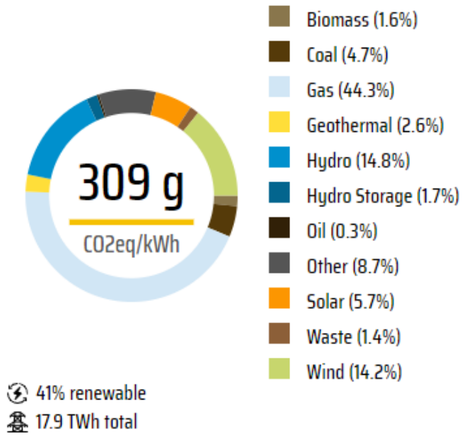


ISPRA. Fattori di emissione per la produzione e il consumo di energia elettrica in Italia

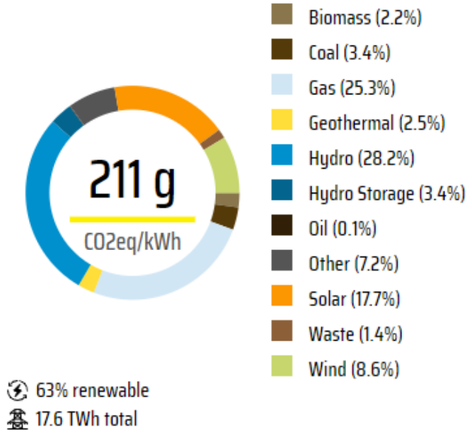
[Electricity carbon intensity in European Member States: Impacts on GHG emissions of electric vehicles]

4. Electric energy production

January 2024

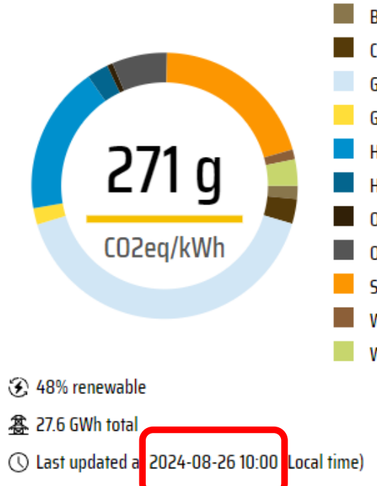


June 2024



NOWTRICITY

CURRENT EMISSIONS IN ITALY



WIND AND SOLAR FORECAST

CURRENT	903 MW	5597 MW
IN 1 HOUR	1341 MW	12743 MW
IN 3 HOURS	1591 MW	12499 MW
IN 6 HOURS	1833 MW	8101 MW
IN 9 HOURS	1294 MW	769 MW

Higher energy production than current, lower emissions
Lower energy production than current, higher emissions

SHOULD I PLUG IN?

YES

Electricity emissions in Italy are below last years average

40.7 g	190 g	407 g	8 g
CO2EQ/KM	FULL LOAD	PER HOUR	PER HOUR

How are these values calculated?

https://www.nowtricity.com/country/italy/

4. Electric energy production

CO2/kWh

August 26th, 2024

10:00 CET

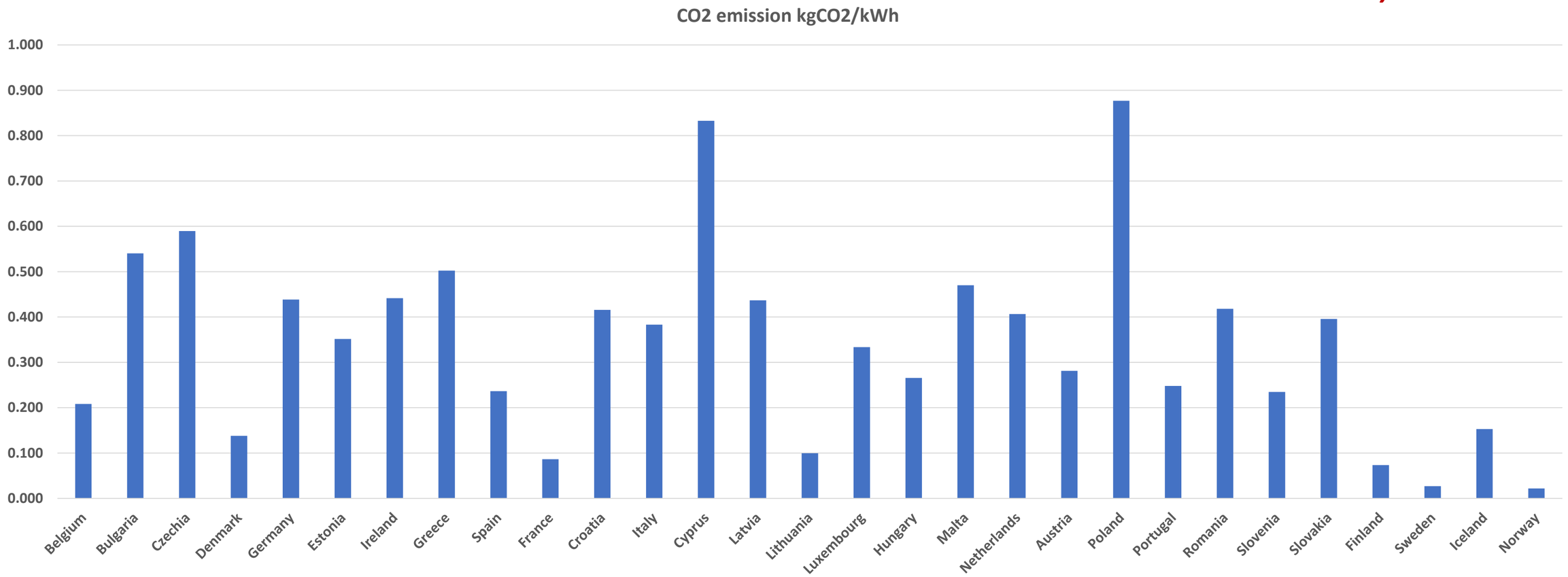
NOWTRICITY

Austria	33 g	Belgium	86 g	Bulgaria	---
98% renewable	CO2eq/kWh	27% renewable	CO2eq/kWh		CO2eq/kWh
Croatia	217 g	Czech Republic	345 g	Denmark	84 g
68% renewable	CO2eq/kWh	24% renewable	CO2eq/kWh	92% renewable	CO2eq/kWh
Estonia	228 g	Finland	48 g	France	19 g
76% renewable	CO2eq/kWh	65% renewable	CO2eq/kWh	27% renewable	CO2eq/kWh
Germany	205 g	Greece	---	Hungary	114 g
79% renewable	CO2eq/kWh		CO2eq/kWh	61% renewable	CO2eq/kWh
Italy	271 g	Latvia	287 g	Lithuania	112 g
48% renewable	CO2eq/kWh	45% renewable	CO2eq/kWh	86% renewable	CO2eq/kWh
Netherlands	189 g	Norway	16 g	Poland	590 g
55% renewable	CO2eq/kWh	99% renewable	CO2eq/kWh	35% renewable	CO2eq/kWh
Portugal	115 g	Romania	---	Serbia	---
85% renewable	CO2eq/kWh		CO2eq/kWh		CO2eq/kWh
Slovakia	67 g	Slovenia	261 g	Spain	71 g
16% renewable	CO2eq/kWh	40% renewable	CO2eq/kWh	69% renewable	CO2eq/kWh
Sweden	15 g	Switzerland	8 g	United Kingdom	---
69% renewable	CO2eq/kWh	52% renewable	CO2eq/kWh		CO2eq/kWh

https://www.nowtricity.com/country/italy/

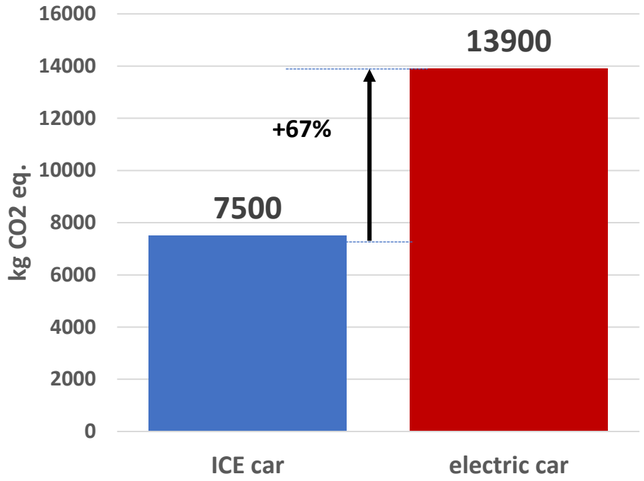
4. Electric energy production

EU Electric energy generation 2021 - GHC emission
(generation only, no upstream, no downstream)



5. Life Cycle Assessment of cars

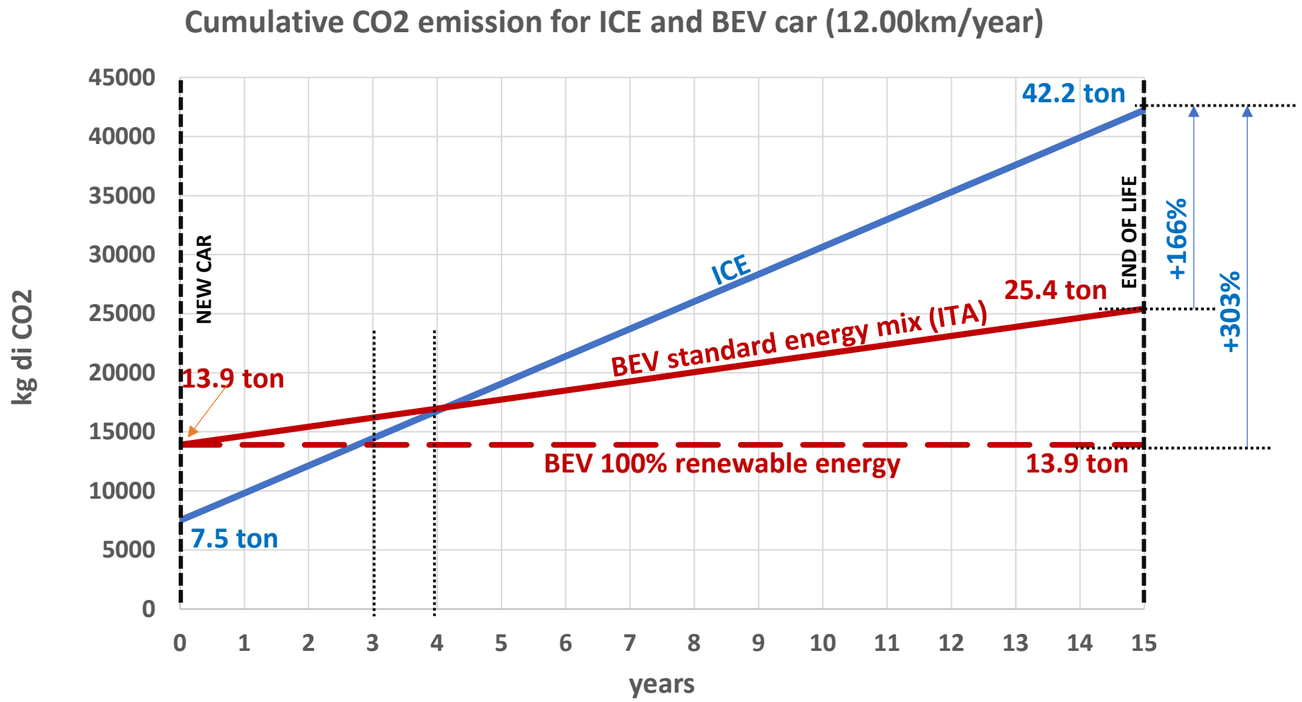
CAR MANUFACTURING



CAR USE WTW Well To Wheel CO2 emission – ITALY

Real world thermal car : $193 \left[\frac{gCO2}{km}\right]$

Electric car IT energy mix): $170 \left[\frac{Wh}{km}\right] 0.357 \left[\frac{gCO2}{Wh}\right] = 60.6 \left[\frac{gCO2}{km}\right]$



Ricardo Energy & Environment Determining the environmental impacts of conventional and alternatively fuelled vehicles through LCA

Prof. Claudio Rossi

LEMAD - Lab. of power electronic and electric drives for sustainable mobility

DEI - Dept. of Electrical Electronic and Information Engineering

University of Bologna

ITALY

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In Europe, within this decade, where it is technologically and economically viable, everything that can be electrified will be electrified, thus making battery technology one of the most important key enablers for the green energy transition facilitating existing and new technologies.

European Commission - Strategic Research Agenda for batteries 2020