

Article

Hydrogen Technology towards the Solution of Environment-Friendly New Energy Vehicles

Murat Peksen

Multiphysics Energy Solutions (MES), 52070 Aachen, Germany; m.peksen@multiphysicsenergysolutions.com

Abstract: The popularity of climate neutral new energy vehicles for reduced emissions and improved air quality has been raising great attention for many years. World-wide, a strong commitment continues to drive the demand for zero-emission through alternative energy sources and propulsion systems. Despite the fact that 71.27% of hydrogen is produced from natural gas, green hydrogen is a promising clean way to contribute to and maintain a climate neutral ecosystem. Thereby, reaching CO₂ targets for 2030 and beyond requires cross-sectoral changes. However, the strong motivation of governments for climate neutrality is challenging many sectors. One of them is the transport sector, as it is challenged to find viable all-in solutions that satisfy social, economic, and sustainable requirements. Currently, the use of new energy vehicles operating on green sustainable hydrogen technologies, such as batteries or fuel cells, has been the focus for reducing the mobility induced emissions. In Europe, 50% of the total emissions result from mobility. The following article reviews the background, ongoing challenges and potentials of new energy vehicles towards the development of an environmentally friendly hydrogen economy. A change management process mindset has been adapted to discuss the key scientific and commercial challenges for a successful transition.

Keywords: hydrogen; sustainability; ecosystem; fuel cell; electrification; transport; change management; new energy vehicle



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1. Introduction

Global CO₂ emissions have drastically increased per year since the 1990s. Due to the industrial emissions, many studies have been conducted to determine their main drivers and potential future trajectories. Several drivers such as the governmental policies, social and economic aspects, technological developments as well as the positioning in market share are of paramount importance to understand the role of primary inputs in CO₂ emissions and their effects on various sectors. Many countries account for the production, consumption as well as the income-based CO₂ emissions to develop efficient CO₂ mitigation strategies [1]. The emissions of the Chinese industrial sector alone, for instance comprises 24.1% of global emissions [2], which proves its great relevance to the global climate policy. Thus, there have been tremendous efforts in research to contribute to climate neutral strategies [2–12]. Decarbonisation processes such as the storage of CO₂ in biological or geological means (such as negative emissions technologies or greenhouse gas removal) as well as solar radiation management techniques to reflect back the sunlight into space are also widely used [13]. Comparison studies showed that consumption-based emission output of US experienced an increase with an accompanying decrease during 1993 to 2013 while that of China still kept rising [14]. This is the reason why Asia pacific zone economies including China, Japan, and Korea are putting more efforts into cross-sectoral clean technologies to reduce climate and environmental issues. The International Energy Agency reports show that during the COVID-19 crisis the renewable energy capacities in 2020 did not decrease as was projected. Furthermore, they have been the only energy source for which demand increased in 2020 despite the pandemic, while consumption of all other fuels declined [15]. The annual renewable capacity additions increased by 45% to almost

280 GW, which has been the highest year-on-year increase since the year 1999. The flagship in the added increase has been addressed as the solar PV development, which led to nearly 50% added increase higher than the pre-pandemic level of 2019. Despite the deceleration in the Asia Pacific region due to pre-subsidy phase outputs, capacity growth accelerates in Europe and North America due to federal tax credit extensions as well as policy supports. The slightly lower additions of wind power are expected to be compensated by the vast increase in the PV summarized together with different technologies and overall annual regional capacity additions in Figure 1.

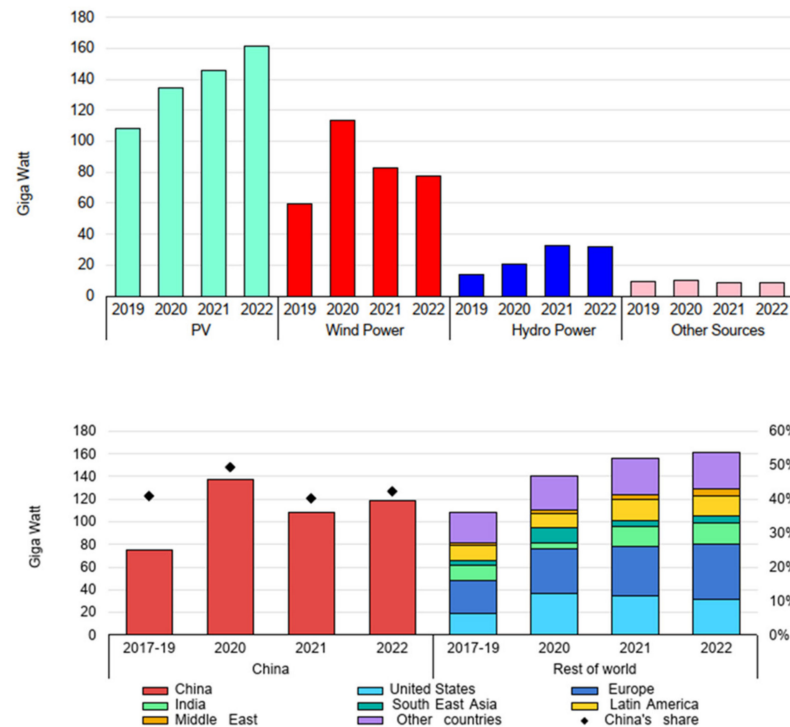


Figure 1. Renewable energy capacity data by technology and region based on Reference [15].

The growth acceleration in Asia will increase again by new policy actions, which is the case particularly for China, chasing climate neutrality by 2060. The renewable electricity source and the methodological concept of carbon dioxide mitigation concepts have been crucial drivers of environmental impacts. Blue hydrogen utilising natural gas and the use of carbon capturing techniques comprising pre combustion, post-combustion and oxyfuel combustion aims to reduce greenhouse gases and is gaining importance [16,17]. Combining these with storage technologies is known as biocarbon capturing and storage that leads to a negative CO₂ balance [18]. These methods, however, seem to be constrained by technological and earth absorption limitations, thus solely their contributions would not be sufficient [19]. If it is considered that today still 71.27% of hydrogen is produced from natural gas, 27.27% from coal, 0.7% from petroleum, and only 0.7% from water electrolysis, the importance of different technologies is clear [20]. Power-to-X is the utilisation approach of energy by converting electricity into energy carriers such as gas, heat, and fuel that affect various sectors. There have been several studies reviewing the life cycle assessment of Power-to-X, as well as depicting the different chains [21]. One of the applications of the Power-to-X processes is to convert renewable electricity originating from clean sources such as the PV or wind power into hydrogen through an electrolysis stage. It is the way green hydrogen is extracted, which has been affecting various sectors. Different processes can also lead to other chemical products classified such as Power to Iron, Power to Hydrogen, Power to Syngas, Power to Methane, and Power to Methanol [22]. As mentioned, the transport sector has been influenced directing towards the use of electrification that is

powered by green hydrogen. Considering the challenges and legislation prerequisites, a power-to-vehicle pathway has been shown to shed light on the demand for conversion to new technologies. Despite that the transport sector is more concerned about the application itself, a well-to-tank illustration such as depicted in Figure 2 explains the typical stages of the energy chain through generation, distribution and utilization and the link to the vehicle sector. This helps to explain the connection between the overall energy sector, climate neutrality, and the transport sector undergoing a change. Ultimately, it is not only about the cars but, in long-term, the whole transportation sector employing railways, ships, etc.

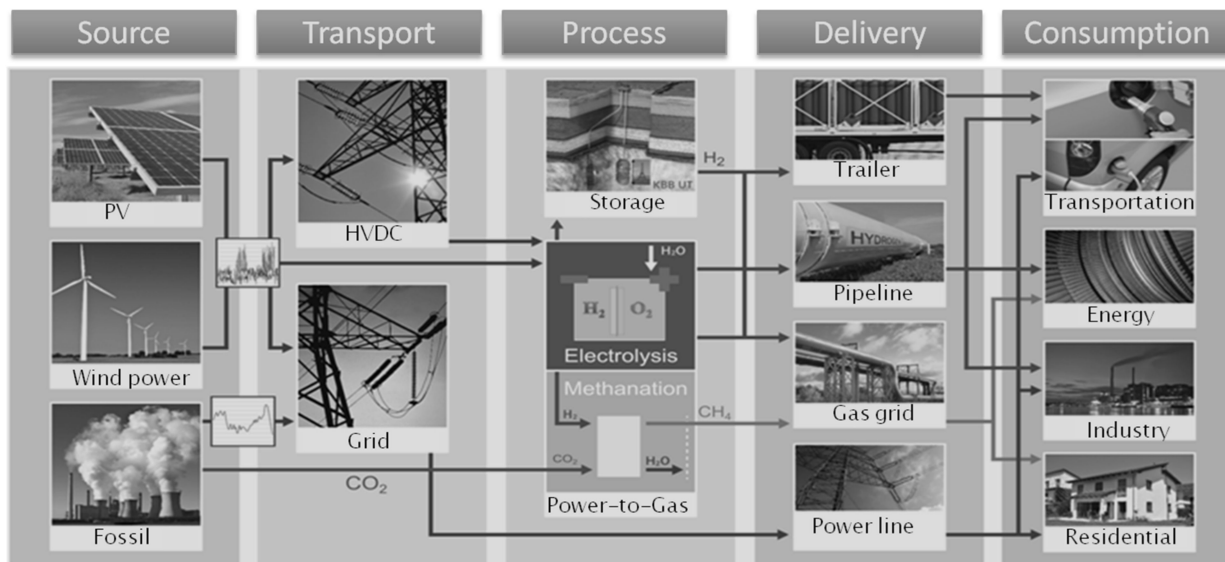


Figure 2. Typical energy economy chain from generation through regenerative resources to utilisation.

Accordingly, the electricity is desired to be generated by alternative energy means such as the wind power and PV, where the use of fossils is mitigated (despite still being used, thus still depicted). The generated electricity is required to be transported by grid technologies to be processed via electrolyzers and be distributed further by means of delivery methods such as pipelines or existing natural gas infrastructure through other chemical processes and ultimately ready served to be utilised by the sectors. To align with the global energy roadmap to reduce CO₂ output, the transport sector needs to cope with an increase in actions, especially for on-road transport. In 2017, the light-duty vehicles accounted for approximately 15% of the EU road transport emissions of CO₂. This value was around 5% of total EU road transport emissions for the heavy-duty vehicles, including trucks and buses. This followed regulations in 2019, setting emission targets for 2030 and a sustainable smart mobility strategy targeting at least 30 million zero-emission cars on European roads. However, according to the EU feasibility and scoping report climate neutral by 2030, the main sources of emissions in EU are still due to mobility (air, visitor travel, staff commuting, delegation and representative travel, vehicle fleet, and other missions) with more than 50% followed by buildings (36%), while IT and food are accepted to be less significant with 5% and 3%, respectively [19]. To fulfil the CO₂ mitigation process, the vehicle manufacturers have been focusing currently on the electrification and increase the use of the so-called new energy vehicles, utilising green hydrogen obtained from regenerative sources. The current article reviews the interactions of ongoing policies, technological, economic, and social challenges and the potential of new energy vehicles towards the ramping of an environmentally friendly hydrogen economy. Recent status of leading economies within the sector is discussed. The article gives an overview about the cross-sectoral multi factors that the stakeholders face, impeding the change management and progress in change for a successful transition.

2. Methods: Change Management for a Successful Hydrogen Economy Transition

Before narrowing the topic to the challenges and ongoing interacting activities of the implementation of hydrogen energy and its effects on the new energy vehicle sector, it is important to address the stakeholder of climate change, i.e., who are involved, who decides on what, etc. It can be briefly held that everyone is a stakeholder of climate change; thus, it is everybody's business. It comprises all society aspects because it affects all stages, processes and people where everything else occurs. Governments, civil societies including various organisations and private citizens forming a public perspective, as well as companies that generate economic, social, and ecological value. They all interact and contribute to an overall change mechanism. Governments through elections, subsidies may influence and create strategies, but activists and other societies may reorient the priorities, political decisions, and roadmaps. The influence of business companies on the other hand has much grown beyond their trading and creation of economic value or workspace. Ultimately, all stakeholders need to work together and accomplish their individual roles and responsibilities. However, to successfully foster a transition of this scale an appropriate change management framework needs to be followed. In the present article, a three-step change management framework proposed by Lewin and Dorwin [23] was used to discuss and understand the challenges that continue to impede a successful change in the new energy vehicle sector impacting the overall climate neutrality target. Figure 3 depicts the three stages of the change management procedure towards the use of new energy vehicles and a CO₂ neutral climate.

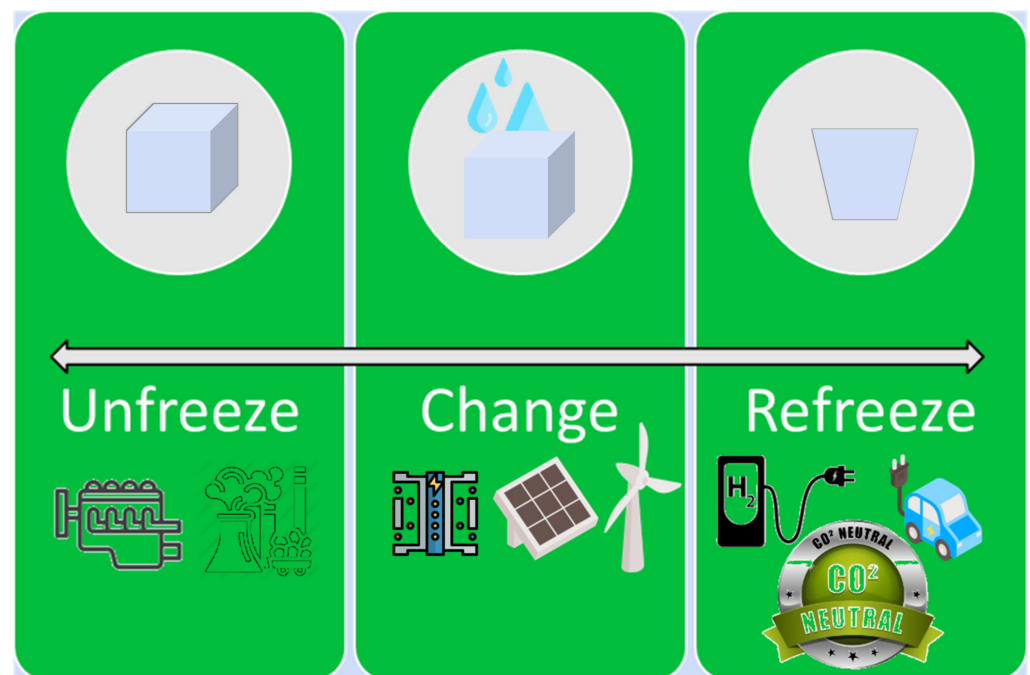


Figure 3. Demonstration of a three-step change management approach towards the use of new energy vehicles and a CO₂ neutral climate analogue to Lewin [23].

Basically, the model implies that the initiation of change can be imagined like an ice cube that needs to be molten before a new shape from liquid water state to a newly formed ice shape can be achieved. This is the working principle that can be adapted analogue to this change management principle. In an ideal case of implementing hydrogen technology towards the use of new energy vehicles and climate neutrality, the three stages of an appropriate change management strategy would be roughly outlined as follows:

- As part of the renewable energy transition, the gradual reduction of fossil fuels needs to progress. As a response, the currently used ICE engine technologies powered by fossil resources need to be mitigated by the vehicle sector.
- Hydrogen generation, distribution, and utilisation have to be initiated and appropriate technology for each step is required. Moreover, for this change, the vehicle sector is forced to undertake major revisions within the propulsion systems.
- The final stage would comprise the consolidation of the transition. This would mean that the changes undertaken so far are stabilized and need to be incorporated into everyday life and used further.

It seems to be a simple strategic procedure. However, there is much behind it, as the change we deal with is a long-term transformational change that has major impacts not only on strategies but also influencing business processes, sectors, and peoples, i.e., all stakeholders. Thus, various viable aspects within each stage have to be taken into account. Otherwise, the challenges pursue and impede the mitigation of CO₂ climate neutrality as the ultimate goal.

Interpreting the stages shows that the main issues already started in the first stage, including the unfreezing of the status quo. The strategy to reach climate neutrality has shown that an initial understanding of the forces and drivers for a change exists. A time plan till 2050–2060 is set with adaptive changes and targets till 2030 and beyond. However, lack of sensitivity to the obstacles that may impede the change in terms of technological, economic, and social aspects is remarkable. Postponing some dates shows that still awareness of the issues demanding change is not fully accepted. One of the most important change management principles, i.e., taking all stakeholders on board and generating dissatisfaction with the status quo is missing. Therefore, realistic targets that all of the stakeholders can carry out is misleading. This influences the level of understanding both at cognitive and emotional level among several stakeholders, directly dropping the motivation by lacking a compelling vision for an environmentally friendly future.

Considering the actual change state gives us hints about how the changes should be performed. This can be interpreted analogously to an organisation having received a strategy and vision from the leadership level, and the management needs to implement these within the business. Likewise in this situation, the implementation is not aligned with the targets yet. The communication chain is not smooth, as change requires persistent repeated communication of the vision among stakeholders. Companies with strict rigid processes are prone to integrating advanced technologies and undergoing a major change. The required processes are costly and are difficult to implement requiring extended subsidies, and when the environment for change within the manufacturers is not ready either, problems arise as well. Once implemented, the service and support may be lacking and resulting in additional issues. Speaking about on-road vehicles, it is unclear either what is expected from the social environment and the end-users to contribute to the vision, as many people do not have confidence in buying these new trendy technologies. The change does not aid much in sustainability if the vehicle itself has deficiencies and does not fulfil all the basic requirements. This is especially important while speaking about the fuelling-charging issues. There have been several tasks for governments and companies at this stage to improve the understanding of the people exactly specifying the expectations as well as reinforcing new ways of encouragement to reach them as end-users. Particularly, repeated communication about the vision and perspectives for the end-users is required as to remove roadblocks and resistance to change. To reach a successful transition and accomplish the change demands the refreeze of the embedded changes into our daily life. This stage is still not reached; thus, there are still some miles to go prior a consolidation can be chased. All processes and necessary systems during the hydrogen pathway need to be ready installed. Also, the technology users such as the transport sector need to adapt their technologies, marketing, after sales, and education of the personnel. The governments need to perform smaller adaptive changes to prevent backsliding into conventional routines and consistently monitor the change progress to be prepared for additional changes. This

requires great efforts, ranging from organising events, speeches up to special trainings to articulate the compelling alternatives that social, economic, and ecological environment can be aspired of. All stakeholders particularly, the end-users, must be convinced that the benefits outweigh the losses and costs of the change. As long as the dissatisfaction with the status quo is not achieved for all stakeholders, most of these evaluations are ignored, and the main driver for a change, i.e., dissatisfaction, is not fulfilled impeding the targets. Dissatisfaction provides the driving force for change. This brings us to the section of main challenges frankly holding this dissatisfaction in balance retarding the change.

3. Current Challenges Impeding a Successful Change to a Hydrogen Economy

The proposed change management perspective in the previous section aimed to understand the link between climate neutrality targets, its implementation, and difficulties toward a sustainable consolidation. It has been obvious that a clear vision from governments is expressed to use hydrogen energy from regenerative sources in future. In addition, the vehicle sector considers hydrogen as a serious alternative to reach their increasingly sustainability objectives. Many demonstration projects have been running world-wide to implement hydrogen technologies within the transport sector. However, the focus of this current section is to emphasize the current challenges we face within the second stage of the change process. It has been highlighted that various drivers including politics, social, ecologic, economic, and technological ones interact to decarbonise the sectors including the transport. The current section depicts the current challenges, which are crucial.

3.1. Political and Ecological Challenges

The role of national and international governments is critical throughout the transition to hydrogen technology and its use in the new energy vehicles. There has been great upsurge of political attention so far despite not yet having reached a multilateral commitment. Even in the Paris Climate Agreement of 2015, it has been stated that no legally binding commitments or targets have been agreed for individual states. Thus, each country takes responsibility to achieve its nationwide goals to fulfil the global targets. Research shows that the link between climate change and its effects on earth systems has been understood but challenged to find meaningful responses at the national level. This has been attributed to the ability to act by the politicians as well as the everyday politic effect, i.e., pressure from electors [24]. Organisations such as the International Energy Agency, International Association for Hydrogen Safety or the Hydrogen Council monitor the world-wide progress. Without getting into individual details of the advances in each country or region, it is targeted to exemplify the impact of politics with some cases of the EU and China. As one of the major economies, the EU Commission adopted a new strategy on hydrogen in 2020 supporting the Green Deal being 2050 climate neutral [25]. This has been extended with recent protocols to target at least 55% net reduction in greenhouse gases by 2030. The green deal aims to bring together different stakeholders to the international dimension. In its roadmap aims and how to achieve section of the initiative, it has been stated that its focus is to “*identify the main barriers that currently prevent scaling-up the production and use of clean hydrogen; use of clean hydrogen in a cost-effective way; cost efficient EU infrastructure; and consultation of citizens for better regulation*”. These points emphasized in the initiative align well with the challenges in change stage one and two mentioned in the previous section of the current article. The desire to integrate social involvement via events and workshops supports the change management suggestions awakening more awareness and improve communication among all stakeholders. Besides these optimisation attempts in the strategy, there have been serious initiatives for the implementation phase of the overall change target. Therefore, collaborative expansion of strategic hydrogen initiatives at the regional, supraregional, and international level aim to bring together stakeholders from academia, government, funding bodies, and the industry to serve as a platform for supporting the implementation procedure. Through the EU Science Hub, various initiatives encompassing research and development, demonstration, application, and standardization of hydrogen

applications are supported. As priority areas for road transport, electric vehicles, alternative fuels, and hydrogen fuel cell vehicles are defined where efforts are given to support the technological innovation within these fields. As Asia Pacific is estimated to be the largest market for the new energy vehicles; a high demand for advances in fuel cell technology owing to the growing use of fuel-cell-powered vehicles in the region is further expected. Having led the adoption of battery electric vehicles (BEVs), China has updated its previous initiative policies that have been progressing since the 1990s. The country has initiated the Thousands of Vehicles, Tens of Cities (TVTC) Program to accelerate the development and implementation of new energy vehicle (NEV) commercialisation. Accordingly, the new energy vehicles technology roadmap expects fuel cell vehicle FCV stocks around 1 million in 2030. To reach the goal, three phases are initiated as depicted in Figure 4.

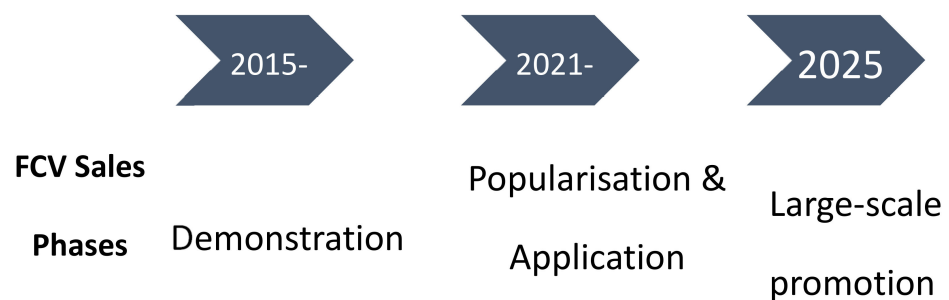


Figure 4. Three phases incentive policy of China for fuel cell vehicles.

From the early phase dominated by demonstrator vehicles up to the popularisation stage, the financial support policy for new energy vehicles 2016–2020 released a subsidy of around 200,000 RMB (~31,000 USD) for each passenger vehicle and 500,000 RMB (~77,500 USD) for each middle/heavy duty bus or truck. This will be extended for fuel cell vehicles until 2022, excluding vehicles with swap-batteries and those costing over ~\$40,000). The subsidy amount will be reduced by 20% in 2021 and 30% in 2022. Due to the large subsidy opportunities, increasing participation of start-ups is observed. Meanwhile, special joint ventures between globally active companies and local Chinese natural gas station construction companies exist to increase the number of hydrogen fuelling stations targeting particularly hydrogen electric buses. The stations built across China are currently around 70. The US Department of Energy predicts that the cost of producing hydrogen power will continue to fall from \$6 kg⁻¹ in 2015 to \$2 kg⁻¹ by 2025, which is motivating. Several studies in the literature have further discussed the political challenges and the progress considering the urbanisation, economics, role, and involvement of industry as well as marketing strategies [4,6–8,21–27]. Particularly, ongoing activities in the field of climate change, implementation of fuel cell technology, and urbanisation and public investments [28–33] are depicted. It should be noted that policy examples from leading economies such as USA, Korea, and Japan are not discussed as to limit the topic on the policy impact on the change process. It can be summarised that increasing policy efforts may spark a dramatic increase in the use of hydrogen fuel-cell-powered vehicles across the world over the next decade by increasing the support and acceptance.

3.2. Technological Challenges

The transport sector has been one of the most important global players within the climate change chain. A two-way interaction between political decisions and new energy vehicle development and deployment is unfortunately not solving the whole problem, as mastering the relevant technologies is a key factor and pre-requisite to successfully implement change. Before discussing the individual topics of the technological side, a brief reminder of the existing technologies relevant for the new energy vehicles has been depicted for an improved understanding. As mentioned earlier, hydrogen (ideally green) being proposed as a new fuel for transportation is targeted to be produced by water electrolysis from renewable energies. In order to realise reductions in emissions as well as to improve energy conversion efficiencies,

the transport sector focuses on the so-called new energy vehicles (NEVs). These are driven by electrical energy (through an electrically driven motor) stored in batteries, capacitors, or utilising energy converters such as fuel cells. EVs [34–37] are proven to be more efficient than internal combustion engines powered by means of fossil fuels. The currently used electric vehicles can be classified into three basic types: battery electric vehicles (BEVs) [38–40], fuel cell electric vehicles (FCEVs) [41–44] and fuel cell hybrid electric vehicles (FCHEVs) [45–49]. Figure 5 demonstrates some fuel-cell-powered vehicle from China where the public transport plays an important role.



Figure 5. The use of fuel cell electric vehicles is progressing in many cities across China.

Battery electric vehicles (BEVs) use a battery or capacitor as the main energy source. The battery is integrated in the vehicle and is charged from the grid. The advantage of this configuration is that it has the lowest mechanical powertrain. The fuel cell electric vehicle powertrain has a similar configuration using a fuel cell energy converter instead of battery or capacitor, whereas the FCHEV powertrain, as the name implies, combines the battery and fuel cell technologies and is also known as range extenders. It aims at the combined use of both energy storage systems and energy converters to power the vehicle. Figure 6 illustrates a typical battery electric vehicle using a fuel cell system as range extender.

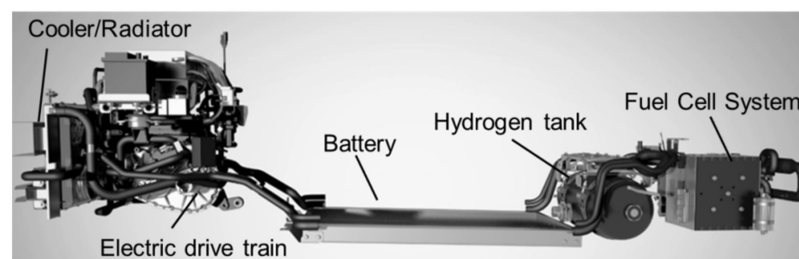


Figure 6. Typical fuel cell range extended electric vehicle: Multiple systems are combined to form a hybrid technology solution [49].

BEVs can only travel a short distance, and the top speed is restricted, which makes this type of vehicles suitable for stop-and-run driving conditions. There have been lots of discussion of advantages and disadvantage of each configuration discussed [50,51]. Without diving deep into the details, some aspects were intended to be mentioned where battery systems still face significant challenges; thus, the use of fuel cell energy utilising

hydrogen is considered in long-term strategy roadmaps. This improves the understanding and sheds light on several questions.

First of all, batteries are still expensive, and the charging of the battery is time consuming; this is why the range of these vehicles is limited. The International Energy Agency has several price expectations given for 2019 as 156 USD/kWh [52] that is currently not achieved. Each battery is also designed following a trade-off between energy and power density. Considering BEVs, the battery is generally sized by the energy requirements to allow a certain range to be reached. Among types such as Li-ion, nickel metal hydride battery (Ni-MH) or sodium nickel chloride, the Li-ion technology is favoured due to its high electrochemical potential and a low equivalent mass. However, in any case, most of the BEVs utilise a mass ranging between 100 and 500 kg for a range of about 150 km. This leads to increased costs with reduced energy efficiencies. Moreover, safety issues such as fires and destruction and delamination due to overcharging, are another weak point that has been attempted to be controlled with advancing battery management systems. Material availability, together with charging stations is limiting the technology. These aspects are important for the logistics sector for example, as many companies drive nights long distances exceeding the battery-powered technologies; thus, they are not willing to invest in multiple technologies for their fleets. Currently, the hybrid (using multiple technologies in one vehicle) range extender solutions using fuel cell battery combinations are tending to lower the capital costs by downsizing the battery as well as extending range. However, the charging infrastructure is still a limiting factor. Charging stations and full battery switching stations are ideas; however, as a part of increased costs, they are associated with dangers where high-voltage electric connections are considered upon opening some sections of the vehicle. The literature reveals some technical details about the individual issues and solution suggestions [53,54]. The other new energy vehicle type considered is the fuel cell electric vehicle. These vehicles can utilise direct hydrogen generated by renewable technologies, which is then stored in a tank mounted to the vehicle. The oxygen supply required for the electrochemical reactions is either supplied through air or in special applications in form of oxygen tanks. The used fuel cell technology provides high energy densities, quiet operation, and their modularity allows for easy construction. Apart from being used in mobile, stationary, and portable applications, they became important in powering vehicles as a main energy source used for long driving distances. Fuel cells are electrochemical converters that have been researched since decades [51–62]. Various fuel cell types according to their electrolyte types and application temperature have been widely studied. Two types, namely the polymer electrolyte membrane fuel cells and the solid oxide fuel cell technology [63–69], have reached commercialisation and great attention; particularly in residential and transport technologies. The literature reveals all aspects of fuel cell technology development, ranging from multi physics design and development [70–76] to integrated systems for combined heat and power sources [77–80]. The pros and cons of each technology have been widely demonstrated. Despite the trend to put more efforts in the SOFC technology due to high efficiencies, the dominating technology currently for vehicle and transport purposes is the PEM variant with its lower application temperature [81–83]. Issues such as cold-start [84–86], durability, and stress induced failure [87,88], as well as still ongoing control strategies regarding purge and drain procedures, i.e., water management [68,89–92] cell degradation due to voltage issues and thermal management [93], are major component-based issues. These can be extended with challenges in an overall efficient cooling system, electronic system including the fuel cell control unit, and if range extender concept is considered, then the battery management system, vehicle control unit, and hydrogen safety concept at vehicle level. The infrastructure of hydrogen fuelling is another aspect that is mitigating the progress in change similar to the charging issue in batteries but on a more complex scale. Apart of the huge cost of the hydrogen filling stations, the transport of the hydrogen as liquid has limited permission in some regions, where gas transport is prohibited due to the nature of hydrogen requiring high pressurisation. Centrally located hydrogen production can produce more fuel but

delivery costs increased which suggests the distributed facilities in turn again with higher production costs due to low volume. Many researchers focus on these topics to solve these issues [94,95]. Finally, all the safety issues posed during generation, transport, and use of hydrogen are highly sophisticated topics [96–99]. Ultimately, the hydrogen topic is on its own a persisting challenge that impedes the change in terms of technology incredibly.

3.3. Social Challenges

As mentioned earlier, to implement a change and consolidate it in the third stage by refreezing and stabilising the desired changes requires acceptance from the societies as most of the end-users regarded as consumers would be the game changer in success and failure. The preferences considering the charging, product variety, benefit of use, and price comparison to conventional vehicles, as well as performance level, are influences. A dissatisfaction of the status quo was the key word to initiate an acceptance among the community. However, the example from the logistic sector given in the previous section indicates the concerns to change running systems that on the other hand prevent a successful change. The conversion of strategy into action has simply not received full recognition yet. A recent study reviewed with great detail the consumer perspective to BEVs [100]. The study investigated demographic, situational, and psychological factors that are social aspects. Technical issues also mentioned in the previous section such as driving range, charging problem, and purchasing cost comprise the main barriers of social concern. Ultimately, these factors support the stage two implementation discussions highlighting the guidance need for consumers that should adopt EVs and are determined to be a missing factor. Actually, the same arguments are also valid for hydrogen fuel cell powered vehicles.

4. Concluding Remarks

The following article aims to review the link between the global climate change strategies for CO₂ mitigation and the proposed hydrogen technology towards the solution of environment-friendly new energy vehicles. Despite that still more than 70% of hydrogen is produced using natural gas, green hydrogen produced by regenerative sources using Power-to-X technologies is the strategy proposed for a change to climate neutrality. Solely the emissions resulting from mobility in Europe is more than 50%. Targeting the wide use of new electric vehicles that operate on batteries and fuel cells is a challenging milestone. The article uses a three-stage change management approach to critically discuss the so-called unfreeze, change, and refreezing phases during a long-term change process. The progress in relation to the decided strategies show that the change has already difficulties in the unfreeze phase as well as the stage two where the implementation of change should ideally take place. Thus, a refreeze stage consolidating a new status quo is not in sight yet. The challenges impeding the progress of a successfully change management have been reviewed. Grouping the challenges under political and ecological, technological, and social aspects enable one to have a thorough understanding. The interactions play a significant role; therefore, feasible adaptive strategies are required during continuous monitoring set by policies. Breakthroughs are only possible by successful implemented key technologies within the whole hydrogen chain. This includes the generation, distribution, and utilisation of hydrogen, the continuous development in fuel cell and battery technologies that are affecting the technology user in this case the vehicle sector with its major impact on the climate neutralisation. The social component plays a significant role affecting directly the total sales share. Consumer awareness, product and infrastructure, and price play a major role here. In the next step, detailed analyses and roadmaps for individual change stages is required. Technology implementation needs to be in exchange with improved communication and all stakeholders so as to build a strong dissatisfaction foundation that should be further investigated in detail.

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