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European Transition to Electric Vehicles: Italy as a Case of Study

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Abstract: The European ban on internal combustion engines has raised several questions from both the automotive players and society. The proliferation of electric vehicles is struggling as it is facing issues related to energy supply and distribution and to infrastructure availability. These problems are considerably different across the various countries. It is consequently a tough challenge to provide a worldwide comprehensive evaluation. In this paper we first outline the common problems to later move to provide a clear picture of the Italian scenario, starting from the available data related to mobility for the period 2018–2022. We outline the main problems to be tackled and the related costs. Italy is an interesting and representative case as it is bound to the timeline set by the European green transition.

Keywords: electric vehicles; energy production; electric grid; sustainable mobility

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1. Introduction

Climate change represents the greatest global challenge faced, impacting the environment and economy [1,2]. The global climate change treaty has driven the enforcement of new environmental regulations from both international organizations and national governments, increasing the accountability of corporations [3,4] and citizens [5,6]. The European Union (EU) has promoted a political strategy targeting a carbon-neutral society by 2050 [7] with several lines of action based on three pillars: (i) information, (ii) incentives, and (iii) prohibitions [8]. Information and incentive policies are aimed at creating an active participation of the population and stakeholders in the paradigm shift to a more sustainable society [9]. Nevertheless, strong legislation is required to force the recalcitrant industrial sectors toward a new environmental consciousness [10].

The automotive industry is one of the crucial sectors that requires a strong nudge to decarbonize [11]. Accordingly, the EU approved legislation that enforced a complete ban on internal combustion engine vehicles (ICE) from 2035 [12]. This deadline has raised several issues related to its feasibility based on energy production, infrastructure, and vehicle production volumes [13], leaving alone the issue of the impact on the environment if a comprehensive life cycle assessment is taken into account. Several European countries fruitfully embraced this challenge with great economic efforts in the renewal and reconceptualization of street mobility [14]. Accordingly, the European vehicle fleet has drastically changed, moving to electric-powered vehicles both with standing-alone batteries (BEVs) and hybrid propulsion (HEV) [15]. The mobility paradigm change must be complemented with the use of green energy sources, avoiding the problem shift across the production chain. The dismission of ICEs will require a huge improvement of both the electric grid transport capability and the electric energy production under the regulation of the Green Deal in order to fulfill the energy demand of a fully BEV fleet [16–18]. In this complex scenario, each European country must tackle similar issues affected by geographical, historical, and economic differences related to existing infrastructures, geopolitical roles, and available investment funds [19,20].

In this work, we focused on the Italian scenario, providing a critical discussion on the current situation of the eighth-biggest world economy [21] in the transition from ICE to BEV. Italy's scenario is intriguing due to both its economic relevance with great imbalances between the north and south regions and geographical issues representing a multifaced case of study. Accordingly, we discuss the actual Italian electric energy production and distribution and the state of the automotive fleet, highlighting the critical issues that must be solved to face the ICE ban starting in 2035.

2. The Electric Energy Ecosystem in Italy: Production and Distribution

As a beginning, we considered critical factors for the conversion of the Italian fleet to full BEV two parameters: (i) the electric energy consumption and production and (ii) the electrical distribution grid. These parameters are crucial in order to evaluate the possibility of improving the actual BEV fleet with an efficient recharge point network across the nation [22].

2.1. The Actual Production of Electric Energy

Italian electric energy production has changed across the years, driven by both national and international stimuli [23]. Since the pandemic era, 'EU Next Generation' and 'EU Green Deal' programs have committed Italian policies to sustainability advancements aiming to reduce the dependence on fossil fuels [24]. As shown in Figure 1a, during the last five years, the Italian energy demand reached a maximum of up to 321 TWh in 2018, with a reduction to 301 TWh during the first year of the COVID pandemic event. After the pandemic period, the energy demand went back to pre-pandemic levels, reaching 320 TWh in 2022. The main issue in the Italian scenario is that the amount of domestic energetic production available for consumption in the period 2018–2022 covered only around 87 ± 1% of the demand. These data identify Italy as an energy importer, suggesting that Italian energetic plans and administration cannot be decided and implemented without international negotiations with EU and non-EU partners [25]. This dependence upon energy imports represents a serious threat to the Italian system, but it is also a strong push towards the implementation of an alternative production supply based on renewable local resources, as reported in Figure 1a (blue dotted line). Electric energy production through renewable energy sources has covered up to 38% of the total demand in 2020, decreasing to 32% in 2022. As reported in Figure 1b, renewable energy sources are well differentiated, with a major role played by hydropower technology, representing around 40% of them in 2021. In 2022, renewable energy production was reduced with a decrement of around 20 TWh of hydropower related to climate factors and gas prices rising [26]. The market quota represented by the other sources did not sensibly change across the last five years, showing only minor fluctuations with the exception of photovoltaic, which has a slowing increase of around 5% a year.

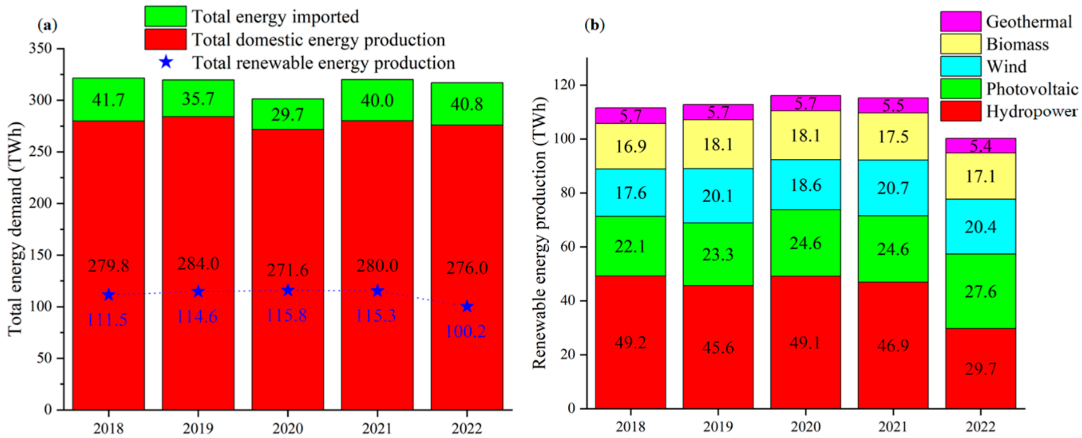

Figure 1. Summary of Italian (**a**) electric energy demand considering the renewable energy quota and (**b**) its composition based on different technologies. Data provided by TERNA driving energy [27].

At present, Italy is far from reaching an energy production fully based on renewable sources, and this will be further slowed down by the cost of a renewable energy-based system transition, estimated in a range from 580 up to EUR 870 M for the European zone [28]. Nevertheless, the Deloitte Economics Institute estimated economic losses caused by climate change in Italy up to EUR 115 M until 2070 in the present scenario [29], supporting the efforts for climate change mitigation actions.

2.2. The Electric Grid and Distribution

The Italian electric grid is a complex and interconnected system that encompasses transmission, distribution, and generation components maintained by several distribution system operators, while the high-voltage transmission grid is managed only by the Italian official transmission system operator TERNA [30,31]. During the last few years, the Italian administration has oriented political efforts toward the integration of renewable electric energy into the traditional grid under the national [32] and international [33] plan of actions. Particularly, the Integrated National Plan for Energy and Climate aimed to achieve a 55% reduction in greenhouse gas emissions and a 30% increase in renewable energy capacity by 2030 [34]. This scenario requires a deep commitment to the modernization of the electric grid, including power plants, transmission lines, and distribution networks [35]. The electric grid and transmission system modernization is of capital importance for solving the actual grid congestion caused by the different consumption of the northern regions compared with that of the southern ones [36]. This requires the implementation of smart grids for the real-time monitoring and control of the transmission and distribution network [37]. Furthermore, the energy storage capacity should increase to match the intermittency issues of renewable energy utilization [38]. As discussed by Buono et al. [39,40], the optimization of north–south energy exchanges and the planned increment in renewable electricity production will require the establishment of new +/− 500 kV HVDC lines across Italy in the framework of the Hypergrid project with a cost of about EUR 11 G to be fully implemented [41].

3. The Italian Vehicle Fleet: Present and Expected Futures

3.1. The Current Scenario of the Italian Vehicle Fleet

As shown in Figure 2, the Italian car fleet has constantly increased during the last five years, reaching 3.93 × 10^7 vehicles in 2022, and it is strongly related to the increment in average income [42]. The increase in car numbers has been discouraged with the incentive of public and alternative private mobility but with very limited appreciable results [43–

46]. Burlando et al. [47] suggested that the increase in car numbers can be due to the poor awareness of the real cost of car ownership related to maintenance and taxes. At the same time, the average age of the cars increased from 10.9 years in 2018 up to 12.2 years in 2022, suggesting a progressive increment of car fleet obsolescence, increasing its carbon footprint [48] and pointing towards an increased reluctance of car owners to buy more modern, less impacting cars.

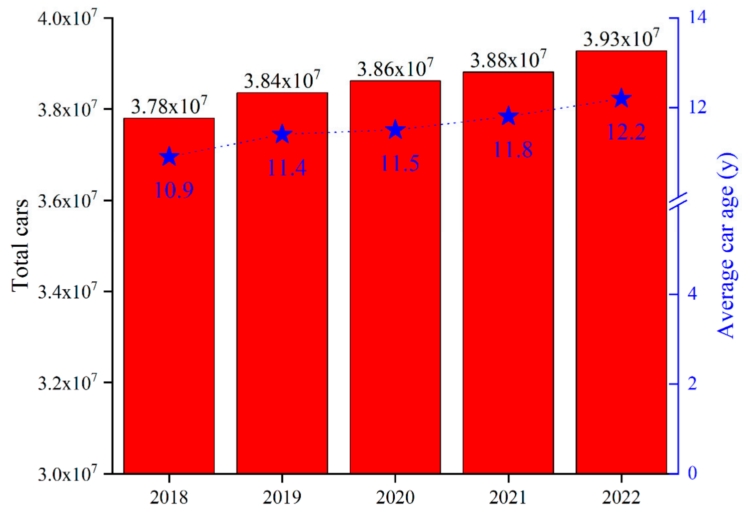

Figure 2. Summary of Italian number of cars and cars average age in the period 2018–2022 as reported by UNRAE [49] (total car in reported as red bar, average car age reported as star dotted line).

As reported in Table 1, ICE represents up to 95.2% of the total private vehicles in 2022, while HEV and BEV represent only 4.0 and 0.8%, respectively. Interestingly, the UNRAE decennial report [50] evaluated in 26.6 years the Italian fleet turnover. This value was considerably higher than the one required to match the turnover hypothesized by the EU for a fully converted to BEV for 2050, considering the ban of ICE from 2035.

Table 1. Italian vehicle distribution in Italy in 2022, as reported by the UNRAE annual report [49].

Vehicles Typology	Vehicles Number
ICE	3.74×10^7
HEV	1.55×10^6
BEV	3.32×10^5

The other key issue of the transition to a full BEV fleet is represented by the electric energy demand and distribution across Italy, as reported in Table 2.

Table 2. Estimation of total energy demand for a full BEV fleet in 2050.

EV Model	Energetic Consumption (kWh/km) [a]	Average Distance Run in 1 Year (km) [b]	Total Yearly Energy Need (TWh)
Mercedes eVito Tourer Extra-Long	0.30	10,712	128.1 [c]/164.9 [d]
Tesla Model 3	0.14		57.2 [c]/77.0 [d]
Average	0.20		81.3 [c]/110.0 [d]

[a] Energetic consumption was reported in agreement with data provided by the Electric Vehicle Database [51]. [b] Average value referred to 2022 [50]. [c] Calculated on the 2022 vehicle fleet. [d] Calculated

the average fleet increment from 2022 to 2050 with an annual increment estimated as the average increment for the 2018–2022 period.

A reliable estimation of the energy consumption of a BEV is a matter of great complexity involving several parameters [52]. Nevertheless, it is possible to make a rough estimate based on the nominal energy consumption and the average distance run in a year, considering the most (Tesla Model 3) and least (Mercedes eVito Tourer Extra-Long) efficient models among the 377 BEVs currently available on the market. Accordingly, the increment of energy requests to satisfy the BEV fleet energy demand ranges from 57.2 up to 128.1 TWh, considering the total conversion of the actual ICE fleet. If we consider an average increase in vehicles based on the last five-year trend (0.96%), the energy demand will increase up to 77.0–164.9 TWh. It is relevant to note that in the same period, Italian energy production has oscillated in the range from −4% (2019–2020 due to the COVID outbreak) up to 3% (2020–2021). Considering the commitment to the European Green Deal, Italian production should be increased in renewable-based energy by up to 18.1–52.1% to cover the BEV consumption in 2050 with a constant yearly based increment of up to 0.7–1.9% lower than average European energy production annual growth of the last five years if it will be dedicated only to BEV recharging [53].

The other key issue for the diffusion of BEV is represented by the widespread availability of sites in which a single vehicle can be recharged, which are called recharge points. As reported in Figure 3, the recharge points have grown during the last five years, reaching 32,776 points in 2022, with 6.1 recharging points every 100 km. Similarly, the recharge infrastructures—sites that included more than one recharge point—have grown slowly but consistently, reaching 16,700 recharging infrastructures in 2022.

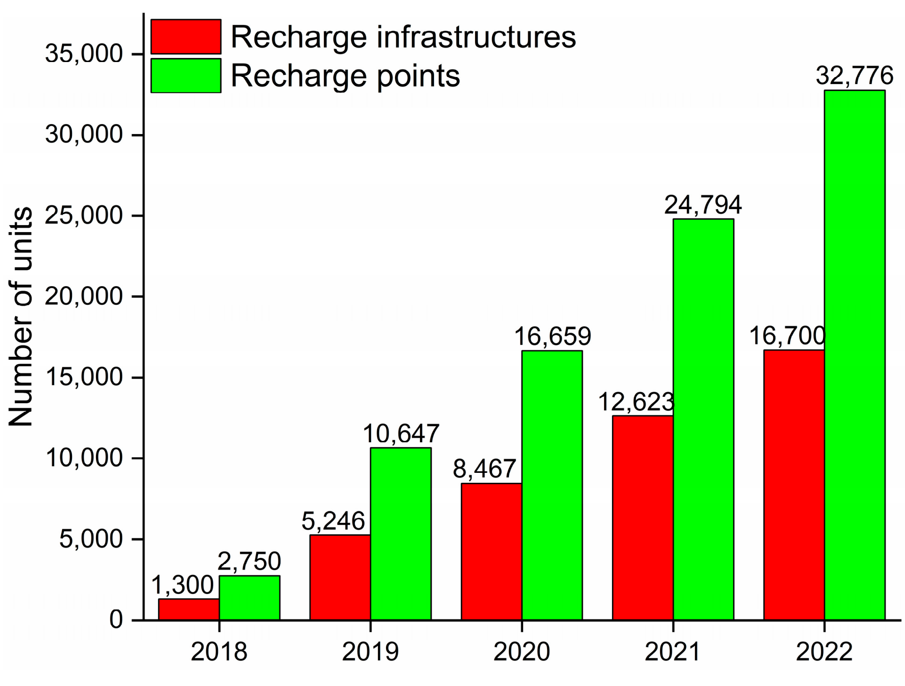

Figure 3. Overview of recharge infrastructure and recharge point in Italy in the period of 2018–2022 [54].

The main issue in the recharge infrastructure is represented by the taxonomy of recharge points. In 2022, 87.8% of recharge points were AC low-power ones (<43 kW), while only 4.9 and 7.3% were represented by fast (44–99 kW) and ultrafast (>100 kW) rechargers, respectively [54], significantly affecting the average recharge time. As reported by Falvo et al. [55], a Tesla Model X requires up to 8 h to be fully recharged in an AC low power while it can be recharged in 30–60 min using a fast recharger point. Based on the driver habits, the authors estimated that the recharge infrastructure should be increased by one order of magnitude and drastically oriented to fast charge in order to meet the ambitious goal of ICE stop by 2035.

3.2. The Conundrum of Transition to a Fully BEV Fleet

As clearly evident, electric energy demand and distribution are the first and main issues in the conversion of the ICE to BEV fleet in Italy. The energy increment production could be achieved with a straight and continuous plan of action compulsorily based on renewable resources in order to contribute to the decarbonization [56] together with the necessity to increment the primary energy savings for the renewable sector, avoiding the loss of up to 48% marked in 2019 [53,57]. This is a hard task considering the actual state of the art and industrial readiness of technology that are far from the economic competitiveness reached out by traditional coal and oil-based platforms [58]. Furthermore, ICE can be fueled with E-fuels or waste- and bioderived drop-in fuels, reducing the carbon footprint without requiring the effort related to BEV management [59,60], even if it could also be hard to implement due to the actual technological limitation related to the technology readiness [61]. The key issue is about the Italian electric distribution system, which is far from being ready to satisfy a fast and ultrafast charge point capillary net. This is an infrastructural deficiency that only the central government with EU support can face due to the magnitude of investment required. Additionally, the Italian landscape is particularly challenging due to the mountain chains that run from north to south, which have poor existing energetic infrastructure across them. This is also a key point for the Hypergrid project, which will run through two parallel lines in east and west Italy with poor interconnections between them. The other limitation is represented by the interconnection with surrounding countries through the Alps barrier by 2035. Furthermore, the additional energy absorption from the grid will be induced by the increment of demand due to non-negligible losses [62], higher than the conventional 10.2% established by Autorità di Regolazione per Energia Reti e Ambiente (ARERA) [63]. This will dramatically decrease the effectiveness of the electric grid with a reduction in recharging service quality both in time and in efficiency.

Moreover, the actual actions excluded heavy transportation from the internal combustion engine ban, but this is an issue that will eventually become unavoidable and hardly manageable. There are no such solid estimations on fully electric heavy truck performances, but the experience of California with the decarbonization of heavy freights suggested a consumption of up to around 1.86 kWh/km [64,65]. Italian heavy freight drivers run approximately 119 Mkm/y [66], and with a fleet of up to 117,500 vehicles over 3.5 t in 2022 [50], it would require an additional 25.7 TWh at least. Considering the energetic issue, the increment of energy production cannot be the only mitigation action run. The reconceptualization and optimization of the BEV structure itself is a mandatory activity in order to reduce the average consumption, while the actual major design efforts are focused on the battery pack optimization [67]. This is mainly due to the scarcity and inhomogeneous distribution of lithium, which is the key component of the lithium-ion battery, the only current battery energy storage system with the appropriate energetic density [68].

As summarized in Table 3, there are also social and industrial factors that are slowing down the diffusion of BEV in the Italian marketplace. The Italian automotive industry has struggled to convert production to BEV [69], even if the Stellantis Group opened a research center dedicated to battery development [70]. Lastly, the social influence of the transition to BEV can increase the socio-economical gap due to the considerably higher costs of BEV compared to ICE [71].

Table 3. Comparative overview of ICE and BEV considering the major issues and strong points.

		
Energetic supply	Oil-derived fuels Drop-in fuels Bioderived fuels E-fuels	Electric energy
Recharge infrastructure	Diffuse on the overall state territory. Consolidate supply chain Very fast recharge	Non-homogeneous diffusion Limited amount of fast and ultrafast charging points Difficult integration in the electric distribution system
Productive infrastructure	Well-known productive technologies Well established Resilient supply chain	Require major investments Require a strong effort in project and implementation Fragile supply chain
Cost for the user	Balanced by several major players Fluctuation in fuel cost due to crude oil price	High cost. Fluctuation in electric energy cost due to energetic market volatility

Nevertheless, the reduction in carbon footprints related to the automotive and transportation sectors must be tackled to mitigate the anthropic effect on the climate. BEVs are actually the more solid alternative to ICE, while other solutions, such as fuel cell-based vehicles, are still far from being widely available [72].

4. Policy Implication and European Perspectives

The transition to a full BEV fleet represents a double-faced coin for the Italian system. On one side, the nudge of the EU should be received by the national government, and operative actions must be implemented to face the ICE stop from 2035. On the other side, the efforts to reach the ICE ban without compromising the Italian economic systems require structural intervention with elevated costs for both public administration and citizenship that are struggling to be accepted.

Nevertheless, the direct action of the Italian government is mandatory to achieve the full conversion of the Italian fleet, mainly with actions and regulations about private and public financial incentives.

Tax credits are the most common financial incentives used by governments to promote BEV purchases, and they are effective in high-income countries such as the United States, in which the federal government offers tax credits of up to USD 7.500 [73].

Actually, a lot of countries enforced incentive programs to accelerate the transition, such as Germany or France, in which central governments have already guaranteed an economic bonus of up to 9000 and EUR 6000 for the purchase of a BEV, respectively [74]. From 2024, the Italian government guaranteed an incentive of up to EUR 13,750 for the conversion of ICE (Euro 0–2), limiting it to those who could prove a yearly income of up to EUR 30,000 [75]. This action has been intended to spread the BEV among the lower-income part of the population but should also be supported by an active policy of low interest or subsidy, as happened in India [74], that is still missed. It has to be noted that the situation of the Italian debt might put restrictions on the amount and scale of incentives that will be detrimental to a recalcitrant selling market situation [76].

The other course of action is related to the dialogue between the government and producers. While the incentives are a matter pertaining to the national government, the direct discussion with private corporations has clearly emerged as a European responsibility more than solely an Italian one. The ICE sales ban deeply affected the overall European economy and, in particular, the Italian one, in which the automotive sector is one of the economic pillars involving up to 53,000 private companies and an annual revenue of up to EUR 150 G [77]. The Italian scenario is highly representative of the overall European picture, with an unfruitful dialogue between the government and the major player of the sector with production sites on Italian territory, the Stellantis Group, that led to a massive loss of workplaces in 2024. This experience strongly suggested the need for a coherent and well-planned proposal that should involve all EU partners.

5. Conclusions

The transition of Italy's car fleet to BEVs will play a pivotal role in reaching the European Union's decarbonization targets under the Green Deal. However, the conversion to a fully BEV fleet has raised significant economic, infrastructural, and social challenges involving policymakers, industries, and citizens. The first and more relevant issue is represented by the modification of Italian energy production and distribution systems. Italy has made significant progress in increasing renewable energy production, but it is still reliant on imported energy, with domestic production consistently falling short of national demand. The dependency upon energy imports limited the freedom of policymakers to implement actions, forcing international negotiation. Nevertheless, the Italian government is actively working towards improving the grid, reducing its inefficiencies and the imbalances between the north and south of the country while stimulating both domestic and industrial sectors. At the same time, the industrial contribution to recharge infrastructure has started to create a capillary net, even if it is far from being up to mark. The transition to BEV presents both economic opportunities and risks with the complex challenge of industrial restructuring that is still lagging. Only through coordinated government policies, private and public investment in renewable energy and infrastructure, and tight collaboration with the industrial sector can Italy hope to reach a transition to a cleaner, greener transportation system.

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References

1. Tol, R.S. The economic impact of climate change in the 20th and 21st centuries. *Clim. Chang.* **2013**, *117*, 795–808.
2. Berrang-Ford, L.; Ford, J.D.; Paterson, J. Are we adapting to climate change? *Glob. Environ. Chang.* **2011**, *21*, 25–33.
3. Reid, E.M.; Toffel, M.W. Responding to public and private politics: Corporate disclosure of climate change strategies. *Strateg. Manag. J.* **2009**, *30*, 1157–1178.
4. Rajavuori, M.; Savaresi, A.; van Asselt, H. Mandatory due diligence laws and climate change litigation: Bridging the corporate climate accountability gap? *Regul. Gov.* **2023**, *17*, 944–953.
5. Dernbach, J.C. Harnessing individual behavior to address climate change: Options for congress. *Va. Envtl. LJ* **2008**, *26*, 107.
6. Weinstein, J. Climate Change Disinformation, Citizen Competence, and the First Amendment. *U. Colo. L. Rev.* **2018**, *89*, 341.
7. Perissi, I.; Jones, A. Investigating European Union decarbonization strategies: Evaluating the pathway to carbon neutrality by 2050. *Sustainability* **2022**, *14*, 4728.
8. Cifuentes-Faura, J. European Union policies and their role in combating climate change over the years. *Air Qual. Atmos. Health* **2022**, *15*, 1333–1340.

9. Arora, N.K.; Mishra, I. COP26: More challenges than achievements. *Environ. Sustain.* **2021**, *4*, 585–588.
10. Chen, L.; Msigwa, G.; Yang, M.; Osman, A.I.; Fawzy, S.; Rooney, D.W.; Yap, P.-S. Strategies to achieve a carbon neutral society: A review. *Environ. Chem. Lett.* **2022**, *20*, 2277–2310. https://doi.org/10.1007/s10311-022-01435-8.
11. Codagnone, C.; Veltri, G.A.; Bogliacino, F.; Lupiánez-Villanueva, F.; Gaskell, G.; Ivchenko, A.; Ortoleva, P.; Mureddu, F. Labels as nudges? An experimental study of car eco-labels. *Econ. Politica* **2016**, *33*, 403–432.
12. Yawger, R. Accelerating the transition to vehicle electrification. *IEEE Power Electron. Mag.* **2022**, *9*, 12–14.
13. Danieli, P.; Masi, M.; Lazzaretto, A.; Carraro, G.; Dal Cin, E.; Volpato, G. Is Banning Fossil-Fueled Internal Combustion Engines the First Step in a Realistic Transition to a 100% RES Share? *Energies* **2023**, *16*, 5690.
14. Niestadt, M. Electric Road Vehicles in the European Union: Trends, Impacts and Policies. EPRS: European Parliamentary Research Service, Belgium. 2019. Available online: https://coilink.org/20.500.12592/bw54s5 (accessed on 17 October 2024).
15. European Alternative Fuels Observatory. Vehicles and Fleet. Available online: https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/european-union-eu27/vehicles-and-fleet (accessed on 17 October 2024).
16. Fetting, C. The European green deal. *ESDN Rep.* **2020**, *53*.
17. Pacesila, M.; Burcea, S.G.; Colesca, S.E. Analysis of renewable energies in European Union. *Renew. Sustain. Energy Rev.* **2016**, *56*, 156–170.
18. Gryparis, E.; Papadopoulos, P.; Leligou, H.C.; Psomopoulos, C.S. Electricity demand and carbon emission in power generation under high penetration of electric vehicles. A European Union perspective. *Energy Rep.* **2020**, *6*, 475–486.
19. Leonard, M.; Pisani-Ferry, J.; Shapiro, J.; Tagliapietra, S.; Wolff, G.B. *The Geopolitics of the European Green Deal*; Bruegel policy contribution; Bruegel: Brussels, Belgium, 2021; Volume 4.
20. Escribano, G.; Lázaro, L. Balancing geopolitics with Green Deal recovery: In search of a comprehensive Euro-Mediterranean energy script. *Real Inst. Elcano (R. Inst.)* **2020**, *15*, 15.
21. Fund, I.M. Report for Selected Countries and Subjects. Available online: https://www.imf.org (accessed on 17 October 2024).
22. Li, M.; Lenzen, M. How many electric vehicles can the current Australian electricity grid support? *Int. J. Electr. Power Energy* Syst. **2020**, *117*, 105586.
23. Borge-Diez, D. Energy Policy, Energy Research, and Energy Politics: An Analytical Review of the Current Situation. *Energies* **2022**, *15*, 8792.
24. Messina, G. The role of the committee of the regions (CoR) to implement the Green Deal at the local level: An overview of Italy. *AIMS Geosci.* **2021**, *7*, 613–622.
25. Martin-Valmayor, M.A.; Gil-Alana, L.A.; Infante, J. Energy prices in Europe. Evidence of persistence across markets. *Resour. Policy* **2023**, *82*, 103546.
26. Esposito, L.; Romagnoli, G. Overview of policy and market dynamics for the deployment of renewable energy sources in Italy: Current status and future prospects. *Heliyon* **2023**, *9*, e17406.
27. Terna. Transparency Report. Available online: https://www.terna.it/it/sistema-elettrico/transparency-report/download-center (accessed on 13 September 2024).
28. ISPI. Between Transition and Security: The Eu's Response to the Energy Crisis. Available online: https://www.ispionline.it/en/publication/between-transition-and-security-eus-response-energy-crisis-36819 (accessed on 17 October 2024).
29. Institute, D.E. Italy's Turning Point—Accelerating New Growth on The Path to Net Zero. Available online: https://www.deloitte.com/it/it/issues/climate/eu-turning-point.html (accessed on 17 October 2024).
30. Corsi, S.; Pozzi, M.; Sabelli, C.; Serrani, A. The coordinated automatic voltage control of the Italian transmission grid-part I: Reasons of the choice and overview of the consolidated hierarchical system. *IEEE Trans. Power Syst.* **2004**, *19*, 1723–1732.
31. Corsi, S.; Pozzi, M.; Sforna, M.; Dell'Olio, G. The coordinated automatic voltage control of the Italian transmission Grid-part II: Control apparatuses and field performance of the consolidated hierarchical system. *IEEE Trans. Power Syst.* **2004**, *19*, 1733–1741.
32. Bubbico, D. Il Pnrr italiano e l'industria nazionale: Alla ricerca di una politica industriale. *Auton. Locali E Serv. Soc.* **2022**, *45*, 309–329.
33. European Community. Il Green Deal Europeo. In *Comunicazione Della Commissione Al Parlamento Europeo, Al Consiglio, Al Comitato Economico E Sociale Europeo E Al Comitato Delle Regioni*; COM (2019); European Community: Brussels, Belgium, 2019; Volume 640.
34. Dell'Anna, F. Green jobs and energy efficiency as strategies for economic growth and the reduction of environmental impacts. *Energy Policy* **2021**, *149*, 112031.
35. Besagni, G.; Vilà, L.P.; Borgarello, M.; Trabucchi, A.; Merlo, M.; Rodeschini, J.; Finazzi, F. Electrification pathways of the Italian residential sector under socio-demographic constrains: Looking towards 2040. *Energy* **2021**, *217*, 119438.
36. Paoletti, E. The Migration of Power and North-South Inequalities: The Case of Italy and Libya; Springer: Berlin/Heidelberg, Germany, 2010.
37. Tuballa, M.L.; Abundo, M.L. A review of the development of Smart Grid technologies. *Renew. Sustain. Energy Rev.* **2016**, *59*, 710–725.
38. Barbetta, M.; Falvo, M.; D'Adamo, C.; D'Orazio, L.; Duca, E. Energy storage systems and distribution grids: A real case study in Italy. In Proceedings of the 2016 IEEE 16th International Conference on Environment and Electrical Engineering (EEEIC), Florence, Italy, 7–10 June 2016; pp. 1–5.

39. Buono, L.; Palone, F.; Papi, L.; Spezie, R.; Tresso, G.; Vacante, P.; Lauria, S.; Pizzimenti, F.; Capponi, F.G. Switching Overvoltages and Polarity Reversal in Presence of HVDC Circuit Breakers. In Proceedings of the 2023 AEIT HVDC International Conference (AEIT HVDC), Rome, Italy, 25–26 May 2023; pp. 1–6.
40. Buono, L.; Guarniere, M.; Marzinotto, M.; Palone, F.; Papi, L.; Spezie, R.; Tresso, G.; Vacante, P.; Pigini, A.; Cortina, R. A sustainable design for the new 500 kV HVDC Italian OHLs. In Proceedings of the 2023 AEIT HVDC International Conference (AEIT HVDC), Rome, Italy, 25–26 May 2023; pp. 1–6.
41. Terna. Terna: Presentato Il Piano Di Sviluppo 2023 Della Rete Elettrica Nazionale. Available online: https://www.terna.it/it/media/comunicati-stampa/dettaglio/piano-sviluppo-2023 (accessed on 20 September 2024).
42. Dargay, J.; Gately, D. Income's effect on car and vehicle ownership, worldwide: 1960–2015. *Transp. Res. Part A Policy Pract.* **1999**, *33*, 101–138.
43. Newman, P. Transport: Reducing automobile dependence. In *The Earthscan Reader in Sustainable Cities*; Routledge: London, UK, 2021; pp. 173–198.
44. Martynushkin, A.; Konkina, V. Quality improvement of public service of automobile transport: Economic evaluation method. In Proceedings of the Russian Conference on Digital Economy and Knowledge Management (RuDEcK 2020), Voronezh, Russia, 27–29 February 2020; pp. 449–455.
45. Danielis, R.; Scorrano, M.; Giansoldati, M.; Alessandrini, S. The Economic Case for Electric Vehicles in Public Sector Fleets: An Italian Case Study. *World Electr. Veh. J.* **2020**, *11*, 22.
46. Mulalic, I.; Rouwendal, J. Does improving public transport decrease car ownership? Evidence from a residential sorting model for the Copenhagen metropolitan area. *Reg. Sci. Urban Econ.* **2020**, *83*, 103543. https://doi.org/10.1016/j.regsciurbeco.2020.103543.
47. Burlando, C.; Ivaldi, E.; Saiani, P.P.; Penco, L. To own or not to own? Car ownership and consumer awareness: Evidence from an Italian survey. *Res. Transp. Bus. Manag.* **2019**, *33*, 100435.
48. Walsh, M.P. Automobile emissions. In *The Reality of Precaution*; Routledge: London, UK, 2013; pp. 142–158.
49. L'Unione Nazionale Rappresentanti Autoveicoli Esteri (UNRAE). *Analisi Del Mercato Autoveicoli in Italia*; UNRAE: Rome, Italy, 2020.
50. L'Unione Nazionale Rappresentanti Autoveicoli Esteri (UNRAE). *L'AUTO 2022 Sintesi Statistica*; UNRAE: Rome, Italy, 2022.
51. Database Electric Vehicles. Energy Consumption of Full Electric Vehicles. Available online: https://ev-database.org/cheatsheet/energy-consumption-electric-car (accessed on 20 September 2024).
52. Carlson, R.B.; Lohse-Busch, H.; Diez, J.; Gibbs, J. The measured impact of vehicle mass on road load forces and energy consumption for a BEV, HEV, and ICE vehicle. *SAE Int. J. Altern. Powertrains* **2013**, *2*, 105–114.
53. inistero Dell'ambiente e Della Sicurezza Energetica. *Relazione Annuale Situazione Energetica Nazionale Dati 2021*; Ministero Dell'ambiente e Della Sicurezza Energetica: Rome, Italy, 2022.
54. MOTUS. *Le Infrastrutture Di Ricarica in Italia*; MOTUS: Pisa, Italy, 2023.
55. Falvo, M.C.; Manganelli, M.; Moscatiello, C.; Vellucci, F. Electrical vehicles and charging stations: State of art and future perspectives. In Proceedings of the 2022 IEEE International Conference on Environment and Electrical Engineering and 2022 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS Europe), Prague, Czech Republic, 28 June 2022–1 July 2022; pp. 1–7.
56. Elavarasan, R.M.; Pugazhendhi, R.; Irfan, M.; Mihet-Popa, L.; Khan, I.A.; Campana, P.E. State-of-the-art sustainable approaches for deeper decarbonization in Europe–An endowment to climate neutral vision. *Renew. Sustain. Energy Rev.* **2022**, *159*, 112204.
57. Calise, F.; Cappiello, F.L.; Vicidomini, M.; Song, J.; Pantaleo, A.M.; Abdelhady, S.; Shaban, A.; Markides, C.N. Energy and economic assessment of energy efficiency options for energy districts: Case studies in Italy and Egypt. *Energies* **2021**, *14*, 1012.
58. Inal, V.; Addi, H.M.; Çakmak, E.E.; Torusdağ, M.; Çalışkan, M. The nexus between renewable energy, CO2 emissions, and economic growth: Empirical evidence from African oil-producing countries. *Energy Rep.* **2022**, *8*, 1634–1643.
59. Ravi, S.S.; Brace, C.; Larkin, C.; Aziz, M.; Leach, F.; Turner, J.W. On the pursuit of emissions-free clean mobility–Electric vehicles versus e-fuels. *Sci. Total Environ.* **2023**, *875*, 162688.
60. Demuynck, J.; Villafuerte, P.M.; Bosteels, D.; Kuhrt, A.; Brauer, M.; Sens, M.; Williams, J.; Chaillou, C.; Gordillo, V. Advanced Emission Controls and E-fuels on a Gasoline Car for Zero-Impact Emissions. *SAE Int. J. Adv. Curr. Pract. Mobil.* **2022**, *5*, 1063–1069.
61. Pasini, G.; Lutzemberger, G.; Ferrari, L. Renewable Electricity for Decarbonisation of Road Transport: Batteries or E-Fuels? *Batteries* **2023**, *9*, 135.
62. Carr, D.; Thomson, M. Non-Technical Electricity Losses. *Energies* **2022**, *15*, 2218. https://doi.org/10.3390/en15062218.
63. Autorità di Regolazione per Energia Reti e Ambiente (ARERA). Available online: https://www.arera.it/it/index.htm (accessed on 21 September 2024).
64. omEV. Analysis of Advanced Battery-Electric Long Haul Trucks. Available online: https://omev.se/2019/09/26/analysis-of-advanced-battery-electric-long-haul-trucks/#:~:text=With%20level%20conditions%2C%20a%20range,use%2C%20range%20of%20course%20drops (accessed on 21 September 2024).
65. Gustafsson, M.; Svensson, N.; Eklund, M.; Öberg, J.D.; Vehabovic, A. Well-to-wheel greenhouse gas emissions of heavy-duty transports: Influence of electricity carbon intensity. *Transp. Res. Part D Transp. Environ.* **2021**, *93*, 102757.
66. Europa, T. Ecco L'Abisso Tra Salari Degli Autisti Camion Dell'Ue. Available online: https://www.trasportoeuropa.it/notizie/autisti/ecco-labisso-tra-salari-degli-autisti-camion-dellue/ (accessed on 21 September 2024).

67. Khan, F.N.U.; Rasul, M.G.; Sayem, A.; Mandal, N.K. Design and optimization of lithium-ion battery as an efficient energy storage device for electric vehicles: A comprehensive review. *J. Energy Storage* **2023**, *71*, 108033.
68. Yu, X.; Sandhu, N.S.; Yang, Z.; Zheng, M. Suitability of energy sources for automotive application–A review. *Appl. Energy* **2020**, *271*, 115169.
69. Pavlínek, P. Transition of the automotive industry towards electric vehicle production in the east European integrated periphery. *Empirica* **2023**, *50*, 35–73.
70. Stellantis. Stellantis Inaugura in Italia Il Suo Primo Battery Technology Center. Available online: https://www.stellantis.com/it/news/comunicati-stampa/2023/settembre/stellantis-inaugura-in-italia-il-suo-primo-battery-technology-center (accessed on 21 September 2024).
71. Josijević, M.; Živković, D.; Gordić, D.; Končalović, D.; Vukašinović, V. The analysis of commercially available electric cars. *Mobil Veh Mech* **2022**, *48*, 19–36.
72. Pramuanjaroenkij, A.; Kakaç, S. The fuel cell electric vehicles: The highlight review. *Int. J. Hydrog. Energy* **2023**, *48*, 9401–9425.
73. Jenn, A.; Springel, K.; Gopal, A.R. Effectiveness of electric vehicle incentives in the United States. *Energy Policy* **2018**, *119*, 349–356.
74. Münzel, C.; Plötz, P.; Sprei, F.; Gnann, T. How large is the effect of financial incentives on electric vehicle sales?–A global review and European analysis. *Energy Econ.* **2019**, *84*, 104493.
75. Confcommercio. Incentivi e Agevolazioni per Veicoli Elettrici. Available online: https://www.confcommercio.it/-/incentivi-auto-elettriche (accessed on 12 October 2024).
76. Lanzini, P. Charging Ahead: A Survey-Based Study of Italian Consumer Readiness for Electric Vehicle Adoption. *Urban Sci.* **2024**, *8*, 142.
77. iCRIBIS. Uno Sguardo All'industria Automobilistica Italiana. Available online: https://www.contenuti.icribis.com/osservatorio/2023/automotive#:~:text=A%20fronte%20di%20un%20ammontare,il%202%2C7%25%20nella%20fascia (accessed on 12 October 2024).

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