Pisco Med Publishing doi:10.18282/pef.v12i1.3308

Original Research Article

Challenges of a sustainable energy and vehicle-related value chain for BEVs and FCEVs through the 5th wave theory

David Novak*, **Hamid Doost Mohammadian***

School of Business and Economic, Center of Sustainable Governance (CSG), University of Applied Sciences (FHM), Bielefeld 33602, Germany.

* **Corresponding author:** David Novak, david.novak1@t-online.de; Hamid Doost Mohammadian, Hamid.Doost@fh-mittelstand.de

Abstract: The transition to sustainable energy and transportation systems presents complex challenges for the value chain of battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs). These challenges are explored through the lens of the 5th wave theory, which predicts the emergence of a new technological paradigm based on clean energy and mobility. One major challenge is the need for a comprehensive infrastructure to support the production, distribution, and consumption of sustainable energy and clean transportation. This includes charging stations for BEVs and hydrogen refueling stations for FCEVs, as well as renewable energy sources such as solar and wind power. Another challenge is the need to develop a circular economy for the production and disposal of BEV and FCEV components, including batteries and fuel cells. This requires designing products for reuse, recycling, and remanufacturing, as well as establishing collection and recycling systems that are both economically and environmentally sustainable. The shift to sustainable energy and transportation requires significant changes in consumer behavior and preferences, as well as policy and regulatory frameworks to support the adoption of BEVs and FCEVs. This includes measures such as incentives for the purchase of clean vehicles, as well as emissions standards and carbon pricing to incentivize the transition to low-carbon transportation. Addressing these challenges will require collaboration across the entire value chain, from vehicle manufacturers and energy providers to policymakers and consumers. By embracing the 5th wave theory and working together to create a sustainable energy and vehicle-related value chain, we can pave the way for a cleaner, greener, and more equitable future.

Purpose: In the overall context of global earth overheating (often downplayed as "climate change"), BEVs and FCEVs are at the core of the road mobility solution to be sought. Although this is recognized in expert circles and now even by most politicians worldwide, there are still many challenges in this regard. The purpose of this paper is to analyze the challenges of establishing a sustainable energy and vehicle-related value chain for battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs) through the 5th wave theory. The paper aims to identify the key challenges and propose solutions for establishing a sustainable value chain for these vehicles.

Design/methodology/approach: The aim was to find out what challenges still exist around the implementation of BEVs and FCEVs. Germany and the EU are exemplary here for most industrialized countries. This paper uses a qualitative approach to analyze the challenges of establishing a sustainable value chain for BEVs and FCEVs through the 5th wave theory. The study is based on a review of existing literature and case studies of countries that have implemented sustainable energy and transportation systems.

Findings: Most people have come to understand that anthropogenic global overheating can only be solved by new technologies (which cost money, time, and behavioral change) in production and application. BEVs and FCEVs appear to be an essential part of the desired solution. Nevertheless, there are currently still numerous challenges and also concrete concerns worldwide, which partially cast the implementation in a questionable light. The findings suggest that establishing a sustainable value chain for BEVs and FCEVs requires a comprehensive infrastructure, circular economy principles, and changes in consumer behavior and policy frameworks. The paper proposes solutions for addressing these challenges, including the establishment of charging and hydrogen refueling stations, the development of circular economy principles for the production and disposal of BEV and FCEV components, and the implementation of policies to incentivize the adoption of clean vehicles.

Affected countries: The situation described here relates to Germany and the EU countries, but it is likely to be comparable, or at least similar, for many industrialized countries. The challenges and solutions proposed in this paper are relevant to countries worldwide that are transitioning to sustainable energy and transportation systems. The paper includes case studies of countries such as Germany, and the EU countries, that have made significant progress in establishing a sustainable value chain for BEVs and FCEVs.

Research/future/practical implications: Yes, there are various hurdles in the introduction of BEVs and FCEVs. Leading association bosses, ministers and government leaders may not want too many changes too quickly themselves; business sees it as an immense cost factor (not to mention technical changes) and private individuals act according to their own motivational factors. In conclusion, it can be assumed that the ability to make money or reduce one's costs with BEVs/FCEVs can be the fastest accelerator in their adoption. This can then best be achieved with simple "out-of-the-box" solutions in mindset (see Novak triangle)[1]. The research implications of this paper include the need for further research on the challenges of establishing a sustainable value chain for BEVs and FCEVs and the effectiveness of the proposed solutions. The future implications of this paper include the importance of establishing a sustainable value chain for BEVs and FCEVs to mitigate climate change and reduce dependence on fossil fuels. The practical implications of this paper include the need for collaboration across the entire value chain to establish a sustainable infrastructure for sustainable energy and transportation systems.

Originality/value: Currently, there are virtually no scientific books that would present the overall context of the challenges around BEVs and FCEVs at a glance. Therefore, only current surveys, market volumes and challenges in environmental and working conditions can be described here. This paper contributes to the literature on sustainable energy and transportation systems by analyzing the challenges of establishing a sustainable value chain for BEVs and FCEVs through the 5th wave theory. The paper proposes solutions for addressing these challenges and includes case studies of countries that have implemented sustainable value chains for these vehicles. The paper provides valuable insights for policymakers, industry stakeholders, and researchers working towards a sustainable energy and transportation future.

Keywords: global earth overheating; hydrogen H_2; battery electric vehicles (BEVs); the 5th wave theory; 7PS model; fuel cell electric vehicles (FCEVs); Novak triangle-motivation/decision making for people to act

JEL codes: D91, Q01, Q42, Q49, Q54, Q56, Q57, R41

Received: 26 February 2023; **Accepted:** 16 May 2023; **Available online:** 21 September 2023

1. Introduction

The transformation to a BEV or FCEV mass market poses challenges for the entire value chain. Starting with politics and the generation of regenerative energy, the charging and hydrogen filling station infrastructure must also be established or built up and the most complete possible recycling of used accumulators must be considered. In addition, there are currently still massive social/humanitarian and ecological problems/misdevelopments in the extraction or mining of basic materials such as lithium and cobalt. However, all this can only be solved by the state getting its own citizens to do what it wants. The solution is probably the implementation of the Novak triangle model[1]. The world is facing a critical challenge of transitioning towards sustainable energy and transportation systems to mitigate climate change and reduce dependence on fossil fuels. Battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs) are key components of this transition, but establishing a sustainable value chain for these vehicles presents complex challenges. These challenges include the need for a comprehensive infrastructure to support sustainable energy and clean transportation, the development of circular economy principles for the production and disposal of BEV and FCEV components, and changes in consumer behavior and policy frameworks to incentivize the adoption of clean vehicles. The 5th wave theory predicts the emergence of a new technological paradigm based on clean energy and mobility. This paper analyzes the challenges of establishing a sustainable value chain for BEVs and FCEVs through the lens of the 5th wave theory. The paper proposes solutions for addressing these challenges and includes case studies of countries that have made significant progress in establishing sustainable value chains for these vehicles. The paper's findings suggest that establishing a sustainable value chain for BEVs and FCEVs requires collaboration across the entire value chain, from vehicle manufacturers and energy providers to policymakers and consumers. The paper concludes by highlighting the importance of establishing a sustainable value chain for BEVs and FCEVs to pave the way for a cleaner, greener, and more equitable future.

2. Background

2.1. The 5th wave/tomorrow age theory or theory of comprehensive everything

Hamid Doost Mohammadian's 5th wave or Tomorrow Age theory, also known as the Theory of Comprehensive Everything (2010–2017)[2–11], proposes a new era of human development that is driven by technological advancement, globalization, and sustainability. This theory provides a framework for understanding the complex challenges and opportunities associated with transitioning towards a sustainable energy and vehicle-related value chain for BEVs and FCEVs. According to the 5th wave theory, humanity is currently in the midst of a transformative period that is characterized by the convergence of multiple waves of technological, economic, social, and environmental change. This convergence is leading towards the creation of a new paradigm of development that is characterized by the integration of all aspects of human activity, including energy and transportation. The 5th wave theory proposes that the sustainable energy and vehicle-related value chain for BEVs and FCEVs represents a critical element of this new paradigm of development. The integration of clean energy sources, electric vehicles, and sustainable transportation infrastructure is seen as essential for creating a more resilient and sustainable future. Moreover, the 5th wave theory emphasizes the importance of collaboration across the entire value chain, including policymakers, businesses, consumers, and other stakeholders, in order to achieve a comprehensive approach to sustainable energy and transportation systems. This collaboration is essential for overcoming the challenges and obstacles associated with the transition towards a sustainable energy and vehicle-related value chain.

- **Aims:** The aim of Doost's 5th wave or Tomorrow Age theory is to provide a comprehensive framework for understanding the transformative period that humanity is currently undergoing. The theory aims to promote collaboration, innovation, and comprehensive approaches to achieving a sustainable future, including in the area of energy and transportation systems.
- **Main topic:** The main topic of this theory is the convergence of multiple waves of technological, economic, social, and environmental change that is leading towards the creation of a new paradigm of development. This new paradigm is characterized by the integration of all aspects of human activity, including energy and transportation.
- **Why:** The Tomorrow Age theory is necessary because of the complex challenges and opportunities associated with the transition towards a sustainable future. This transition requires a comprehensive

approach that integrates all aspects of human activity and involves collaboration among all stakeholders, including policymakers, businesses, consumers, and other actors.

- **When:** This theory was first proposed, introduced, developed by Hamid Doost Mohammadian in 2010–2017[2–11].
- **Who:** Hamid Doost Mohammadian is the primary author and proponent of the 5th wave or Tomorrow Age theory or theory of comprehensive everything.
- **Whom:** The 5th wave or Tomorrow Age theory is relevant to policymakers, businesses, consumers, and other stakeholders who are involved in the transition towards a sustainable future, including in the area of energy and transportation systems.
- **Where:** The theory of comprehensive everything is applicable globally, as the challenges and opportunities associated with sustainable development are relevant to all countries and regions.
- **Expected results:** This theory is expected to promote collaboration, innovation, and comprehensive approaches to achieving a sustainable future, including in the area of energy and transportation systems. The theory may also inform policymaking and business strategies in this area.
- **Future concerns:** The transition towards a sustainable future, including in the area of energy, sustainable energy, and transportation systems, presents a number of challenges and uncertainties. These include technological, economic, social, and environmental challenges, as well as geopolitical and institutional factors.
- **Expected conclusions:** The mentioned theory suggests that a comprehensive approach, informed by collaboration and innovation, is necessary to overcome the challenges associated with the transition towards a sustainable future. The theory emphasizes the importance of integrating all aspects of human activity, including energy and transportation, to create a more resilient and sustainable future.

Prof. Doost's 5th wave theory (known as tomorrow age theory or theory of comprehensive everything) is a comprehensive framework for understanding, forecasting, preventing, and facing the complex today's challenges and tomorrow's crises to provide a comprehensive readiness for tomorrow's sustainable energy challenges, crises, and concerns at the first edge of tomorrow which is from 2020–2030 for providing opportunities associated with sustainable development and these today's challenges and tomorrow's crises waves at the first edge of tomorrow (regarding future concerns for sustainable energy) are as below which is shown in **Figure 1**.

- Risk of contagion of Covid-19,
- Crises of contagion of the other biological attack,
- Risks caused by economic shift and rescission,
- Crises caused by social anxiety,
- Challenges by high greenhouse gas emissions and climate pollution,
- Crises caused by climate change,
- Crises caused by technologies,
- And finally, crises caused by biodiversity collapse.

2.2. The waves/ages (1st, 2nd, 3rd, and 4th waves)

Every day, the globe changes due to human civilization progress and technological advancement. For example, in four stages, the Industrial Revolution transitioned from water and steam power mechanization to mass manufacturing to information technology.

2.2.1. First wave (Agriculture Age)

The earliest wave, referred to as pre-industrial, or Industry 0.0, began approximately 70,000 years ago using fire, light, and wheels. This was primarily about mechanical manufacturing and farm business.

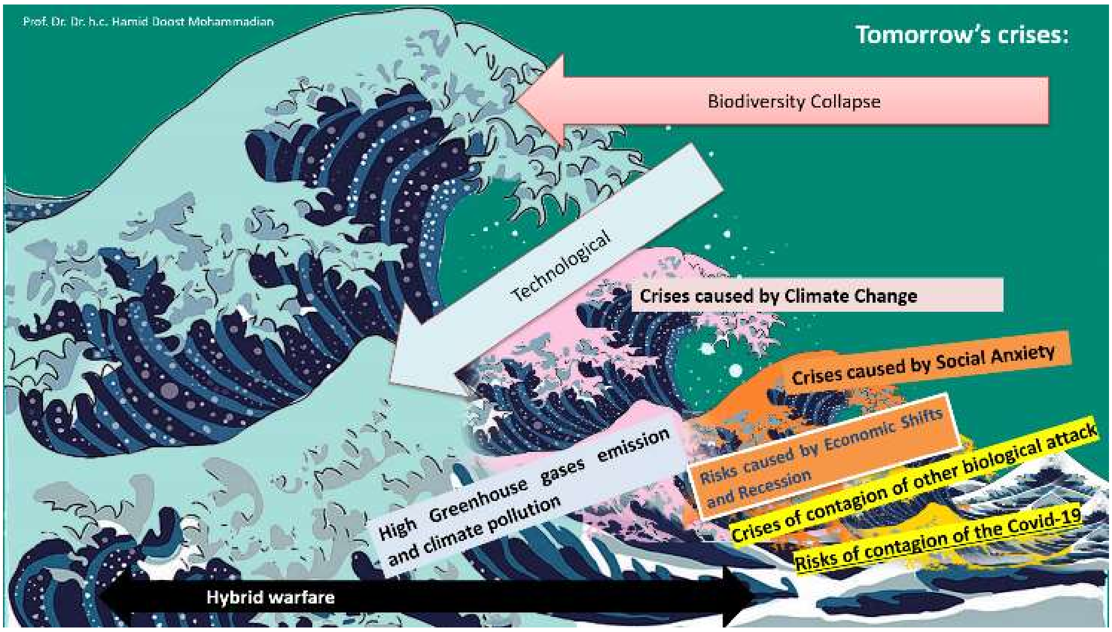

Figure 1. Tomorrow's crises (future concerns) waves at the edge of tomorrow[8].

2.2.2. Second wave (Industrial Age)

The second wave began around the 17th century, with the implementation of steam power, mechanization, chemical industry, and water machine, collectively referred to as Industry 1.0, in addition to mass production, assembly lines, and electrical energy collectively referred to as Industry 2.0.

2.2.3. Third wave (Post Industrial Age)

Industry 3.0 was founded on the growth of computers, automation, electronics, and information and communication technologies over the 20th century.

2.2.4. Fourth wave (Digitalization Age)

The fourth wave is sometimes referred to as Industry 4.0. It emerged in the second half of the 20th century due to the digitization and automation of every component and production process within a business. As a result, it has a tremendous impact on all parts of life, not just productivity.

The Tomorrow Age theory provides a useful framework for understanding the complex challenges and opportunities associated with establishing a sustainable energy and vehicle-related value chain for BEVs and FCEVs. This theory emphasizes the importance of collaboration, innovation, and comprehensive approaches to achieve a more sustainable future. **Figure 2** shows the comprehensive view of the societies and industries of the 5th wave theory.

The 5th wave theory is a conceptual and practical topic that describes a new wave of technological development in which renewable energy and communication technologies will converge to create a highly interconnected and sustainable society[13]. This wave is also referred to as the Internet of Things (IoT) and is characterized by the integration of various technologies, including renewable energy sources, electric vehicles, and smart grids. The transition to a sustainable energy and vehicle-related value chain for battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs) presents significant challenges in terms of infrastructure, technology, and policy. This transition involves the integration of renewable energy sources into the electricity grid, the establishment of a network of charging and refueling stations, the development of cost-effective and high-performance batteries and fuel cells, and the implementation of supportive policies and regulations. One of the major challenges is the establishment of a reliable and cost-effective infrastructure for charging and refueling BEVs and FCEVs. This requires the deployment of a network of charging and refueling stations that can meet the growing demand for electric and hydrogen vehicles. The deployment of such infrastructure requires significant investment and coordination among various stakeholders, including automakers, utilities, government agencies, and private investors. Another significant challenge is the development of cost-effective and high-performance batteries and fuel cells. The current generation of batteries and fuel cells has limited energy density, range, and durability, which restricts the adoption of electric and hydrogen vehicles. Therefore, there is a need to develop new materials and manufacturing processes that can improve the performance and reduce the cost of batteries and fuel cells. In addition to these technological challenges, the transition to a sustainable energy and vehicle-related value chain for BEVs and FCEVs requires supportive policies and regulations. These policies should provide incentives for the adoption of electric and hydrogen vehicles, promote the deployment of renewable energy sources, and encourage the establishment of a network of charging and refueling stations. The transition to a sustainable energy and vehicle-related value chain for BEVs and FCEVs requires significant investment, innovation, and collaboration among various stakeholders. It also presents significant opportunities for economic growth, job creation, and environmental sustainability.

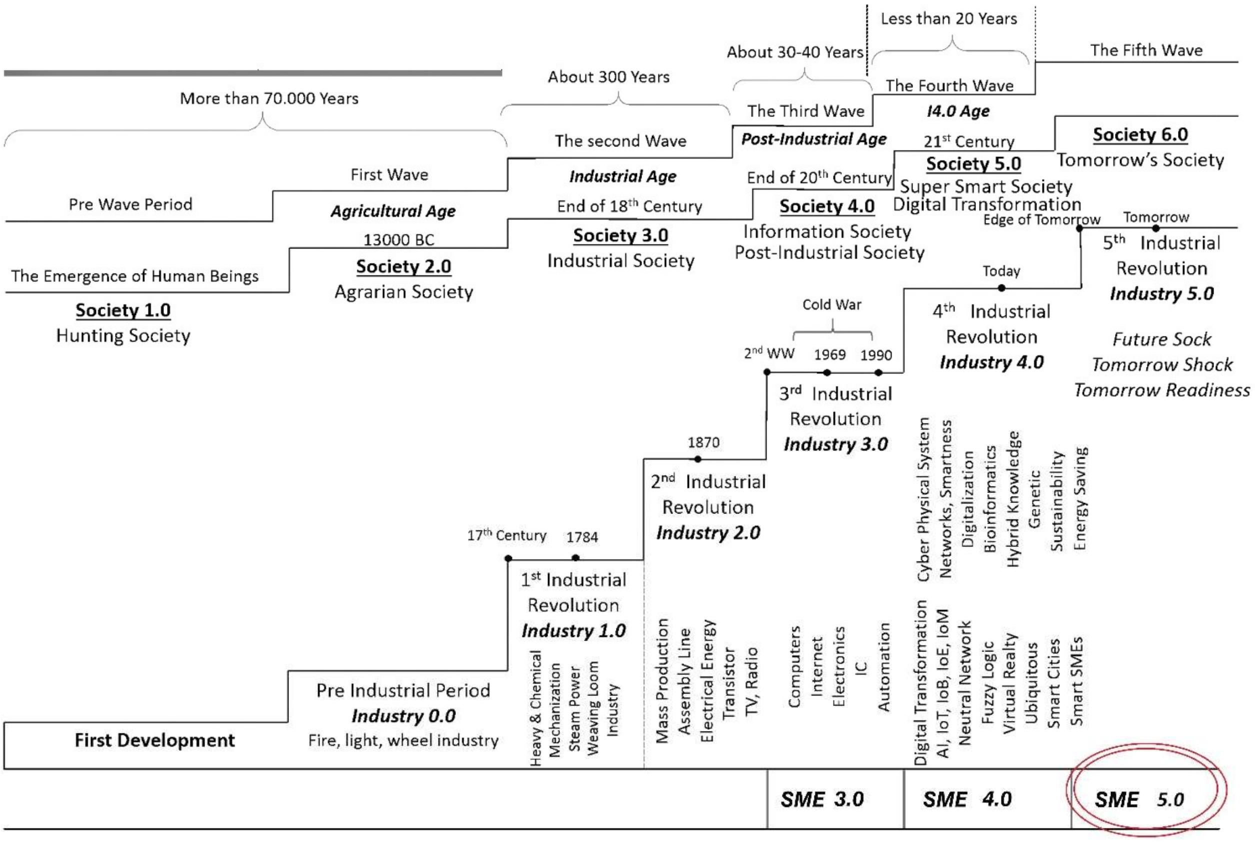

Figure 2. A comprehensive view of the societies and industries of the 5th wave theory[12].

2.3. Seven pillars of sustainability (7PS) model

The 5th wave theory is based on some related theories, models, methods, and concepts. One of these main models is the seven pillars of sustainability (7PS) model proposed by Hamid Doost Mohammadian[2–11]. The 7PS model, provides a framework for understanding the different dimensions of sustainability. The model identifies seven key pillars, with culture being given the highest priority, followed by environmental, social, economic, educational, technical, and political pillars. In addition, the model also emphasizes the importance of peace and love in achieving sustainability. When it comes to challenges of a sustainable energy and vehicle-related value chain for BEVs and FCEVs through the 5th wave theory, the 7PS model can be useful in addressing sustainability concerns related to these technologies. For example, the environmental pillar can help guide efforts to reduce the environmental impact of the production and use of BEVs and FCEVs. The economic pillar can be used to ensure that these technologies are affordable and accessible to a wide range of consumers, while the technical pillar can provide guidance on how to optimize the performance and efficiency of these vehicles. Overall, the 7PS model can help ensure that the transition to BEVs and FCEVs is sustainable and equitable. Doost's 7PS model is a comprehensive framework for understanding the complex challenges and opportunities associated with sustainable development which is shown in the **Figure 3**. The 7PS stand for culture, environment, society, economy, technology, politics, and peace, and represent the different aspects of human activity that need to be integrated to achieve a sustainable future. The seven pillars of sustainability model, or the 7PS model, is a framework for sustainable development that identifies seven key areas that need to be considered to achieve long-term sustainability. The priority of the pillars is as follows:

- *P1. Cultural (the first priority)*
- *P2. Environmental*
- *P3. Social*
- *P4. Economical*
- *P5. Educational*
- *P6. Technical*
- *P7. Political*

Finally, the addition of peace and love as overarching principles emphasizes the importance of promoting peaceful and loving relationships between people and with nature. It highlights the need for a holistic approach to sustainability that considers the interconnectedness of all things and promotes harmonious coexistence.

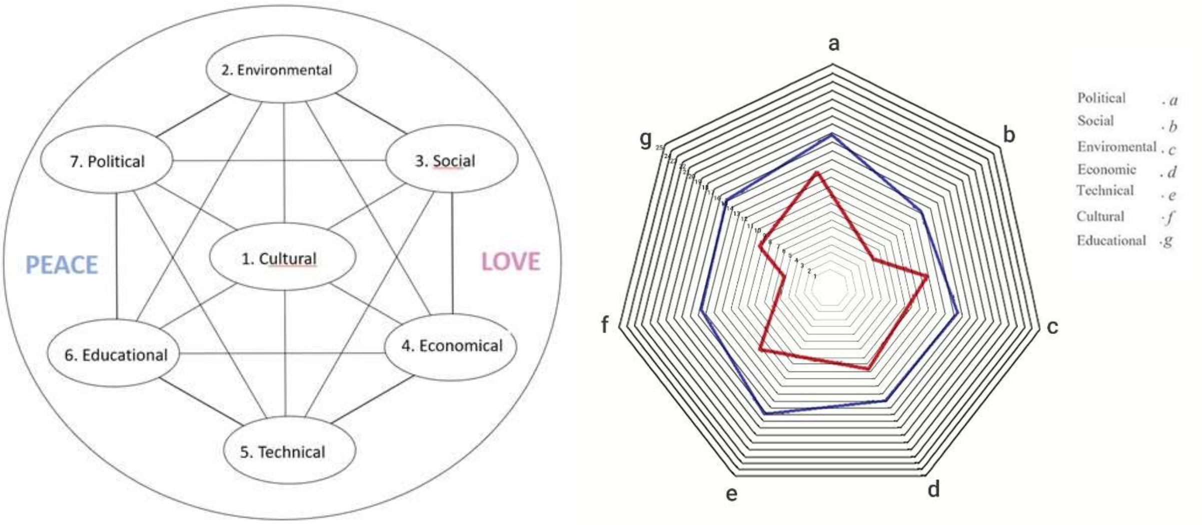

Figure 3. 7PS model with the pillars' priority, connections & peace/love[8,12].

In **Table 1**, you can see the priority of the seven pillars of sustainability model by using Fuzzy-AHP method.

Table 1. Ranking of 7PS model indexes by using Fuzzy AHP methods[12].

7PS model indicators	Source	Rank
Economical	0.324	4
Social	0.353	3
Environmental	0.382	2
Technical	0.251	5
Cultural	0.481	1
Educational	0.221	6
Political	0.175	7

Here, we will discuss how the 7PS model can be applied to the challenges of a sustainable energy and vehicle-related value chain for BEVs and FCEVs through the 5th wave theory.

- Culture: Cultural factors play an important role in shaping human behavior and values, which in turn influence the adoption and use of sustainable energy and transportation systems. For example, cultural norms and beliefs around car ownership and mobility can affect the uptake of electric vehicles (EVs). To overcome cultural barriers, it is important to promote awareness and education around the benefits of sustainable energy and transportation systems.
- Environment: The environmental impact of energy and transportation systems is a major challenge that must be addressed to achieve a sustainable future. The adoption of BEVs and FCEVs can help to reduce emissions and improve air quality, but their production and disposal also have environmental impacts that need to be mitigated. Strategies such as circular economy and sustainable production can help to minimize the environmental impact of these technologies.
- Society: Social factors, such as income inequality and access to transportation, can influence the adoption and use of sustainable energy and transportation systems. To ensure that everyone has access to these systems, it is important to address social inequalities and ensure that the benefits of sustainable development are distributed fairly.
- Economy: Economic factors, such as the cost and availability of energy and transportation systems, can also influence their adoption and use. While the cost of BEVs and FCEVs is decreasing, they are still more expensive than traditional gasoline vehicles, and there are concerns around the availability of charging and refueling infrastructure. To promote the adoption of these technologies, it is important to invest in the development of infrastructure and provide incentives for consumers and businesses to switch to sustainable energy and transportation systems.
- Technology: Technological innovation is key to achieving a sustainable energy and transportation system. The development of new and improved batteries, fuel cells, and charging infrastructure can help to improve the efficiency and usability of BEVs and FCEVs. However, there are also concerns around the environmental and social impacts of these technologies, which need to be addressed through sustainable production and disposal methods.
- Politics: Political factors, such as regulations and policies, can also influence the adoption and use of sustainable energy and transportation systems. Governments can provide incentives and subsidies for the development and adoption of these technologies, as well as regulate the production and disposal processes to ensure that they are sustainable and environmentally friendly.

Peace and love: Finally, the aspect of peace is also important to consider, as conflicts over resources and energy security can have significant impacts on sustainable development. By promoting cooperation and collaboration among different stakeholders, it is possible to reduce the risk of conflicts and ensure that the benefits of sustainable development are shared globally. The 7PS model provides a comprehensive framework for understanding the complex challenges and opportunities associated with sustainable energy and transportation systems. By integrating the different aspects of human activity, it is possible to create a more sustainable and resilient future. However, achieving this requires collaboration and innovation among policymakers, businesses, and consumers, as well as a commitment to addressing the social, environmental, and economic challenges associated with sustainable development.

2.4. Political challenges in Germany as of 2022

"EU states and parliament agree: From 2035 only emission-free new cars" is the headline of the Handelsblatt[14]. According to this, negotiators of the EU states and the European Parliament have agreed that from 2035 no more passenger cars with diesel or gasoline engines may be sold. There has been a lot of discussion about this in the German government in particular, as the FDP has advocated the use of e-fuels. E-fuels are synthetically produced fuels that bind CO_2 during production, but which are released back into the atmosphere during combustion[14]. Even though a milestone has obviously been reached in this context, steps towards an emission-free mobility sector road, it must be noted that the decision to only be allowed to sell ZEVs from 2035 onwards does not mean that no more CO_2 emissions will be emitted from 2035 onwards. Old combustion engines will still be on German roads well beyond 2035. However, the decision certainly gives hope, as it makes it clear that the EU states want to make a serious change in the automotive industry towards lower CO_2 emissions and underpin this with appropriate legislation. When examining the political challenges in Germany as of 2022 in establishing a sustainable energy and vehicle-related value chain for BEVs and FCEVs through the 5th wave theory, the seven pillars of sustainability (7PS) model can provide a useful framework for analysis. The 7PS model includes the following factors: culture, environment, society, economy, technology, and politics.

- P1: Culture: In Germany, there is a strong cultural attachment to traditional combustion engine vehicles, particularly in the luxury car market. This cultural attachment has created a barrier to the widespread adoption of electric vehicles, which may require a shift in cultural norms and attitudes towards clean transportation.
- P2: Environment: Germany has set ambitious targets to reduce greenhouse gas emissions and increase renewable energy production. However, the country's reliance on coal-fired power plants as a source of energy has been a source of controversy and has led to criticism that the country is not doing enough to transition towards clean energy sources.
- P3: Society: The lack of a comprehensive infrastructure for charging and hydrogen refueling stations is a social challenge that impacts the adoption of electric vehicles, particularly in rural areas. This issue highlights the importance of addressing social equity concerns in the transition towards a sustainable energy and vehicle-related value chain.
- P4: Economy: The automotive industry is a key player in the German economy, but the transition towards electric vehicles has posed significant challenges for the industry. The high costs of transitioning to electric vehicles and the need for investment in new infrastructure and technology may impact the industry's competitiveness in the global market.
- P5: Technology: Technological innovation is critical for establishing a sustainable value chain for BEVs and FCEVs. Germany has a strong tradition of innovation, but the transition towards clean energy and transportation systems requires significant investments in new technologies and research

and development.

- P6: Politics: The slow pace of policy implementation to incentivize the adoption of clean vehicles and the lack of a comprehensive infrastructure for charging and hydrogen refueling stations are political challenges that impact the transition towards a sustainable energy and vehicle-related value chain. However, the German government has introduced several policies and initiatives to address these challenges, including subsidies for the purchase of electric vehicles and tax incentives for companies that invest in charging infrastructure.

The 7PS model provides a useful framework for analyzing the political challenges in Germany as of 2022 in establishing a sustainable energy and vehicle-related value chain for BEVs and FCEVs through the 5th wave theory. Addressing these challenges requires a comprehensive approach that involves collaboration across the entire value chain, innovative policy frameworks, and investments in infrastructure and technology.

If Germany is now considered a member of the EU, the greatest political challenge is to achieve the goals that have been self-imposed in the context of climate protection. Specifically, this means achieving greenhouse gas neutrality by 2050 and implementing the 2030 climate protection program, which involves saving 55% of climate-damaging greenhouse gases, such as CO_2, compared to 1990[15]. In order to establish pure electromobility and hydrogen technology in the road sector, this results in further challenges.

To enable the penetration of the market by electromobility, the German Federal Cabinet adopted the so-called “Master Plan Charging Infrastructure” in November 2019. Among other things, the goal is one million charging points for electromobility and 10 million e-vehicles by 2030[15]. Looking at the past, it becomes clear that these targets are indeed ambitious. Already in 2020, we were about 18% behind the target of 50,000 charging stations[16].

With regard to hydrogen, this specifically means implementing the national hydrogen strategy from 2020. The aim of the hydrogen strategy is to consider the entire hydrogen value chain and establish it as a decarbonization option. In the long term, the focus is on green hydrogen, as only this is sustainable in the long term. Support for a rapid market ramp-up and the establishment of value chains are fixed objectives of the national hydrogen strategy. To achieve this goal, hydrogen H_2 must be made competitive, a German domestic market for hydrogen technologies must be developed, and at the same time, imports must be ramped up. Economic opportunities are also to be exploited by helping to shape and support the potential of industrial policy. This includes both financial support for research and development in the field of hydrogen H_2. To this end, the federal government has already provided 700 million euros in funding from 2006 to 2016 through the National Innovation Program for Hydrogen and Fuel Cell Technology (NIP), and a further 1.4 billion euros will follow in the period from 2016 to 2026. These funds will be used, among other things, to conduct application-oriented basic research and to strengthen real laboratories for the energy transition. They are intended to accelerate the transfer of technology and innovation from theory to practice[17].

2.5. Green hydrogen H_2 as the long-term solution for permanent sustainability

Ultimately, only green hydrogen is truly sustainable in perspective, since neither emissions nor permanent waste are produced as with nuclear energy. In this context, therefore, the question arises as to whether Germany will be able to meet the future demand for green hydrogen on its own.

If all renewable energy sources in Germany are used to produce green hydrogen at an electrolyzer efficiency of 70%, it is possible in the best case to meet the projected total green hydrogen demand of the German steel industry. That’s it. For fuel cell vehicles FCEVs, however, there is then no longer enough green hydrogen H_2 available. In addition, 50.5% of Germany’s energy production is from renewable sources—if these were only used for hydrogen production, all other electrical consumers would have to be fossil-based[18]. Thus, it is clear that there is not enough green hydrogen H_2 as of 2022. A look at the national hydrogen strategy also shows this. By 2030, generation plants for green hydrogen H_2 with a total capacity of up to 5 GW are to be built in Germany, including the offshore and onshore power generation required for this. The required electrical capacity of up to 20 TWh could produce up to 14 TWh of green hydrogen H_2, but at the same time, the German government assumes that hydrogen demand will increase from 90 to 110 TWh by 2030. Therefore, another 5 GW generation plant should also be built by 2035, 2040 at the latest, without using fossil fuels[19]. Thus, despite the planned construction of new H_2 production plants, Germany will definitely not be able to meet its own demand for green hydrogen H_2 by itself. The creation of new and diverse energy partnerships will therefore be necessary to address the deficit and is both an opportunity and a challenge proposed by Synwoldt and Novak[20].

Another challenge for green hydrogen H_2 in certain regions of the world will be the lack of sufficient fresh water, since for 1 liter of electrolysis hydrogen, at least 9 liters of freshwater, are needed. In coastal regions, seawater desalination plants can solve the problem[20]. According to a study by the Lappeenranta-Lahti University of Technology, which was commissioned by the German Energy Agency, the electrical consumption of seawater desalination plants is low (3.6 kWh/m^3) and can probably be reduced even further (2.6 kWh/m^3 in 2050)[18]. However, it remains to be seen how high the cost share for seawater desalination will actually be. While the Lappeenranta-Lahti University of Technology assumes a share of between 12% and 21% of the hydrogen production costs[18], analyses by the German Federal Ministry of Education and Research put the share at only around 1%[18]. Green hydrogen, also known as renewable hydrogen or sustainable hydrogen, is produced by splitting water into hydrogen and oxygen using renewable electricity sources such as wind or solar power. This process is called electrolysis, and it produces no greenhouse gases, making it a clean and sustainable energy source.

Green hydrogen has many potential applications in industries that require high-energy density fuels such as transportation, chemical manufacturing, and electricity generation. It can be used as a fuel for fuel cell electric vehicles (FCEVs), which emit only water and heat as byproducts, or as a feedstock for industrial processes. In terms of its potential as a solution for permanent sustainability, green hydrogen is a zero-emission fuel that can help reduce greenhouse gas emissions and combat climate change. It can also reduce dependence on fossil fuels and increase energy security. However, the widespread adoption of green hydrogen faces challenges such as high production costs, lack of infrastructure for distribution and storage, and limited scalability. Despite these challenges, the potential benefits of green hydrogen make it an attractive option for a sustainable energy and vehicle-related value chain. As renewable energy sources such as wind and solar power continue to grow, the cost of producing green hydrogen is expected to decrease, making it a more competitive alternative to fossil fuels. Additionally, as governments around the world set ambitious climate goals, green hydrogen is likely to play a crucial role in achieving those targets.

2.6. Expansion of renewable energies in Germany

The expansion of renewable energies in Germany plays a central role in the challenges that have to be taken into account in a mass market for BEVs and FCEVs. BEVs only make ecological sense if they are also charged with electricity from renewable energies. The same is true for FCEVs—the CO_2 footprint of a mid-range FCEV fueled with hydrogen from lignite is actually significantly worse than that of a mid-range internal combustion vehicle fueled with diesel or gasoline.

This is one reason why the Energy Transitions Commission (ETC) concludes “that the pace of renewable energy expansion must be increased five- to sevenfold by 2030"[18]. The reason for this is the expected increase in final electrical energy consumption to 70% in 2050, as the heating market and mobility are expected to be predominantly powered by electricity. For comparison, the share was 20% in 2022[18]. If it is assumed that the annual mileage remains constant and BEVs and FCEVs each share the road mobility sector by 50%, this results in an annual electricity demand of around 290 TWh[21]. Here, too, a comparison is worthwhile: in 2021, annual electricity generation from renewable energies in Germany totaled 233.6 TWh[22]. In order to increase the share of renewable energies in Germany, existing potentials must therefore be used and the massive expansion of on- and offshore wind energy plants, as well as solar plants, must be massively forced and proactively expanded.

According to a modeling by the Fraunhofer Institute, the theoretically achievable potential of wind energy plants in Germany is about 200 GW onshore and about 85 GW offshore. In the optimum case, an electrical output of about 400 GW could be generated by photovoltaics[21]. To exploit this potential, the installed capacity of wind turbines would have to increase by about 446% from 63.9 GW (2021) and that of photovoltaics by 680% (from 58.7 GW in 2021)[22]. If we now relate the potential outputs of wind power and photovoltaics to generation values from 2021 (wind power: 113.76 TWh, photovoltaics: 49.06 TWh[22]), this results in a potential annual electricity generation of about 507 TWh for wind power and 333 TWh for photovoltaics.

It can therefore be concluded that through the consistent and massive expansion of renewable energies in Germany, there is theoretically a high potential to generate most of today's energy demand (568.8 TWh[22]) plus the electrical energy required for electromobility (290 TWh), itself. However, it also becomes clear that Germany will not manage to become energy self-sufficient according to its own calculations. Especially if the intention is included that not only the mobility sector road should be decarbonized, but also the entire industry. New energy partnerships with non-European countries can and must lead to the realization of this goal nevertheless according to the scientists Synwoldt and Nova[20].

The expansion of renewable energies in Germany is a crucial aspect of achieving sustainable energy and reducing the carbon footprint. The 5th wave theory and 7PS model can provide a framework for addressing the challenges associated with the sustainable energy and vehicle-related value chain for battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs). In terms of the 7PS model, the environmental pillar (P2) is particularly relevant for the expansion of renewable energies. This pillar emphasizes the need to reduce environmental impacts, preserve natural resources, and promote sustainable development. By transitioning to renewable energy sources such as wind and solar power, Germany can significantly reduce its greenhouse gas emissions and contribute to global efforts to combat climate change.

However, the transition to renewable energy sources also requires attention to other pillars of the 7PS model. For instance, the economic pillar (P4) is important for ensuring that the expansion of renewable energies is financially feasible and sustainable. This could involve exploring innovative financing models, incentivizing private sector investment, and promoting the growth of new industries related to renewable energy.

The technical pillar (P6) is also crucial for the expansion of renewable energies. This pillar emphasizes the importance of developing and implementing new technologies to support sustainable development. In the case of renewable energy, this could include advancing energy storage technologies and developing more efficient and cost-effective solar and wind energy systems.

Finally, the political pillar (P7) is critical for enabling the expansion of renewable energies. This pillar emphasizes the importance of effective governance and policy frameworks to support sustainable development.

This could involve creating incentives for renewable energy investments, implementing regulations to support the transition to renewable energy, and fostering international cooperation to address global climate change challenges. The 5th wave theory and 7PS model can provide a useful framework for addressing the challenges associated with the expansion of renewable energies in Germany. By focusing on key pillars such as environment, economy, technology, and politics, Germany can accelerate its transition to a more sustainable energy future.

3. Case studies

There are several case studies that can be examined when discussing the challenges of a sustainable energy and vehicle-related value chain for BEVs and FCEVs in Germany and the EU countries. Here are a few examples:

- Germany's Energiewende (energy transition): Germany has been a leader in the transition to renewable energy sources, with its Energiewende program aiming to reduce greenhouse gas emissions by 80%–95% by 2050. The program involves a variety of measures, including the expansion of renewable energy sources, energy efficiency improvements, and the phase-out of nuclear power. The implementation of the Energiewende has faced some challenges, particularly in terms of the high costs of renewable energy subsidies and the need to address grid integration issues.

- Electric vehicle adoption in Norway: Norway has become a global leader in electric vehicle adoption, with EVs accounting for over 50% of new car sales in 2020. This success can be attributed to a variety of factors, including generous government incentives, a supportive infrastructure, and a strong cultural emphasis on sustainability. However, challenges remain, particularly in terms of ensuring that EV adoption does not exacerbate existing social inequalities and that the production of EVs does not rely on environmentally harmful practices.

- The EU's Clean Energy Package: In 2018, the European Union adopted the Clean Energy Package, a set of measures aimed at increasing the use of renewable energy sources, improving energy efficiency, and creating a more integrated energy market. The package includes targets for member states to increase their use of renewable energy sources, as well as measures to promote the deployment of smart grids and energy storage technologies. However, implementation of the package has faced some challenges, particularly in terms of ensuring that it is aligned with the EU's broader sustainability goals and that it does not have unintended negative consequences for consumers or energy market participants.

3.1. Germany

There are several factors related to Germany's sustainable energy and vehicle-related value chain for BEVs and FCEVs that can be analyzed through the lens of the 5th wave theory and 7PS model. Some of these factors include:

- Government policies: Germany has implemented several government policies to promote the use of renewable energy and electric vehicles, such as subsidies for purchasing EVs and the development of charging infrastructure. These policies align with the 7PS model's focus on political and economic pillars.
- Technological advances: Germany is home to several leading automotive manufacturers, which are investing heavily in the development of BEVs and FCEVs. This aligns with the 5th wave theory's focus on high 4th and 5th technologies.
- Cultural factors: Germany has a strong culture of environmentalism and sustainability, which has

influenced consumer preferences towards more environmentally-friendly transportation options. This aligns with the 7PS model's focus on cultural and social pillars.

- Economic factors: The growth of renewable energy and electric vehicles has created new economic opportunities in Germany, such as the development of new industries and job creation. This aligns with the 7PS model's focus on economic and educational pillars.
- Infrastructure: The expansion of charging infrastructure for electric vehicles is a critical factor for promoting their adoption in Germany. This aligns with the 5th wave theory's focus on digital readiness and recovery strategies.

These factors can be analyzed and assessed using the 5th wave theory and 7PS model to better understand the challenges and opportunities for sustainable energy and transportation in Germany.

3.2. The EU countries

As case studies for EU countries, the factors affecting the sustainable energy and vehicle-related value chain for BEVs and FCEVs through the 5th wave theory include:

- Regulatory environment: EU countries have different policies and regulations related to renewable energy, carbon emissions, and energy efficiency. The regulatory environment can affect the adoption and implementation of sustainable energy and vehicle-related value chain solutions.
- Infrastructure development: The development of infrastructure for renewable energy sources and charging infrastructure for electric vehicles is critical for the successful implementation of sustainable energy and vehicle-related value chain solutions.
- Technology development: Advancements in technology related to energy storage, hydrogen fuel cells, and electric vehicle batteries play a crucial role in enabling the transition to sustainable energy and vehicle-related value chain solutions.
- Investment and financing: The availability of funding and investment opportunities can support the adoption and implementation of sustainable energy and vehicle-related value chain solutions in EU countries.
- Public awareness and education: Raising public awareness about the benefits of sustainable energy and vehicle-related value chain solutions and educating the public about how to use and maintain these technologies can accelerate their adoption.
- Political support: The support of policymakers and government officials at the national and regional levels is critical to achieving sustainable energy and vehicle-related value chain solutions in EU countries.
- Collaborative partnerships: Partnerships between stakeholders, including governments, private sector companies, research institutions, and non-governmental organizations, can help drive innovation and accelerate the implementation of sustainable energy and vehicle-related value chain solutions.

4. Results and discussion

4.1. Results

As per the 5th wave theory and 7PS model, the transition to sustainable energy and vehicle-related value chain is crucial for the future of Germany and the EU. This transition involves a shift towards renewable energies and the adoption of cleaner and more efficient vehicles, such as battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs).

In Germany, the expansion of renewable energies has made significant progress, with over 50% of electricity generation coming from renewable sources in 2021. However, there is still room for improvement in the transportation sector, as the share of electric vehicles (EVs) is still relatively low compared to traditional combustion engine vehicles. The German government has set a target of having 7 to 10 million EVs on the roads by 2030 and is providing incentives and subsidies to encourage their adoption.

In the EU, the transition to sustainable energy and vehicle-related value chain is also a priority. The European Green Deal, announced in 2019, sets a target of reaching net-zero emissions by 2050, and includes initiatives to promote the use of renewable energies and the adoption of EVs. The EU is also investing in research and development of new technologies, such as green hydrogen, to facilitate the transition to a sustainable energy and vehicle-related value chain.

The implementation of the 5th wave theory and 7PS model in Germany and the EU is a positive step towards achieving long-term sustainability in the energy and transportation sectors. However, it will require continued effort and investment to ensure a successful transition.

4.2. Discussion

The challenges of a sustainable energy and vehicle-related value chain for BEVs and FCEVs through the 5th wave theory and 7PS model in Germany and EU countries are complex and multifaceted. Different factors play a crucial role in addressing these challenges and ensuring a sustainable future.

- One key factor is the political will and support for the transition to renewable energy sources and sustainable transportation. Germany has been a leader in this regard, with a goal to reach 80% renewable energy by 2050 and the implementation of policies and incentives to support the adoption of BEVs and FCEVs. However, the situation is not the same in all EU countries, with some lagging behind in their efforts to transition to a sustainable energy and transportation system.

- Another factor is the availability and accessibility of renewable energy sources and the infrastructure to support them. Germany has made significant investments in renewable energy infrastructure, including wind and solar power plants and charging stations for BEVs and FCEVs. In contrast, some EU countries may face challenges in accessing renewable energy sources and building the necessary infrastructure, which could slow down their transition to sustainable energy and transportation systems.

- The cost of transitioning to sustainable energy and transportation is also a significant factor. While the cost of renewable energy has decreased significantly in recent years, it is still more expensive than fossil fuels in some cases. Additionally, the cost of BEVs and FCEVs can be higher than traditional gasoline or diesel-powered vehicles. Policies and incentives, such as tax credits or subsidies, can help offset these costs and encourage adoption.

- Finally, societal factors, such as cultural norms and consumer attitudes, also play a role. In some EU countries, there may be resistance to the adoption of BEVs and FCEVs due to a preference for traditional vehicles or a lack of awareness about the benefits of sustainable transportation. Addressing these societal factors through education and outreach programs can help accelerate the transition to sustainable energy and transportation systems.

- Addressing the challenges of a sustainable energy and vehicle-related value chain for BEVs and FCEVs through the 5th wave theory and 7PS model in Germany and EU countries requires a comprehensive approach that considers political, infrastructural, economic, and societal factors. While progress has been made in some areas, there is still much work to be done to achieve a sustainable future.

Based on the "The 5th wave theory", we need to use the new concept for SMEs in energy sector which is named "HYBRID SMEs/SME 5.0/Tomorrow's SMEs" and based on the 3D Socio-Eco-Environment SMEs model whose priorities are:

1) *Environmental responsibility*
2) *Social cohesion*
3) *Economic efficiency*

The 5th wave theory forecasted energy crisis at the first edge of tomorrow (2020–2030), which has led to the creation of communities, societies, cities, and businesses founded on high technologies, IoT, and appropriate business strategies concerned with sustainability which can create new concepts and new businesses, societies, and cities which are capable of tackling future concerns. These are commonly known as "Tomorrow's Society and Business" and "Super-Intelligent Society", and they function in a super-intelligent business environment. Another theoretical basis is the "i-sustainability plus theory", which is made up of the trinity of open innovation, sustainability, and 4.0 smart high technologies, e.g., digitization and ubiquitous and super-intelligent society (Society 6.0). This construct, which includes the idea of sustainable energy, smart society, and city, is evaluated as a new idea of urban living in tomorrow's business, and societies entitled URBAN 6.0 (invented, introduced, and developed by Prof. Dr. Hamid Doost Mohammadian). The theoretical basis for this approach is diverse, but the focus lies on the 5th wave theory, which has various implications with the below priority which is the results of the calculation of the three matrixes, which is shown in **Figures 4** and **5**:

1) SMEs with environmental responsibility including a focus on blue-green sustainable energy;
2) SMEs with social cohesion; and
3) SMEs with economic efficiency.

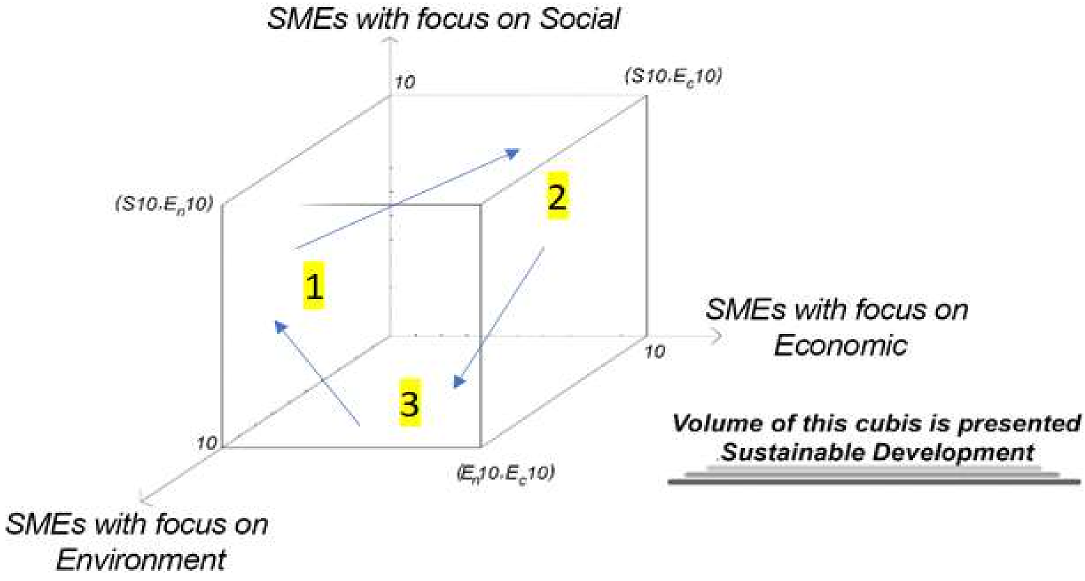

Figure 4. 3D Socio-Eco-Environmental SMEs indexes model for sustainable energy[8].

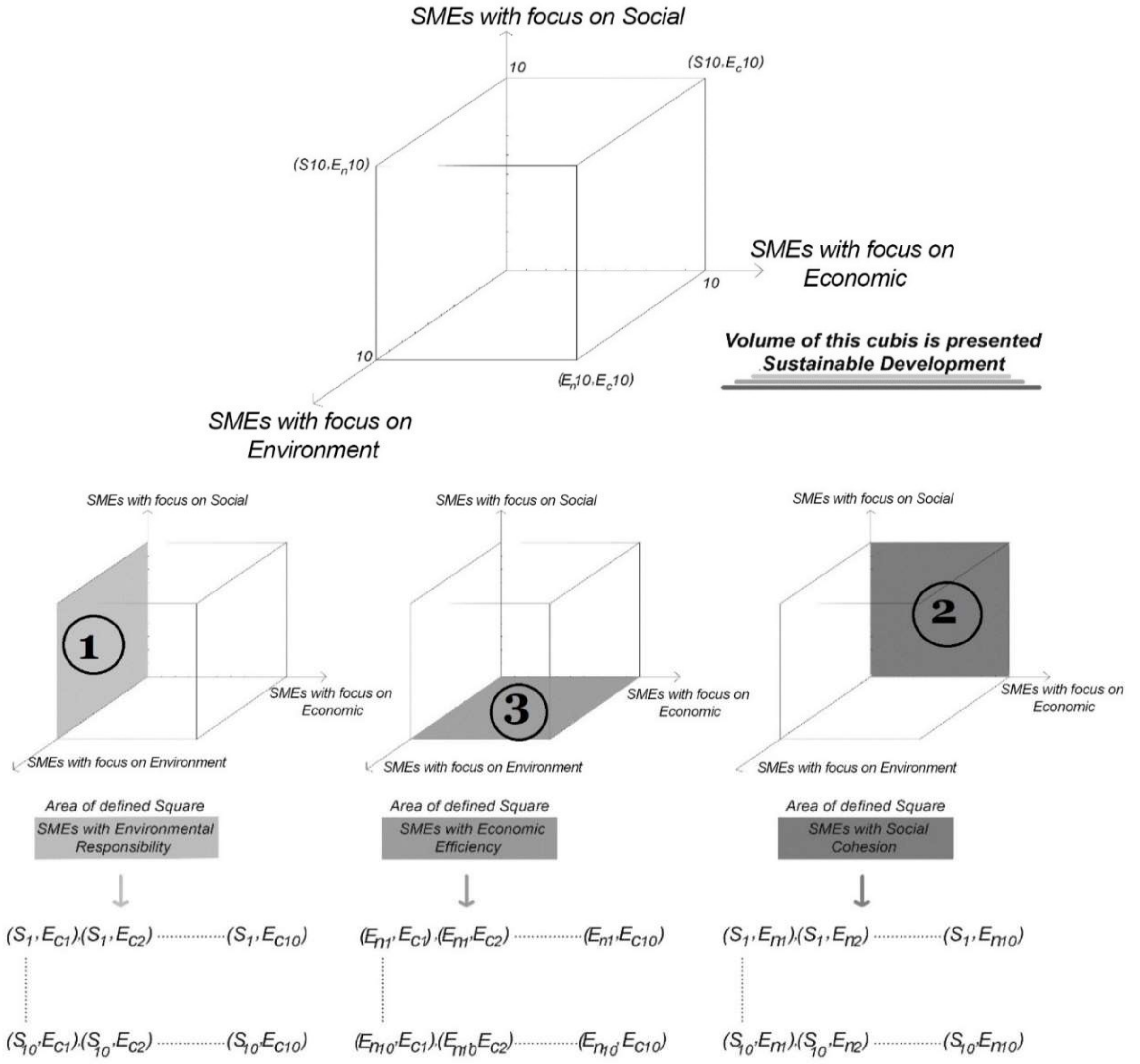

Figure 5. 3D Socio-Eco-Environmental SMEs model with three matrices for sustainable energy[8].

4.2.1. Problem of water wastage in the extraction of lithium using the example of northern Chile

Chile's lithium production accounted for approximately 26% of global lithium production in 2020. Chile also has just <42% of the world's lithium reserves. In first place is Australia, with a mine production share of 48% worldwide and reserves of just <26%. Together, these two countries account for about 75% of global production. In recent years in particular, significant lithium resources have been identified worldwide as a result of ongoing exploration. For example, as recently as 2017, Chile was believed to have 7.5 million tons of lithium reserves (in 2021, it was already 9.2 million tons), in contrast to Australia, which had only 1.6 million tons in 2017 (in 2021, it was already many times that amount: 5.7 million tons)[23].

Lithium production takes place very differently in the two countries because of geological distribution. In Australia, lithium is dissolved from mineral rock, with lithium content of about 1%–5%. In Chile, on the other hand, the raw material lithium is extracted from salt lakes. The brine (groundwater containing minerals and lithium), which comes from a depth of several 100 meters, is pumped out and then fed into very large evaporation basins. Here, the brine evaporates due to the intensive solar radiation over a period of up to 12 months. The amount of lithium is very low and is <1% in the brine (the initial lithium content in Salar de

Atacama is about 0.15%[24]). For 1 ton of lithium, about 2 million liters of groundwater are needed and to dissolve the lithium carbonate from the brine afterwards, various chemicals such as kerosene, hydrochloric acid, alcohol or calcium oxide are used. This type of lithium production is problematic because it lowers the groundwater table, causing the ecosystem to become unbalanced and farmers' drinking water wells to dry up[25]. It is estimated that the Chilean company SQM and its American partner Albermale extract and evaporate more than 63 billion liters of saltwater annually. In addition, freshwater is used to purify the lithium product, resulting in four times as much water being withdrawn from the region between the years 2000 and 2015 as would have been added naturally[26]. As the groundwater table continues to drop due to heavy brine extraction, existing rivers and wetlands, without a chance to regenerate, are drying up. The existence of the native flora and fauna is massively threatened by this, as their habitats are constantly reduced and the former food chains are permanently interrupted. The existing ecosystem will be irretrievably destroyed for decades[27].

Government intervention is proving difficult. In 1981, a new water code was passed to resolve long-standing ambiguities regarding rights relationships. The result of the new legislation was to secure a free market for tradable water rights—the goal was to privatize water resources and water management. Despite a water reform in 2005, these principles remained in place and the state's ability to intervene continued to be severely limited[28].

Also, a little further south in the Atacama region, where the Maricunga salt flat is being explored, the country's second-largest lithium reserves are believed to exist, but the indigenous Colla community complains that they are being bypassed when it comes to deciding whether mining should be allowed in the area. The impact of mining, however, is great for them in particular, due to the uncertain impact on water sources that are vital to their survival. Companies involved in developments in the region are Salar Blanco (Australian-Canadian), Codelco (Chilean), and SQM (Chilean)[26]. The SQM company, which used to be called Soquimich, is now the largest lithium producer in the world. The company is repeatedly part of investigations due to tax evasion, money laundering, and illegal campaign financing[27]. Currently, a bill is being debated in the Chilean Congress that could declare the corporation's lithium mining a national interest and allow for the immediate expropriation of the company[29]. Despite the large lithium reserves and a 26% share of lithium production worldwide, Chile has only a comparably small benefit because Chinese companies in China do the further processing of the lithium—so the real value creation takes place China and Chile's profit generation is minimal in this regard[30].

Solvent extraction, for example, could improve the situation in Chile. It allows the direct production of lithium or lithium compounds from lithium-bearing brines, without the use of evaporation ponds. By this way, the residual brine, freed from impurities, can be pumped back into the subsurface, which would significantly relieve the overall water balance. Another advantage is that this type of lithium extraction takes only a few hours. For this method, as for other methods of lithium extraction, it is a prerequisite that they must function in a long-term stable and reliable manner and that production costs for the lithium extracted in this way must fall competitively with evaporation ponds, otherwise a relevant market penetration cannot be assumed[24].

The problem of water wastage in the extraction of lithium is a significant challenge that affects not only the regions where lithium is extracted but also the entire value chain of sustainable energy and vehicle-related industries, including those in Germany and the EU countries. The lithium extraction process in northern Chile involves pumping brine from underground aquifers into large evaporation ponds, where the sun evaporates the water and leaves behind the concentrated lithium salts. This process requires large amounts of water, which is a scarce resource in this arid region.

- The problem of water wastage in the extraction of lithium has several implications for the sustainable energy and vehicle-related value chain in Germany and the EU. Firstly, the demand for lithium for batteries used in electric vehicles and renewable energy storage is expected to increase dramatically in the coming years. This will require more lithium extraction, which could exacerbate the water scarcity problem in regions like northern Chile.

- Secondly, the water wastage problem highlights the need for sustainable sourcing of raw materials for the sustainable energy and vehicle-related industries. The 7PS model places environmental sustainability as the second priority after culture, and the use of water resources is an essential component of environmental sustainability. Ensuring sustainable sourcing of lithium and other raw materials will require innovative approaches to reduce water use in the extraction process and to reuse and recycle water wherever possible.

- Thirdly, the problem of water wastage highlights the need for international cooperation and collaboration to address sustainability challenges in the sustainable energy and vehicle-related value chain. Germany and the EU have been leaders in promoting sustainability and climate action, and they have the opportunity to work with countries like Chile to develop sustainable solutions for the extraction of lithium and other critical raw materials.

- Lastly, the problem of water wastage in the extraction of lithium is a significant challenge for the sustainable energy and vehicle-related value chain, and it highlights the need for innovative and sustainable approaches to raw material sourcing, international cooperation and collaboration, and the integration of environmental sustainability in the value chain.

4.2.2. Problem of child labor in cobalt production in the Democratic Republic of Congo

The Democratic Republic of Congo (DRC) remains the world’s leading source of cobalt, accounting for >70% of global cobalt mine production. With the exception of production in Morocco and artisanal cobalt mined in the DRC, most cobalt is extracted as a byproduct of copper or nickel. China is the world’s leading producer of refined cobalt, most of which is made from partially refined cobalt imported from the DR Congo. China is simultaneously the world’s largest consumer of cobalt, with >80% of consumption coming from the rechargeable battery industry[23]. Cobalt demand will also increase due to the sharp rise in demand from electric vehicles. The study titled “Raw Materials for Future Technologies 2016” concludes, for example, that in 2035 selected future technologies could require cobalt contents of about 120,000 tons annually[31]. A sharp increase in raw material demand for electric vehicle BEVs in the EU is projected, representing a fivefold increase in 2030 and a 15-fold increase in 2050[32]. This increasing demand is opposed by the DRC as the main producer, which implies supply and price risks. Cobalt mined using simple and non-industrial methods, artisanal mining, is the focus of criticism. Artisanal mining in particular is characterized by unpredictable supply and social grievances in the form of child labor and precarious working conditions[31]. The work of United Nations expert groups on the DRC, as well as international civil society, has shown how the systematic plunder of natural resources and other forms of wealth in the country is linked to war, conflict, and the associated human rights abuses that have been prevalent in the region for nearly two decades[33].

The child labor that is common there is among the worst forms of child labor and includes work that exposes children to physical, psychological, and/or sexual abuse; working underground, underwater, at dangerous heights, and/or in confined spaces; and working with dangerous machinery, equipment, and tools, manually handling and/or transporting heavy loads. This involves collecting minerals from tailings piles in active and inactive industrial mining concessions, or working in streams and lakes near the concessions washing and sorting rocks. Likewise, child labor occurs underground. In 2014, it was estimated that approximately 40,000 boys and girls worked in all mines throughout the former Katanga province[34]. The physical consequences of the work are severe. Children are often employed to carry heavy bags (weighing about 20 to 40 kg), and carrying and lifting heavy loads can be immediately injurious, or lead to long-term damage such as joint and bone deformities, bone deformities, and back, muscle, and musculoskeletal injuries. Some children work 10–12 h/day, and some of them even remain underground for 24 h before being transported back to daylight. In doing so, they are exposed to the permanent lethal risk of being buried by a mine collapse[34]. In addition to the dangerous work, the children are also exposed to the permanent risk of becoming victims of physical abuse, drug abuse, sexual exploitation and violence by security personnel. These incidents are extremely rarely reported, as the children are aware that they themselves are breaking the law by working and illegally entering mining areas. They usually work independently and sell the collected minerals to traders. Payment is $1–2/day (depending on the weight of the bag) with children reporting that they are paid less than adults, robbed by them, or have to pay protection money to security personnel. Due to these practices, there is hardly anything left even from the little money[34].

A decision to stop sourcing cobalt from artisanal mining would only result in an increasing lack of transparency in mining and give the false impression that small-scale mining is generally problematic. Instead, governance, taxation, and transparency issues play a critical role in addressing conflict financing, smuggling, child and forced labor, unsafe working conditions, and harmful environmental impacts. To promote sustainable development, impacts need to be considered beyond mining, and the entire cycle from exploration to mining, to mine closure, to reclamation of the entire site, and to post-mining business opportunities must be considered[33]. In the course of this, the European Parliament has supported measures to regulate the entire value chain of batteries ethically and without hesitation. On this basis, negotiations between the EU Parliament and the EU governments are to be initiated[32]. The problem of child labor in cobalt production in the Democratic Republic of Congo (DRC) is a significant challenge in the sustainable energy and vehicle-related value chain for BEVs and FCEVs. Cobalt is a key component in the production of lithium-ion batteries used in electric vehicles, and the DRC is responsible for over 60% of the world's cobalt supply. The mining of cobalt in the DRC is often done by small-scale, artisanal miners, and reports indicate that child labor is prevalent in this sector. Children as young as seven years old are employed in hazardous conditions, working long hours, and being exposed to toxic substances. This practice is not only unethical but also violates international labor laws. In contrast, Germany and EU countries have strict labor laws and regulations that prohibit child labor and ensure fair and safe working conditions. The 7PS model emphasizes the importance of social sustainability, including labor standards, which should be upheld throughout the value chain. To address the problem of child labor in cobalt production, companies in the sustainable energy and vehicle-related value chain must take steps to ensure that their cobalt supply chains are free from child labor. This can be achieved through responsible sourcing practices, including transparency, traceability, and verification of supply chains. Furthermore, companies can support initiatives aimed at addressing child labor in the DRC, such as investing in education and providing alternative livelihoods for affected communities. The problem of child labor in cobalt production highlights the importance of social sustainability in the sustainable energy and vehicle-related value chain. Companies must take a holistic approach to sustainability, addressing social, environmental, and economic factors, to ensure that their products are truly sustainable.

4.2.3. Recycling of used accumulators

When considering the challenges of building a mass market for BEVs or FCEVs, one aspect is always of central importance: the accumulator; often colloquially referred to as simply as the battery. The technical possibilities of recycling used accumulators will become much more important in the future, because the global demand for electric vehicles, digital technology and renewable energies will increase strongly. Specifically, this means an expected 14-fold increase in demand by 2030, with the EU potentially accounting for 17% of this demand. In conjunction with the increase in sales figures, the quantity of accumulators, which are disposed of as waste after use, will also rise. To reduce the environmentally damaging downside of electric vehicles, accumulators should be reused, remanufactured, or recycled after use[32]. In March 2022, Members of the European Parliament agreed to revise the 2016 Battery Directive[35]. The aim of the new regulation is, among other things, to protect the environment and human health, as well as to reduce resource consumption, towards a truly functioning and continuous circular economy with regard to spent batteries[36]. This also includes ensuring that human rights and due diligence are respected along the entire battery and accumulator value chain, as well as meeting minimum targets for recovering cobalt, lead, lithium, or nickel from used materials. In addition, recycling plays a key role in ensuring the medium- and long-term supply of the strategic metals[35]. The number of portable batteries collected for recycling has already increased significantly in recent years. While in 2009 the EU had about 50,000 tons, within 10 years this figure doubled to 100,000 tons, so that in 2019 about 51% of the portable batteries sold in the EU were sent for recycling. The figure is expected to increase to 70% by 2025 and 80% by 2030, and 100% for automotive, industrial and electric vehicle batteries. Negotiations with EU governments are underway to implement these proposals[32].

In addition to the political challenges that have to be overcome at the European level, the technical challenges of recycling must also be mastered so that a new mass market for passenger cars can be created in a sustainable manner. This becomes clear as the volume of Li-ion batteries to be recycled in Europe will grow very strongly in the future. Already in 2030, it is assumed that about 230,000 tons of recycled material will be recycled annually, in 2040 even 1,500,000 tons. As a result, the recycling industry will also have to grow by 30% annually in order to cope with the materials generated. While most waste is initially expected to come from cell production and production rejects, in the medium and long term, accumulators from electric vehicles will challenge the industry's growth rate[37]. It should be noted here that statistics are not yet available for the service life of accumulators from electric vehicles; manufacturer warranties only refer to a service life of 10 years or 100,000 to 200,000 km mileage[37].

The 5th wave theory concentrates on the readiness for sustainable energy in today's challenges and tomorrow's crises to change into the new age that we are just entering. Within this comprehensive framework, the applicant aims to implement readiness strategies and design a future scenario to apply these theories and evaluate the results to design empirical investigation from my theoretical approaches (cf. on 5th wave theory). The 5th wave theory is designed to: (1) forecast; (2) prevent; and (3) face the post-sustainability impact of today's energy challenges and tomorrow's energy shocks using (a) open innovation, (b) implementation, (c) development, and (d) application of these technologies to provide a blue-green sustainable energy and digital innovative readiness and recovery strategies with the CSR approach (e.g., for the Urban 6.0, SME 5.0 in Industry 5.0, and the super-intelligent society entitled Society 6.0). In getting the world back on its feet, with environmental responsibility, social cohesion, and economic efficiency for investments, cohesion is crucial to ensure a balanced recovery from the coronavirus pandemic and make sure that no one is left behind which is shown in **Figures 5** and **6**. With the REACT-EU initiative, we want to extend the crisis response and repair measures to the most affected sectors and regions. Specifically, this initiative will help us to:

1) reinforce the health care system;
2) support affected citizens by creating jobs for them;
3) enhance basic services for citizens; and
4) make the world economies more resilient and sustainable.

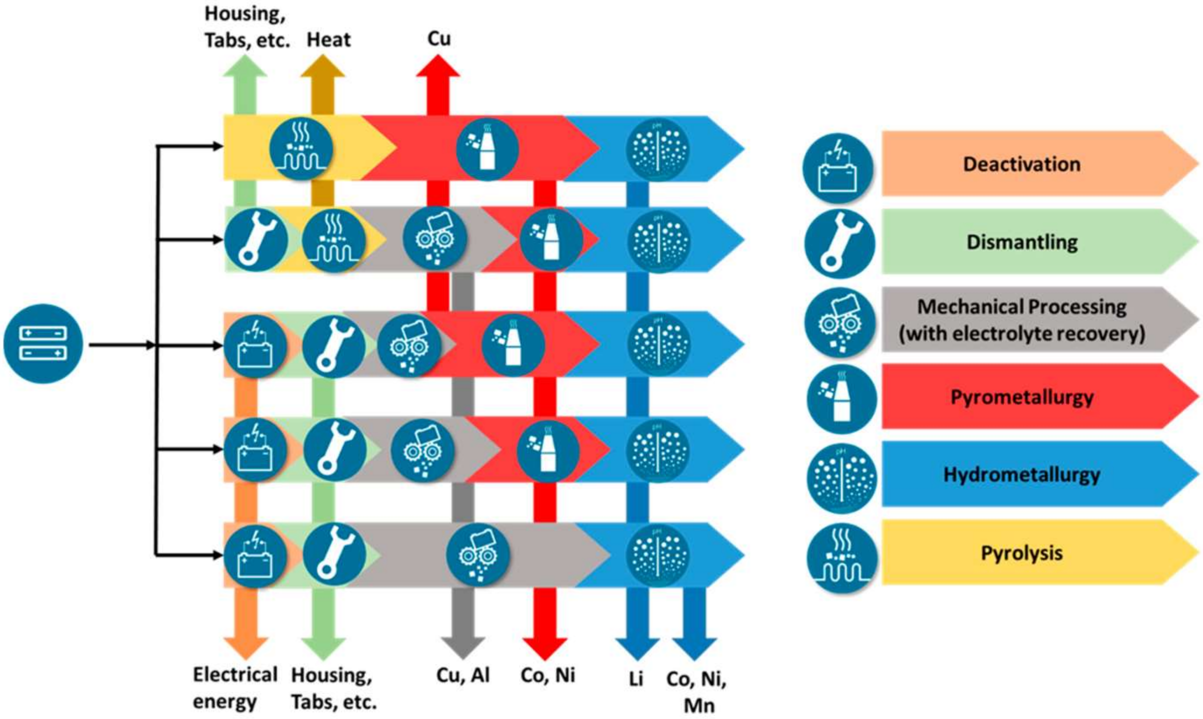

Figure 6. General overview of some potential recycling process chains in different combinations. Source: Doose et al.[38].

In principle, a combination of different technologies is used in the recycling of Li-ion batteries, which are divided into "manual and automated dismantling steps, as well as mechanical, pyrometallurgical and hydrometallurgical processing steps (basic operations)"[39].

Overall, the overview of the processing steps in **Figure 1** shows that many different recycling processes are possible. They are either already used industrially or are being developed on a pilot scale. As a requirement for a future process chain, in addition to achieving high recovery rates of >90% or even 95%, sufficient material purities for further use as battery material must also be achieved at the same time. The recycling system must be highly flexible in order to achieve the most energy-efficient multi-material recovery possible. The appropriate combination of the different processing stages is the key here. Future recycling processes for Li-ion batteries must not only be able to process new materials, but also replace energy-intensive processes currently used for classic Li-ion batteries with low-energy and environmentally friendly process steps[38]. In this context, there is still an enormous amount of development work to be done, partly because no plant technology has yet become established[37].

For a sustainable electric vehicle mass market, there are still numerous other tasks that need to be solved in the recycling process. For example, rechargeable batteries are significantly larger and heavier than those of small electronic devices, which results in specific preparation steps. To prevent hazards during storage, onward transport and further processing, they must also be in a safe mechanical or electrochemical state[40]. For further development work, it is therefore important to find out how damaged accumulators can be transported in the future. In addition, there is the recording of life cycles and aging mechanisms in order to further optimize battery systems, as well as the development of a disassembly-friendly design, which includes detachable cell connections. Finally, the focus must be on increasing the competitiveness and cost-effectiveness of ecological recycling[40]. "Beyond these process steps of recycling, aspects concerning collection, [...], second-life, second-use and discharge are highly relevant"[37].

Recycling of used accumulators is a crucial element in ensuring a sustainable energy and vehicle-related value chain for BEVs and FCEVs in Germany, EU countries, and globally. The recycling of used accumulators reduces the environmental impact of battery production, extends the life cycle of batteries, and conserves valuable resources. In Germany and EU countries, there are regulatory frameworks in place to ensure the proper disposal and recycling of used accumulators. The EU Battery Regulation, for example, requires member states to establish collection and recycling targets for batteries and set minimum recycling efficiency standards. Germany has also established a national battery regulation that requires the collection and recycling of used accumulators. Recycling of used accumulators involves the recovery of valuable metals, such as lithium, cobalt, nickel, and manganese. These metals can be reused in the production of new batteries, reducing the need for new resource extraction. However, the recycling of batteries is still a relatively new industry, and there are challenges to be addressed, including the development of efficient and cost-effective recycling technologies and the establishment of collection and logistics systems for used batteries. In general, the recycling of used accumulators is an essential component of a sustainable energy and vehicle-related value chain for BEVs and FCEVs. The establishment of effective regulatory frameworks, investment in recycling technologies and infrastructure, and the promotion of responsible end-of-life battery disposal by manufacturers and consumers are critical to achieving a sustainable battery value chain.

4.2.4. The braking of society in the introduction of renewable energies and their applications in the form of new products

Whether people do something is largely based on their motivation. This decides to do something or not. One of the most famous depictions of human motivation is the famous Maslow pyramid with its five levels. However, this is not only a few days old, but also quite heterogeneous and cannot be used sensibly here. If you look at how some states proceed to get their own population to behave in some way, from the point of view of the authors, only three rough concepts can actually be distinguished from one another: American, German and Russian. Ultimately, it is usually at least a matter of a state that its own population, which is usually very heterogeneous, does what the government/administration of the state wants[41]. The philosophy, which also includes behavior, names three main reasons: desire, opinion/principle and goal. If you now bring these theoretical approaches in the direction of people’s behavior in relation to new needs and measures relating to renewable energies and the implementation by the population in your own country, you can come to the following logical and very easy to understand representation: The money-based method is described here as “The American Way” because in hardly any other country does money seem to be as common a cause of action as in the USA. The desire is presented as a desire for money, because money is the main means of providing for one’s daily subsistence. At the same time, it is probably felt to be in short supply by most people worldwide (one would like more of it). Freedom is valued here with a maximum, because people decide for themselves whether they want to earn money with something or not. At the same time, time and effort are minimal, since everyone can decide for themselves immediately and without the state and its laws.

The opinion or principle as belief is part of the mindset of people. Not only in politics, but also in trade unions, associations and ultimately, of course, in religions, given attitudes are the measure of desired behavior. This attitude of mind, which is desired in public, can be achieved through various measures, including all kinds of opinion-forming via communication, argumentation, persuasion and ultimately also a kind of “talking to death” (talking at someone until they are forced to give up for the sake of peace and/or agrees). This approach is referred to here as “The German Way” because it seems to be typical for Germany. The freedom here is partially much less than in the USA and lasts much longer, since there are numerous political steps and laws and convincing the population via the media can take years. At the same time, a process of awareness must also take place among people.

The goal is something that is aimed for in the short, medium and long term. Since, according to Freedom House, around 28% of all countries around the world are dictatorships and another around 32% are only partially free, lack of freedom in these countries can be described as a core characteristic. In this total of about 60% of all states, the goal of the people should be, at least not to suffer disadvantages through coercion, persecution and punishment. The people there will therefore be motivated to do what the state wants, without being/having to be convinced of it, as in the German way, and with-out being able to earn money, as in the American way. However, the risk of penalties may be considered so great that the implementation time and effort are very low. At the same time, however, freedom also tends towards zero. It is therefore called "The Russian Way" here.

It can be summed up: The ways in which a state can get its people to do something can be summed up as: money, or opinion/belief, or coercion/punishment.

The ways in which a state can get its people to do something can be summed up as money, opinion/belief, or coercion/punishment (**Figure 7**[1]).

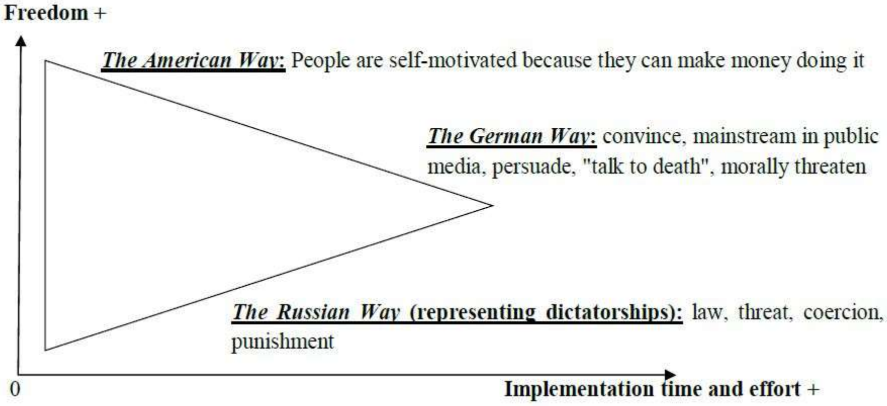

Figure 7. Novak triangle. Source: Derived by author Novak D first published in December 2022 Hydrogen H_2[1].

When making or implementing climate protection solutions such as H_2, BEVs and FCEVs, especially since the global temperature is increasing faster and faster, the time factor is obviously crucial. From the author's point of view, only simple "out-of-the-box" solutions that 1) are easy to understand, 2) are technically easy to implement and are therefore 3) inexpensive. So, the supplier can explain it to the potential customer in a simple way, who will then understand it immediately; the provider can easily install and activate the solution at the customer's; the customer can afford it because it is inexpensive and, ideally, even earn money with it. These "out-of-the-box" solutions must be standardized and certified in advance and then only require standardized approval by official control bodies according to Novak[1].

The introduction of renewable energies and their applications in the form of new products can cause a significant change in society. The transition from traditional energy sources to renewable energy sources requires a significant amount of investment in new technologies, infrastructure, and training. This transition can cause a "braking of society" as individuals and communities adapt to these changes. This can cause resistance, frustration, and a slower adoption of renewable energy technologies. The 5th wave theory suggests that the transition to renewable energy is part of a larger trend towards a more sustainable and responsible society. However, this transition will not happen overnight, and there will be significant challenges along the way. The 7PS model provides a framework for addressing these challenges by considering the different pillars of sustainability, including cultural, environmental, social, economic, educational, technical, and political factors. In Germany and EU countries, there has been significant investment in renewable energy technologies and infrastructure. However, there have been challenges in the adoption of these technologies, including resistance from traditional energy industries, grid management issues, and political disagreements. The 7PS model can be used to address these challenges by considering the cultural, environmental, social, economic, educational, technical, and political factors involved in the transition to renewable energy. The "braking of society" in the introduction of renewable energies and their applications is a significant challenge that must be addressed. The 5th wave theory and 7PS model can provide guidance for addressing these challenges and transitioning to a more sustainable and responsible society.

5. Conclusion and future suggestions

5.1. Conclusion

The existing political challenges in implementing and introducing new technologies such as BEVs and FCEVs are still great and progress is too slow for various reasons. Green hydrogen H_2 is the solution to permanent sustainability, but Germany and the EU will probably be dependent on H_2 imports for a long time, if not forever. This is due to the far too slow expansion of renewable energies in Germany, but this is also partly based on Germany's special circumstances. In today's countries that mine/manufacture and sell lithium, there are massive problems with the use of the limiting factor (drinking) water due to the production processes. The problem of child labor in the cobalt mines of the DR Congo is an unacceptable crime against children who cannot defend themselves. This must never become the basis for supposedly climate-friendly cars. The recycling of used accumulators is at best still in its infancy and must be massively expanded in the interest of environmental protection. In order to achieve success more quickly, the solution should be sought via the American Way (self-motivation of people through the possibility of earning money with it (Novak triangle)) and that, mind you, worldwide.

In conclusion, the transition towards sustainable energy and vehicle-related value chain for BEVs and FCEVs faces numerous challenges that need to be addressed. The 5th wave theory and 7PS model provide a comprehensive framework for understanding these challenges and identifying potential solutions.

In Germany and the EU countries, progress has been made in expanding renewable energies, promoting the circular economy, and improving the sustainability of the value chain for BEVs and FCEVs. However, challenges such as the water wastage in lithium extraction, child labor in cobalt production, and the need for effective recycling of used accumulators need to be addressed. Furthermore, the transition towards sustainable energy and vehicle-related value chain requires the involvement of all stakeholders, including governments, businesses, and individuals. This involves cultural, social, economic, educational, technical, political, and environmental factors, which should be addressed through a holistic approach that prioritizes the well-being of society and the environment. The challenges of a sustainable energy and vehicle-related value chain for BEVs and FCEVs can be addressed through a combination of technological innovation, policy interventions, and changes in societal attitudes and behaviors. This transition represents a significant opportunity to create a more sustainable and equitable future for all. The challenges of a sustainable energy and vehicle-related value chain for BEVs and FCEVs through the 5th wave theory and 7PS model are complex and multi-faceted. Both Germany and EU countries face similar challenges, such as the need for infrastructure development, policy support, and overcoming social and cultural barriers. However, there are also specific challenges unique to each country, such as Germany's energy transition and the EU's reliance on imported lithium and cobalt. To achieve a sustainable energy and vehicle-related value chain, it is important to focus on all seven pillars of sustainability, with culture being the first priority, in addition to peace and love. This includes considering environmental, social, economic, educational, technical, and political factors. To address specific challenges, solutions such as the expansion of renewable energies, the development of green hydrogen, the implementation of circular economy principles, and the ethical sourcing of critical minerals can be implemented. Collaboration between government, industry, and society is crucial in creating a sustainable energy and vehicle-related value chain. Achieving a sustainable energy and vehicle-related value chain will require ongoing efforts and dedication, but the benefits of a cleaner, more sustainable future are well worth the challenges.

5.2. Future suggestions

Based on the challenges and factors discussed earlier, there are several future suggestions for sustainable energy and vehicle-related value chains for BEVs and FCEVs through the 5th wave theory and 7PS model for Germany, EU countries, and in general. These suggestions include:

- Collaboration between stakeholders: Governments, industries, and consumers must work together to promote sustainable practices and create a circular economy in the energy and vehicle-related value chain. This includes the responsible sourcing of raw materials, the recycling and reuse of batteries, and the reduction of carbon emissions throughout the entire value chain.
- Investment in research and development: Continued investment in research and development is necessary to drive innovation and improve the efficiency and sustainability of renewable energy and electric vehicles. This includes the development of new technologies, such as solid-state batteries, and the improvement of existing ones, such as hydrogen fuel cells.
- Support for renewable energy infrastructure: Governments and industries should invest in the infrastructure necessary to support the growth of renewable energy sources, such as wind and solar power. This includes the development of energy storage systems, smart grids, and electric vehicle charging networks.
- Consumer education and incentives: Consumers play a crucial role in promoting sustainable practices in the energy and vehicle-related value chain. Education and incentives, such as tax credits and subsidies, can encourage consumers to make more sustainable choices, such as purchasing electric vehicles and using renewable energy sources.
- Addressing social and ethical issues: Social and ethical issues, such as child labor and water wastage in the extraction of raw materials, must be addressed through responsible sourcing practices and ethical supply chains.

The future suggestions for sustainable energy and vehicle-related value chains for BEVs and FCEVs through the 5th wave theory and 7PS model require collaboration between stakeholders, investment in research and development, support for renewable energy infrastructure, consumer education and incentives, and addressing social and ethical issues. By implementing these suggestions, we can work towards a more sustainable and equitable energy and vehicle-related value chain for the future.

Here are some future suggestions on the challenges of a sustainable energy and vehicle-related value chain for BEVs and FCEVs through the 5th wave theory and 7PS model for Germany and EU countries, as well as low sustainable countries like Chile and DR Congo:

- Increase investment in research and development of sustainable technologies and materials, including the development of more efficient and environmentally friendly extraction methods for materials like lithium and cobalt.

- Encourage the development and adoption of circular economy practices, such as recycling and reuse of materials, to reduce waste and increase resource efficiency.
- Develop policies and incentives that promote the use of renewable energy sources, such as solar and wind power, and encourage the adoption of electric vehicles and fuel cell vehicles.
- Address social issues related to the production of materials used in sustainable technologies, such as child labor in cobalt mines in the DR Congo, by promoting ethical sourcing and investing in community development programs.
- Develop international agreements and cooperation frameworks that encourage the adoption of sustainable practices and technologies in all countries, including low sustainable countries like Chile and DR Congo.
- Implement education and awareness campaigns to promote sustainable behaviors and increase public awareness of the importance of sustainability.
- Increase collaboration between different stakeholders, including governments, industries, and civil society, to ensure a more comprehensive and coordinated approach to sustainability challenges.

Author contribution

Conceptualization, DN and HDM; methodology, DN and HDM; software, DN and HDM; validation, DN and HDM; formal analysis, DN and HDM; investigation, DN and HDM; resources, DN and HDM; data curation, DN and HDM; writing—original draft preparation, DN and HDM; writing—review and editing, DN and HDM; visualization, DN and HDM; supervision, DN and HDM; project administration, DN and HDM; funding acquisition, DN and HDM. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

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