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‘2022 – the first year of the EV era in Japan?’ The COVID crisis and its impact on the Japanese automobile industry

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Abstract: Has the COVID pandemic just been another crisis that had hit the Japanese automobile industry over the past three decades or has it been a watershed moment with respect to the shift to electric cars (EVs)? After presenting data regarding the development of Japanese industry and the evolution of policies for ecological friendly cars, the paper argues that, given that all major automobile markets and most foreign competitors are shifting towards battery electric vehicles (BEVs), the Japanese automobile producers have no choice other than abandoning conventional combustion engines including hybrid technologies and changing their strategies as well to BEVs. They do so, not because of government carbon neutral policies or out of conviction of the ecological superiority of BEVs, but just out of pure pragmatism in order to maintain their international competitiveness regarding products and production. COVID did not trigger but accelerated these developments.

Keywords: Japanese automobile industry; electric vehicles; carbon neutral strategies; automobile supply chains; sustainable mobility; CASE; Japan.

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1 Introduction: 30 years of difficult times for the Japanese automobile industry

Is the COVID-19 crisis just another crisis that has hit the Japanese automobile industry over the past 30 years, or is it a real turning point? Already immediately after the financial crisis happened in September 2008, Fukui Takeo, president of Honda at that time, said in an interview in January 2009, announcing the withdrawal of Honda from Formula 1 racing sports, that the automobile industry with the shift form internal combustion engines (ICEs) to battery vehicles is undergoing a one-in-a-century transformation. With this shift, the complete concept of car manufacturing is changing, and that Honda with its proud history of environmental innovations can and must never loose in the field of environment [Nikkei Business, (2022), pp.5–6].

Only a few years later, on the 11th of March 2011, Japan experienced indeed a watershed moment, this time in the energy sector. The triple disaster of earthquake, tsunami and, resulting from both, the multiple nuclear reactor melt-down at the Fukushima Nuclear Powerplant in the North-East of Japan, laid an unbalanced energy policy bare that was one-sidedly in favour of nuclear energy. Pushed by the lobbyists of the powerful electricity oligopolists, Japan, which was worldwide leading in renewable energy generation until 2006, abandoned all major investments in expanding green technologies and opted for the 'simple' solution, nuclear energy. Currently, only 7 out of 59 nuclear reactors are in operation, 26 are under inspection, and another 26 are inoperable or are to be decommissioned (Nuclear Regulation Authority as of August 2022). Resulting from the Fukushima disaster, Japan had to shift energy supply considerably to fossil fuels again. This fact and the lack of renewable energy supply constitute a major obstacle to a swift transition to battery electric vehicles (BEVs) or fuel-cell vehicles (FCVs).

The recent multiple crises of the Japanese automobile industry have of course also to be perceived against the background of the structural changes the industry went through since the mid-1980s. Particular after the burst of the economic bubble in the first half of the 1990s, the share of overseas production of Japanese manufacturers increased sharply. In 2007, foreign production overtook domestic production, and in 2018 Japanese carmakers built twice as many cars abroad as in Japan. Over the same period of time, however, domestic production declined in several steps by about 4 million cars or roughly one third. Domestic automobile production in Japan in 2021 was the lowest since the mid-1970s. Since the heydays of Japanese car manufacturing at the beginning of the 1990s, annual domestic production dropped by about 5.5 million cars. Even more than production, sales shifted away from Japan. In 1990, still 46.5% of all cars manufactured by Japanese companies were sold in Japan, in 2021, it was only 18.2%, less than two cars out of 10. And like production, also domestic sales volume continuously decreased from 5.1 million passenger cars in 1990 to just 3.7 million in 2021 (data: Japanese Automobile Manufacturers Association – JAMA).

Over the same time period, not only sales numbers declined, but also the structure of the Japanese car market changed completely. Until the 1990s sales of standard cars (above 2,000 cc) were neglectable, and the Kei-cars (mini cars with less than 660 cc) had just a rather small share in the domestic market. About 90% of all cars sold in Japan were middle-class cars (up to 2,000 cc). Until 2021, the share of the formerly dominant small cars has decreased to just 26%, while Kei-cars and standard cars have become the largest

market segments. Besides social-economic changes, this structural market shift reflects the demographic development as well as changes in consumer behaviour and in general attitudes to automobiles in Japan. In particular, the younger generations have increasingly lost interest in cars and have reduced spendings for buying and running cars considerably.

Another major development in the Japanese car market has been the continuous shift towards *hybrid cars* (HVs). This shift resulted from the implementation of a new car taxation scheme that aimed at accelerating the spread of more fuel-efficient cars as well as of so-called next generation cars (hybrid, plug-in hybrid, clean-diesel, fuel-cell and natural gas vehicles). Together with an incentive programme for the purchase of eco-cars to support Japanese car manufacturers during the global financial crisis, this new tax scheme was first introduced in 2009. Amended multiple times until today, this new taxation regime has indeed changed the Japanese car market profoundly, particular regarding HV sales.

The paper intents to analyse whether:

1 The COVID-19 crisis has been just another crisis for the Japanese automobile industry, or whether it has initiated a profound change of the automobile manufactures strategies with respect to shifting to electric vehicles.

2 Next, we will turn our attention to government policies that were initiated to:
   a accelerate or accommodate the shift to electric vehicles (and more broadly sustainable mobility)
   b to secure necessary competences in R&D and production to maintain the technological capabilities essential for building electric or hydrogen cars.

2 Domestic and international production, sales and exports: crises in comparison

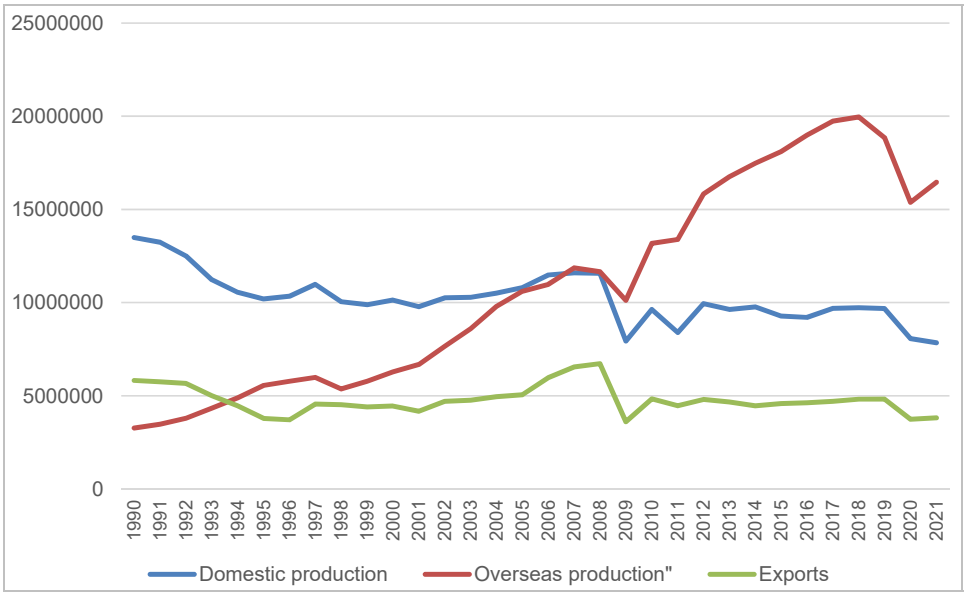
First, we briefly look how COVID has affected production, sales and exports of Japanese automobile manufacturers. The point of reference and comparison will be the financial crisis of 2008/2009.

Japanese domestic automobile production declined from an average of about 13 million cars in the first years of the 1990s, to about 10.5 million cars between 1993 and 2008. After the financial crisis until 2019, yearly average production shrank again further by one million cars to about 9.4 million cars. Quite in line with shrinking domestic production, also the share of exports dropped until the second half of the 1990s. Until the year 2000, the export ratio remained quite stable at around 44%. Between 2000 and the financial crisis of 2008, however, the export ratio rose to 58%, thus keeping domestic production over 10 million cars per year. Until 2019, it was again exports, accounting for about half of domestic production volume, that helped stabilising production and maintaining employment in the auto sector that had suffered a steep decline due to the financial crisis.

Differently to the financial crisis of 2008, COVID in particular affected overseas production of Japanese manufacturers negatively, partially because of the problems related to semi-conductor supplies. Whether domestic production will recover after COVID to a pre-pandemic level is very questionable. So far, data for 2022 are indicating a further decline, exactly in line with the motor industry's development since the burst of the economic bubble.

The expansion of global production of the Japanese automotive industry stands in sharp contrast with local production development. Foreign production as share of total production of Japanese car manufacturers in 1985 was just 6.7%. Until 1990, it has increased to 19.4%, and in 2021 it was 68%. In other words, the share of domestic production declined from 93.3% in 1985 to just 32.3% in 2021.

Figure 1 Domestic and international production as well as exports of Japanese automobile manufacturers (see online version for colours)



Source: JAMA

Sales of passenger cars in Japan are also slowly, but steadily decreasing over the last one and a half decades. With 2.67 million cars sold on average per year individual motorisation took off in the 1970. Sales increased to 3.49 million in the 1980s, to 4.38 million in the 1990s, and peaked with 4.44 million in the first decade of the 21st century. However, market contraction already set in around 2005. The new taxation regime and the eco-car purchase incentive scheme introduced in 2009 only for a short-term interrupted the downturn tendencies in the Japanese car market.

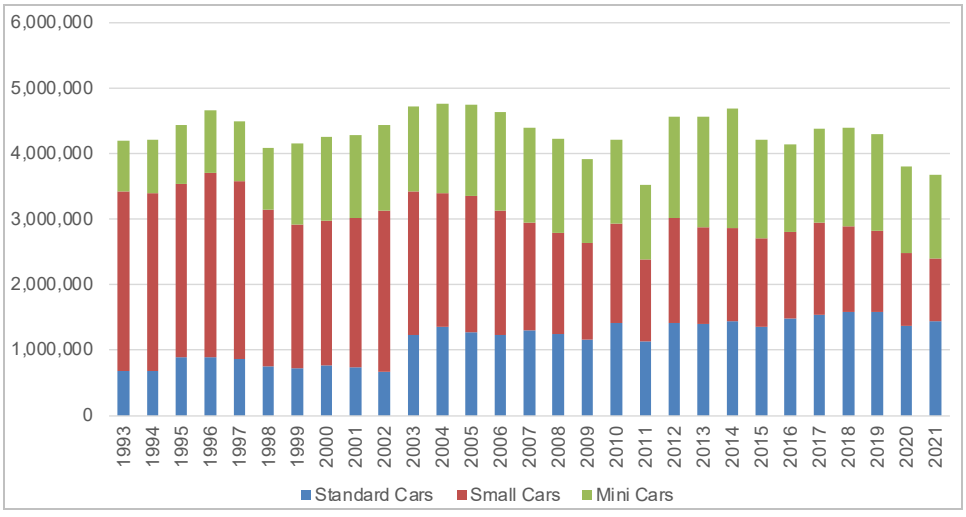
In addition, over the last 30 years, the structure of the Japanese car market has changed profoundly. Consumers' preference is increasingly on Kei-cars (mini cars) on the one hand, and on larger more powerful cars (standard cars), on the other hand, a trend that actually set in already in the mid-1990s. More recently, after 2009, the market structurally shifted to HVs, which will be discussed below in more detail.

Regarding the impact of COVID on domestic sales and exports of passenger cars, we observe, first, that similar to the financial crisis and the Fukushima triple disaster, car exports were far more negatively affected than domestic sales, despite the fact that, differently to 2009, no market stabilising measures were taken in reaction to COVID.

Secondly, differently to 2008, the impact was shorter and already six months after the outbreak of the pandemic, sales and exports had mostly recovered. This notwithstanding,

thirdly, there is a higher volatility in domestic sales and exports still continuing due to regional production lockdowns and to problems related to the supply of semiconductors.

Figure 2 Domestic sales of passenger cars (see online version for colours)



Source: JAMA

3 Efforts for greening the Japanese automobile industry before COVID

Already long before Japan announced its carbon neutral (CN) strategy, numerous government plans were implemented aiming at the spread of alternative engine technologies, in particular electric cars (EVs). However, all these plans were not really successful until, in 2009, a new automobile taxation regime provided substantial financial incentives for purchasing cars with superior fuel-efficiency and cars with alternative propulsion technologies (next generation cars).

3.1 The evolution of automobile policies for spreading low emission and electric vehicles

The efforts for spreading alternative engine technologies, as shown in Table 1, can be divided into three phases: the first phase from the mid-1970s until the end of the 1990s, a second phase from 2000 to 2007, and finally, a third phase after 2007.

First proposals for spreading EVs date back to the 1960s, as environmental pollution became an ever more serious problem particular in urban areas. An initial programme for developing EVs and EV related technologies was launched by the Ministry of International Trade and Industry (MITI) in 1971.

Reacting towards soaring energy prices after the oil shocks of 1973 and 1979, three plans, all called 'Basic Plan for the Spread of Electric Vehicles' were implemented by MITI in 1977, 1983 and 1991, respectively. The plans' ambitious objectives of spreading up to 200,000 electric vehicles, however, stood in sharp contrast to the actual roll-out of just about 800 to 2,500 new EVs.

Table 1 Plans for spreading electric vehicles

	Date of implementation	*Name of the plan Ministry in charge*	*Timeframe*	*Target number of vehicles*	*Market effect and evaluation*
1st phase	1977 April	1st Basic Plan for Spreading EVs MITI	1986	200,000	Total dissemination rate was 800 to 2,500 vehicles. Vehicles possessed by associations, local governments, and administration bodies used for public services and other official tasks. However, the use remained restricted to limited specific tasks and the targeted level of dissemination was never achieved.
	1983 December	2nd Basic Plan for Spreading EVs MITI	1990	5,000	
	1988 March	Basic Plan for Spreading Low Pollution Cars Ministry of Environment	1998	No target	
	1991 October	3rd Plan for Spreading Electric Vehicles MITI	2000	200,000	
2nd phase	2001 July	Action Plan for Spreading Low Pollution Vehicles Ministry of Economy, Ministry of Environment and Ministry of Land, Infrastructure, Transport and Tourism	2010	No target	Dissemination 2,500 to 10,000 cars. Exceeding public administration, car usage extended to household users. Applying an experimental approach, and model-type operations, usage patterns comprised car-sharing and rental car usage. However, dissemination did not proceed to commercial level.
3rd phase	2007 May	Initiative for Next Generation Vehicles and Fuels METI	2010	1 million	EV produced in larger quantities was sold in the first phase to corporate businesses, also later administrative and public usage remained dominant. Applying in principle an experimental approach and model-type operations, usage patterns like car-sharing, car leasing as well as taxi operations were introduced. In 2010, sales to private households began with rising expectations that EVs will spread to private users in the future.
	2009 May	Strategy for Spreading Next Generations Vehicles Ministry of Environment	2020 2050	2 million 8.8 million	
	2010 April	Strategy 2010 for Spreading Next Generation Vehicles METI	2020	15%-20% share of EV and PHV in new registrations	

Source: Tsuchiya and Ikeya (2011)

With the implementation of the 'Action Plan for the Development and Spread of Low Emission Vehicles' in 2001, the Japanese Government shifted its focus from pollution prevention and energy savings to combating climate change in order to achieve the CO_2 emission reductions Japan had committed to in the Kyoto Protocol. With that broader mobility issues like car sharing or low emission car rental systems gained more attention.

The most recent programmes, the 'Next Generation Vehicles and Fuel Initiative' (2007), the 'Strategy for the Spread of Next Generation Vehicles' (2009), and the 'Next Generation Vehicle Strategy 2010', focused again more specifically on the dissemination of EVs, setting clear target figures of up to 2 million EVs to be registered until 2020 and 8.8 million by 2050 [Tsuchiya and Ikeya, (2011), pp.2–4]. In order to meet these ambitious plans, the manufacturers engaged in widespread regional pilot projects to develop 'smart communities' with the intention to prepare the ground for a large-scale roll-out of electrified cars [Faivre d'Arcier and Lecler, (2014), pp.330–338]. Toyota has continuously worked on this smart community concept and in 2021 launched the Woven City Project that aims at developing a whole city from scratch for testing future sustainable mobility concepts.

Despite the manufacturers' efforts, however, all targets were not met until 2020, and the number of 8.8 million EVs by 2050 is not any longer relevant.

One main problem of the government's past programmes was the slow development of the necessary infrastructure for EVs, which also did not encourage the car manufacturers to invest in the development of new EV models.

3.2 The 2009 Automobile Taxation Regime and its impact on the spread of next-generation vehicles

Japan's exhaust fumes emission standards for cars, first introduced in 1966, have been amongst the most rigorous in the world. With the introduction of first fuel-efficiency standards in 1979, which were a part of a broader 'Energy Savings Bill', Japan was as well a forerunner. In 1998, the so-called top-runner principle was adopted, that commits all manufactures to meet a certain efficiency standard until a given time based on the product with the best energy performance. For cars, this principle was first applied in 1999, as efficiency standards for diesel cars for 2005 and for gasoline cars for 2010 were set (MLTI, Target Standards HP).

Differently to the European Union (EU Regulation 2019/631), which sets a CO_2 emission target, all car manufacturers have to meet on average, the Japanese efficiency standards are calculated based on the worldwide harmonised light duty test cycle (WLTC), the energy value of the fuel used, and the weight of the car. Based on these factors, the distance a car has to run using 1 litre of gasoline, diesel or kw/h electricity is calculated individually for every car model. Taking future technological improvements into account, this calculation provides the basis for the introduction of progressively stricter efficiency standards [METI, (2019), pp.3–6].

An ecological component in the Japanese automobile taxation system was first introduced in 2001 by lowering taxation on new smaller cars, while increasing taxation on older cars [RIETI, (2002), p.2]. Modifying this approach, the government worked out a plan for applying fuel-efficiency standards for the calculation of automobile taxation. In this way, the government provided incentives to the customers for buying more fuel-efficient cars on the one hand, while, on the other hand, pressuring the car

manufacturers to continuously improve the environmental performance of their cars and to bring more next generation cars on the market.

The new vehicle taxation was introduced in April 2009 together with an incentive scheme for the purchase of eco-cars, which was very similar to the German scrappage scheme (Abwrackprämie), but made the financial support, different to the German scheme, directly dependent on the ecological performance of the new car. Both, the new taxation regime and the incentive scheme, succeeded in stabilising the domestic automobile market during the financial crisis, providing some relief to the Japanese manufacturers that faced dramatically declining sales in the domestic and overseas markets. Exceeding this short-term effect, the taxation reform profoundly changed consumer behaviour. Sales of cars with improved fuel-efficiency and of next-generation cars increased considerably as the automobile manufacturers brought ever more cars on the market that qualified for the tax benefits. In fact, the new taxation regime provided exactly the support JAMA (2010) had asked the government for already in 2008 in order to reach the METI's ambitious objectives of up to 70% of next-generation vehicle by 2030.

Table 2 Current taxation scheme for next generation cars and cars with superior fuel-efficiency based on 2030 fuel-efficiency standards

Vehicle type	*Pollution*	*Fuel-efficiency*	*Tax reduction/exemption*
Electric cars Fuel-cell cars Natural gas cars (CNG-LNG) (2018 standards) PHEV	No requirements	No requirements	Automobile weight tax (first inspection of new car) Tax exemption
Green-diesel passenger cars	No requirements	No requirements	Automobile weight tax (first inspection) Tax exemption
Gasoline cars/natural gas cars (LPG-cars) (hybrid vehicles included)	50% lower pollutant emissions than 2018 emission standards	Achieving 90% of 2030 fuel-efficiency standards	Automobile weight tax (first inspection) Tax exemption
		Achieving 75%–85% of 2030 fuel-efficiency standards	Automobile weight tax (first inspection) 50% tax reduction
		Achieving 60%–70% of 2030 fuel-efficiency standards	Automobile weight tax (first inspection) 25% tax reduction

Source: JAMA

Since 2009, automobile taxation basically distinguishes three groups of automobiles. First, the group of next generation vehicles, second, the group of low emission cars with superior fuel-efficiency, and thirdly cars that do not meet the required fuel-efficiency or exhaust fumes standards for receiving tax benefits. Next generation cars basically are exempted from the purchasing tax and the tonnage tax, based on the car's weight, while low emission cars enjoy a certain percentage point rebate on both taxes, depending on the

level of their fuel-efficiency and the level of exhaust fume reductions. With the introduction of new fuel-efficiency and exhaust fume standards in 2011, 2012 and 2021, also the requirements as well as the tax benefits were adjusted.

After the introduction of the new taxation regime until 2012, it was in particular cars with superior fuel-efficiency, qualifying for a tax reduction of 50% to 75%, which dominated sales in Japan. At the same time, market share of cars not qualifying for any reduction continuously declined to less than 20% (data: JAMA). With a constantly increasing number of cars on offer, next generation cars began to dominate market demand after 2012, reaching a share of almost 40% in 2020.

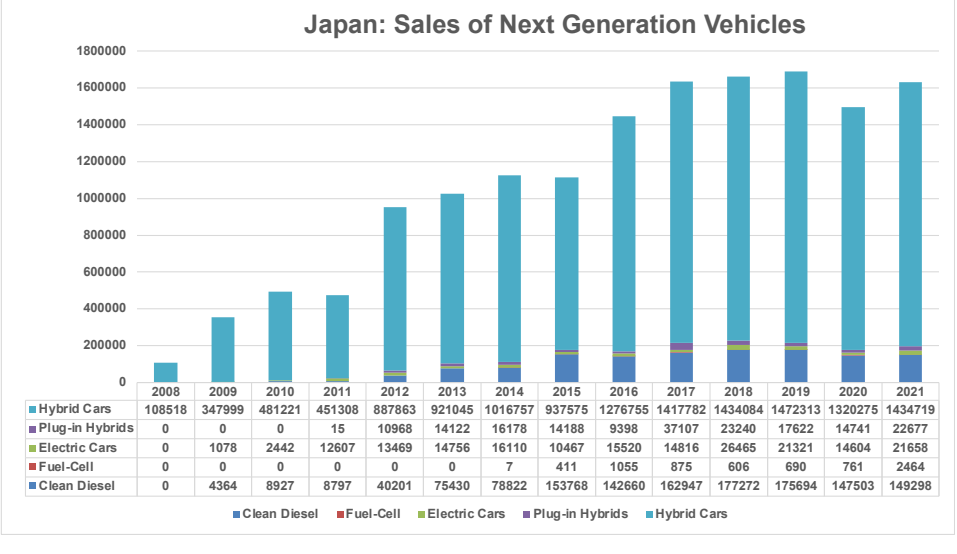
Table 3 Market share of next generation passenger cars in total sales (%)

2008	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
2.6	9.0	11.7	13.4	20.8	22.5	24.9	29.7	34.8	36.4	37.8	39.2	39.4	44.4

Source: JAMA

However, as Figure 3 shows, the vast majority of next generation cars that were sold have been HVs and clean diesel (CD) cars, while the share of EVs, FCVs and PHVs has remained extremely low.

Figure 3 Japan: sales of next generation vehicles (see online version for colours)



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Hybrid Cars	108518	347999	481221	451308	887863	921045	1016757	937575	1276755	1417782	1434084	1472313	1320275	1434719
Plug-in Hybrids	0	0	0	15	10968	14122	16178	14188	9398	37107	23240	17622	14741	22677
Electric Cars	0	1078	2442	12607	13469	14756	16110	10467	15520	14816	26465	21321	14604	21658
Fuel-Cell	0	0	0	0	0	0	7	411	1055	875	606	690	761	2464
Clean Diesel	0	4364	8927	8797	40201	75430	78822	153768	142660	162947	177272	175694	147503	149298

Source: JADA

The share of HVs in all next generation cars never felt below 84%. Between 1997 and 2016, Toyota (2017), indisputably the world leader with respect to the production of HVs, sold roughly half of all its hybrids worldwide just in Japan. As the Japan Automobile Manufacturer Association emphasises, Japan has succeeded in reducing CO_2 emissions from cars between 2001 and 2018 by 22%, while in comparison CO_2 emissions in Germany only declined by 5% and in the USA even increased by 1% [JAMA, (2021a), p.5]. The association explicitly attributes this reduction in greenhouse gases to the high share of HVs, emphasising that the overall CO_2 emissions of hybrid and plug-in HVs are

comparable to EVs and FCVs, when taking car production and recycling into consideration.

However, since all major automobile regions, in particular China and Europe quickly proceed in the direction of BEVs, there are voices increasingly warning that the persistence of the Japanese manufacturers on HVs, might just end up in another 'Galapagos' market like the Kei-car market [Fukao, (2022), pp.13–25].

It seems that Japanese manufacturers have kept their focus so firmly on hybrid technologies not in order to remain flexible with respect to future powertrain choices, as sometimes argued, but out of conviction that hybrid and in particular plug-in hybrid technologies are most effective in reducing the overall CO_2 emissions from cars [Mokudai, (2020), pp.137–138].

As we will see in the next part of the paper, there are mainly two reasons for the obvious shift of Japanese manufactures to BEVs. The one is regulations regarding the classification of HVs in foreign markets and related to that the decision to ban sales of HVs together with ICE cars in the near future.

The second is international competitiveness in respect to both, products and production. Both, regulation and competitiveness, are also central issues in Japan's Carbon Neutral Policy 2050 and the Green Growth Strategy.

4 COVID and its impact: a radical change of Japan's automobile policies and automobile manufacturers' strategies towards electric cars?

Has COVID influenced government policies with respect to sustainable mobility? How do these policies correspond to related issues like energy policies or infrastructure development? Did Japanese automobile manufacturers in reaction to COVID alter their strategies regarding the development of next generation vehicles, in particular electric vehicles (EV) and fuel-cell vehicles (FCV). COVID might not have been the reason for triggering certain policies and developments, but it might have contributed to the decision making at government as well as corporate levels. In this part, we will concentrate on Japan's Carbon Neutral Policy 2050 and the Green Growth Strategy as well as on the stance of the Japanese automobile industry towards these government's policies.

4.1 Japan's Carbon Neutral Policy 2050

In October 2020, the Japanese Government announced that Japan like other developed countries aims to achieve carbon neutrality by 2050. In January 2021, Prime Minister Suga outlined Japan's CN strategy focusing on:

1 the significance for Japan to pursue the 2050 carbon neutrality strategy

2 the necessary government investments especially in strategically important industries

3 the implications for the energy and the mobility sector

4 the economic impact on growth, private and foreign investment, as well as employment.

Prime Minister Suga emphasised that:

1 Economic growth has to be decoupled from the use of natural resources, and that environmental protection is essential for Japan's socio-economic transformation, for stimulating investments, increasing productivity, modernising its industrial structure and for future prosperity.

2 Further, he announced to provide an 'unparalleled' two trillion yen 'Green Innovation Fund' and to grant other tax credits in order to support companies developing and commercialising cutting-edge technologies like for instance next-generation solar power, low-cost storage batteries and carbon recycling.

3 Regarding the energy sector, he promised considerable investments for expanding hydrogen and renewable energies, for the digitalisation of energy generation and modernisation of the power grid. And Suga announced that also Japan will ban sales of new ICE cars from 2035 on.

4 Finally, he predicted that these measures would generate 240 trillion yen private and 3,000 trillion yen foreign direct investments in environmental technologies, contributing to an additional annual GDP of 190 trillion yen until 2050 and creating many new employment opportunities [Ministry of the Environment, (2021), p.5].

4.2 The Green Growth Strategy and the future of (auto)mobility

In June 2021, the Japanese Government presented on 158 pages Japan's 'Green Growth Strategy'. Part A outlines how the Green Innovation Fund is supposed to support a wide range of cross-sectoral R&D activities, before Part B addresses issues specifically related to certain industries.

4.2.1 Green Innovation Fund and R&D support efforts

The Green Innovation Fund, which is administered by New Energy and Industrial Technology Development Organization (*NEDO*), will provide preferential financial support to companies that are conducting R&D in areas (priority fields) particularly important for achieving carbon neutrality and maintaining international competitiveness.

Research subsidies are provided on the basis of three parameters:

1 CO_2 reduction potential and economic spill-over effects

2 necessity for political support (technical difficulty and possibility of practical application)

3 market growth potential and contribution to international competitiveness.

An additional 'investment promotion tax system' will be implemented in order to support the establishment of production facilities for products with large decarbonisation effects, as well as facilities that contribute to decarbonisation and to increased value adding in production processes in particular with respect to:

1 compound power semiconductor devices and semiconductor substrates used for manufacturing them

2 lithium-ion batteries for EVs and PHVs

3 stationary lithium-ion batteries

4 high efficiency fuel-cells

5 main exclusive parts for offshore wind power generation.

Most of these key products are directly related to the automotive industry [Japanese Government, (2021), pp.7–10].

4.2.2 Industry sector policies: automobile industry

In Part B of the *Green Growth Strategy* policies are outlined for specific industries with high growth potential. These industries are:

1 energy related industries

2 production and logistics related industries

3 home and office related industries [Japanese Government, (2021), p.28].

Regarding automobile industry policies, the first thing that stands out is that the automobile industry is grouped together with the battery storage industry, which gives a clear indication that the overall policy objective is the electrification of automobiles. After 2035, sales of new passenger cars with ICEs will be banned. Sales of electric commercial vehicles below 8 tons should reach 20%–30% by 2030 and 100% by 2040. Without giving specific target figures, heavy commercial vehicles (above 8 tons) are supposed to shift to hydrogen or synthetic fuels, while the motorcycle industry should also shift towards electricity.

In the context of electromobility, extending support for R&D, further capital investments, standardisation and intensified international cooperation should help to increase the competitiveness of domestic battery producers.

The target for 2050 is carbon neutrality in production, use and disposal of automobiles. Finally, the government emphasises that all future automobile policies have to be in line with energy and other industrial policies, have to take people's daily life and work realities, the needs for mobility and logistics as well as the requirements for regional and urban planning into consideration [Japanese Government, (2021), pp.60–61].

Following these general considerations, the government's automobile policy until 2050 is outlined in detail in three sections:

a electrification and change of car usage

b CN fuels

c batteries.

Promoting vehicle electrification and transforming the use of automobiles

In the first subsection a, *expanding the introduction of electrified vehicles*, mainly targets for the expansion of the charging infrastructure are set. Until 2030, it is planned to install 150,000 new charging facilities including 10,000 quick chargers at service stations and 30,000 charging points accessible in public space in order to make charging EVs as convenient as refuelling of a gasoline car is at the moment. 150,000 new charging facilities would constitute a fourfold increase from the 38,903 existing ones in 2020

(Enechange EV Charge, 2022). In addition, 1,000 new hydrogen filling stations are to be installed.

A second point is addressing the need for fundamentally reviewing the taxation scheme for eco-cars (see above) and the implementation of other regulations prioritising EVs like special parking zones in order to achieve carbon neutrality by 2050 [Japanese Government, (2021), pp.61–63].

In subsection b, *promotion of policies that work in tandem with energy policies*, the government outlines its plan to widely expand renewable energy generation, and to increase the amount of low-cost decarbonised electricity for battery production and for running EVs. A special focus with this respect is on maintaining the competitiveness of domestic manufacturing industries [Japanese Government, (2021), p.63].

In subsection c, *strengthening electric vehicle related technologies like storage batteries, fuel-cells and electromotors, strengthening the supply and value chains*, the government makes commitments to promote next generation battery development, to advance technologies that reduce CO_2 emissions throughout the vehicle lifecycle, and to decarbonise all automobile related industries. Certain levels of domestic production should ensure the resilience of supply and value chains [Japanese Government, (2021), pp.63–64].

Subsection d, *change the way of car usage*, is focusing on road and urban infrastructure modernisation, in particular on automated driving systems and digital technologies in order to provide sustainable mobility and more effective logistic services. Improved technical equipment, automated driving and car connectivity should reduce accidents, increase the resilience of all transportation systems, and cut energy consumption for data processing [Japanese Government, (2021), pp.64–65].

Subsection e, *cooperation with Asia and other countries for promoting the use of electrified vehicles*, urges companies and policy makers to promote international harmonisation of charging and other technical standards. Enhanced technical cooperation with suppliers in regions with strong presence of Japanese manufacturers (esp. ASEAN) should help Japanese OEMs expanding their market shares of EVs all over Asia [Japanese Government, (2021), p.65].

Subsection f, *electrified vehicles for disaster response*, refers especially to the situation in Japan, where natural disasters regularly disrupt gas, water and electricity lifelines. Passenger EVs should be able to provide households with electricity for lighting and for using electric kitchen appliances. Moveable storage batteries should provide electricity for nursing homes, homes for the elderly and hospitals [Japanese Government, (2021), p.65].

Subsection g, *mobility and society 2050*, finally projects a vision of future mobility, which satisfies all individual mobility needs as well as the needs for transportation of goods. The mobility systems in the future are highly resilient and free of accidents and congestion. The electrification of automobiles will contribute to smart city upgrading and improve disaster resilience [Japanese Government, (2021), pp.65–68].

Section B, *CN fuels*, focuses in particular on production expansion and commercialisation of CN fuels other than hydrogen for aviation, maritime and heavy road vehicles use. Synthetic fuels (e-fuels) would have the advantage that the existing gasoline distribution infrastructure as well as the existing ICE technology could be used. Until 2050, production cost and selling price of CN fuels should be lower than gasoline.

In Section C, *batteries*, the government commits to ensure stable supply of domestically produced batteries, to support industries along the value chain, and to

implement policies designed to strengthen the competitiveness of the Japanese battery industry in light of initiatives in China, Korea, and the EU ('European Battery Alliance') in this sector [Japanese Government, (2021), pp.65–68].

In the following paragraph, we will look at the stance the Japanese automobile manufacturers and their trade association JAMA take with respect to the above outlined national policies, and whether and how these policies influence the manufacturers' product strategies. Are the Japanese manufacturers abandoning the ICE and shifting to BEVs? And might this be somehow related to the COVID pandemic?

4.3 Japan's CN and green growth strategies: stance and strategies of the Japanese automobile industry

First, there is no common stance of the Japanese automobile manufacturers with respect to the above outlined government's Carbon Neutral 2050 and Green Growth Strategy as there is no common strategy regarding the electrification of automobiles. Too different are the product strategies of the manufacturers, and too different is their respective position in the domestic market. Honda has a relatively low market share in Japan, and also the share of domestic production in global production is the lowest of all Japanese manufacturers. Mazda is mainly producing in Japan, but with more than 80% of cars exported, the company is highly dependent on export markets. Therefore, decisions taken in Europe, or the USA might be more influential on product policies of both companies than decisions taken in Tokyo. Nissan and Mitsubishi have certainly to follow considerations of Renault regarding global platforms and global sourcing strategies. Toyota traditionally is the most powerful player in Japan with a domestic market share of about 40%. Therefore, its influence on the Japan Automobile Manufacturers Association, where Toyota's president Toyoda Akio serves as chairman, might be considerable. However, JAMA is not a Toyota lobby group, but represents all 5.5 million people that work in automobile manufacturing and automobile related industries in Japan [JAMA, (2021c), p.3].

JAMA in the past few years has been quite critical with respect to the government's plans for the electrification of automobiles and the transition period from ICE cars to EVs. JAMA has constantly referred to HVs as electrified cars, hybrid electric cars (HEVs). Excluding HVs, Japan would rank with just 0.5% EVs far behind China (3.4%), Europe (2.2%) and the USA (1.4%), while including hybrid vehicles, as JAMA does, Japan would with 34.8% in sales in 2019 by far lead the world in automobile electrification. However, the decisive point is that no other world region classifies HVs and PHVs as EVs but as conventional ICE cars.

With respect to transition periods to EVs, JAMA's criticism is particularly directed at issues related to Japan's energy mix. Resulting from the drastic reduction of nuclear energy generation after the 2011 Tohoku Earthquake, the share of fossil energy in Japan's energy mix has drastically increased. Given the only slowly increasing share of renewable energies, it is predicted that the share of fossil energies in energy consumption will still exceed 50% in 2030. As a consequence of this, also prices for renewable energy will remain considerably higher than in other important automobile producing countries, which will negatively affect both production costs and running costs of EVs.

Table 4 Energy mix, energy costs, and spread of ecological cars in comparison

		Japan		*Europe*		*USA*		*China*	
		2019	*2030*	*2019*	*2030*	*2019*	*2030*	*2019*	*2030*
Energy mix	Renewable	19%	22%–24%	30%	60%	18%	35%	27%	40%
	Thermal power	75%	56%	37%	23%	63%	49%	68%	-
		Japan		*Europe*		*USA*		*China*	
Costs (Euro cent)	Solar	11.8		5.1		4.4		4.2	
	Wind	14.2		5.7		3.8		4.1	
	Therma	9.2		8.9		5.7		5.0	
	Cost relation	re>th		re<th		re<th		re<th	
		Japan		*Europe*		*USA*		*China*	
Automobiles	EV	0.5%		2.2%		1.4%		3.4%	
	PHV/HV	34.3%		6.3%		3.3%		2.8%	
	Total	34.8%		8.5%		4.7%		6.2%	
		Japan		*Europe*		*USA*		*China*	
Sales in 2019	EV	20,000		1,170,000		240,000		710,000	
	PHV/HV	1,480,000		3,420,000		550,000		590,000	
	Total	1,500,000		4,600,000		790,000		1,300,000	

Source: JAMA (HP without year)

JAMA further emphasises that the Japanese car manufacturers' approach to opt for transition technologies (hybrid and plug-in-HVs) and the application of ever stricter fuel-efficiency standards, has resulted in a 22% reduction of CO_2 emissions from cars between 2001 and 2018. JAMA further stresses that the newly introduced fuel-efficiency standards for 2030 will again contribute to a 32% increase in the average mileage a passenger car runs from 19.2 km/l in 2016 to 25.4 km/l in 2030, contributing to an equivalent reduction of CO_2 emissions (JAMA, HP without year).

The other major point JAMA as well as the Automobile Business Association of Japan, editor of the *Automotive Yearbook of Japan*, are arguing is that automobiles only contribute a small share to CO_2 emissions.

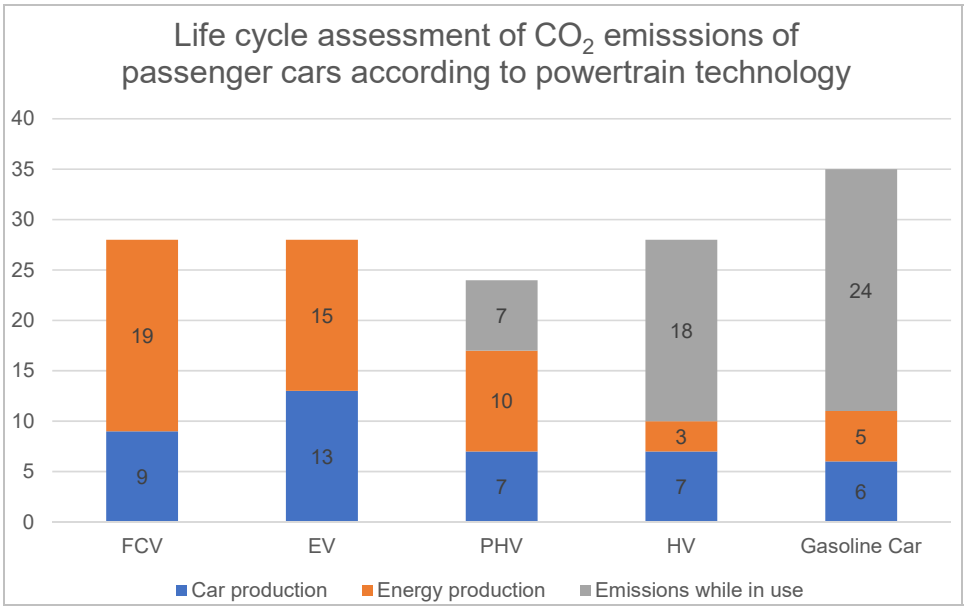
Acknowledging the need for taking decisive actions against global warming, a special feature article in the latest *Automotive Yearbook*, however, questions the reasonableness of abandoning the automobiles core technology, the ICE. The editors argue that the whole transport sector, of which automobiles are just a part, contributes only one-fifth to total CO_2 emissions, and that no other sector or industry is completely abandoning its core technologies [ABA, (2021), p.2].

Further, they demand that the calculation of CO_2 emissions attributable to cars has to be done on the basis of the life cycle assessment (LCA) method, including all steps from raw material extraction, production, usage to recycling of cars. Based on the LCA method, which calculates emissions 'well to wheel' and not just 'tank to wheel', EVs or FCVs are roughly emitting the same amount of CO_2 like HVs or PHVs, because production and recycling of EVs and FCVs are far more energy intensive than that of

HVs or PHVs [ABA, (2021), pp.4–5]. Based on International Energy Agency (IEA) data and applying the LCA calculation method, JAMA arrives at the below displayed amount of CO_2 emissions for passenger cars with different powertrain technologies over a ten-year period and a yearly mileage of 15,000 km.

Despite the concerns and criticism of Japanese automobile manufacturers and trade organisations, and regardless the fact that most countries at the moment have just announced dates of phasing out ICE cars without implementing binding legislation, Japanese automobile manufacturers have considerably shifted their strategies towards EVs (BEVs as well as FCVs) during the COVID pandemic.

Figure 4 Life cycles assessment of CO_2 emissions (in tons) (see online version for colours)



Source: JAMA (2021b, p.14)

Renault's alliance partner Nissan in November 2021, presenting its 'Nissan Ambition 2030' Plan, announced the introduction of 23 new electrified cars, of which 15 will be BEVs. Just in the first three weeks after Nissan in May 2022 has presented its first EV Kei-car, the Nissan Sakura, 11,000 customers order the car. Mitsubishi, the other Renault partner, announced that it aims at 50% electrified models in its portfolio until 2030 contributing to a 40% reduction in company CO_2 emissions.

Toyota in December 2021 updated its EV strategy announcing the launch of 30 new BEV models aiming at yearly sales of 3.5 million until 2030. At the centre of this strategy is the new bZ model series, which will be produced in Japan and China. Some models will be sold under different names as Subaru vehicles.

Finally, Honda also intends to introduce 30 new EVs worldwide until 2030, aiming at yearly sales of 2 million (Enechange EV Charge, 2022).

At the same time, almost all Japanese car manufacturers also updated their plans for the regional rollout of zero-emission vehicles (ZEVs), which means BEVs and FCVs. With this respect, Honda has presented the most consistent strategy. With the exception

of Japan with just 20%, Honda intends to increase the share of ZEVs in its car sales in all developed countries (including China) to 40% until 2030. This ratio should then increase to 80% in all developed regions until 2035, and finally to 100% by 2040 [Fourin, (2022), p.30].

Toyota's strategy is most consistent for Europe, where the company intends to increase the share of ZEVs in sales from 10% in 2025 to 50% in 2030 and to100% in 2035. Wirth respect to the Lexus brand, Toyota plans a full-line upgrade until 2030 with 100% BEVs on sale in Europe, North America and China. From 2035 on all Lexus cars should be BEVs worldwide [Fourin, (2022), pp.26–27]. Based on latest sales figure projections, Toyota plans to sell 2 million ZEV worldwide, of which 1.5 to 1.8 million shall be sold in the USA until 2030 (Toyota, 2021).

Finally, Nissan has announced that electrified vehicles will take a 50% share in its worldwide sales by 2030. For sales in the USA market, the company projects a share of 40% of BEVs. EVs are expected to account for more than 75% of sales in Europe, more than 55% in Japan and more than 40% in China by 2026, but no specific percentage figures for BEVs are given [Fourin, (2022), pp.28–29].

There are two main reasons for the shift. First, the global competitors of Japan's manufacturers like Daimler, Volvo or Hyundai move decisively in the direction of 100% EVs cars as early as 2030. Also, EV sales figures in established car markets like Germany indicate, the question is not whether there will be a shift to EVs, but just how quickly it will happen. And the world's largest and most strategically important market for all car manufacturers, China, is decisively pushing ahead with its EV strategy, which means, the Japanese manufacturers cannot afford not to follow the trend.

The Japanese market, despite its size of 5 million cars sold annually, of which 90% are domestic, is not large and important enough to influence global trends. It is not even big enough for the Japanese manufacturers to pursue different strategies than in other world markets. And in the EV market it is the foreign brands that are setting the tone in Japan, particular in the upper market segments.

The second reason is concerns regarding the competitiveness of the Japanese automobile industry as a whole. The Japanese automobile sector employs 5.5 million people or 8.2% of the total workforce. Roughly 50% of production is exported, which means that up to one million jobs are directly depending on automobile exports, generating an income of about 15 trillion yen per year, which is almost equivalent to Japan's expenses for energy imports [JAMA, (2021b), p.12].

Therefore, income and jobs are at risk, if Japanese car manufacturers are not producing cars, which are sought after in the world export markets. In addition, Japanese exports could face restrictions in case of too high CO_2 emissions in the production processes, which also is an issue of competitiveness. Therefore, the Japanese producers have to achieve carbon neutrality in their domestic factories. For this, large-scale expansion of CN energy generation is essential, which is why JAMA is pressuring the government to drastically increase supplies from CN energy sources. Until 2050, all Japanese car manufacturers aim at achieving CN manufacturing. Toyota has set its goal for CN manufacturing in its own factories for 2035 (*Nikkei*, 2021).

Under the above-outlined circumstances, the Japanese automobile industry had to change its course. Also, in Japan, the days of ICE cars, including HVs, seem to be numbered.

Finally, what influence did COVID have on the developments of the past two years? Definitely, COVID was neither the reason for the government to launch its CN or green

growth strategies nor for the Japanese car manufacturers' move towards EVs. However, the far-reaching changes in peoples' daily and working lives that were caused by the pandemic, for sure had considerable influence particular on mobility and the acceptance and spread of EVs.

Some influencing factors were:

1 To avoid crowded public transport, the car became again attractive for short distance work commuting, shopping and caring about other personal businesses.

2 Home office, remote-work and satellite offices altered peoples' mobility needs, in particular within the range of 'the last mile'.

3 On a considerable scale, people, particularly young families, have moved during the pandemic from expensive city centres to less densely populated areas, where they can afford more spacious, modern housing.

It has already become standard that new family houses are equipped with handwash basin at the entrance, room or at least space for home office, solar panels and charging facilities for EVs! The shift to EVs provides car manufacturers also opportunities for establishing new business models, not just in Japan [Proff et al., (2019), pp.57–60]. The Japanese producers particularly seek new business opportunities in the housing business, integrating EVs into the house's energy system.

These trends undoubtedly will continue. And maybe indeed, as the provider of EV charging facilities Enechange EV Charge titled on its HP, the year 2022 will go down in Japanese automobile history as the 'first year of the EV era'.

5 Conclusions

After decades of economic stagnation and regularly occurring crises that in general have affected particularly the Japanese automobile industry negatively, the paper asked what impact the COVID crisis had on the Japanese automobile industry and whether the pandemic somehow influenced or accelerated the shift to EVs and sustainable mobility.

A short overview over past developments and current situation of the Japanese car industry (market, production, exports), showed that the crises (world Financial Crisis 2009, Tohoku Earthquake 2011 and COVID after 2020) did not alter the broad trends in the Japanese auto industry, which there are:

1 continuously declining domestic sales and production

2 increasing share of overseas production and sales

3 a structural change in the car market with Kei-cars and larger 'standard cars' increasingly becoming the dominant market segments.

In the second part of the paper, we have seen that Japan already in the 1970s made numerous, but unsuccessful attempts to introduce low emission cars and EVs. This shift only started with the introduction of fuel-efficiency standards in the early 2000s and the new taxation regime of 2009 that provided tax advantages to customers of cars with superior fuel-efficiency and next generation cars. In the first place, this new tax regime boosted sales of HVs, which increased their market share to almost 40%.

Similar to 2009, as incidentally the financial crisis coincided with the Japanese Government's implementation of sustainable development policies, the COVID crisis 2020 coincided with the implementation of the 2050 Carbon Neutral and Green Growth Strategies. Common to both crises is, that neither initiated the changes in the industry, the financial crisis did not initiate the shift to low-emission and HVs after 2009, nor did COVID initiate the shift to EVs after 2020. Both, however, accelerated the shifts. Due to the changes in peoples' daily and working lives, which were brought about by the pandemic, the mobility needs, means and patterns as well began to change in the direction often referred to with the abbreviation CASE (connected, automated, shared and electric).

Also, the Japanese manufacturers, that were focusing on hybrid and plug-in hybrid technologies, had finally begun to alter their strategies and swiftly shift to BEVs. This strategy change is solely based on the manufacturers' pragmatic considerations, that, as all other major automobile producers and markets shift to BEVs, they also have to follow this path. Otherwise, they would be unable to remain globally competitive. In this respect, competitiveness is not just an issue of bringing competitive CN cars on the market, but also being competitive with regard to CN production. For achieving both, the Japanese Government will have to take decisive actions and considerably accelerate and increase the generation of renewable and other forms of CN energies as outlined in the 2050 Carbon Neutral and Green Growth Strategies.

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