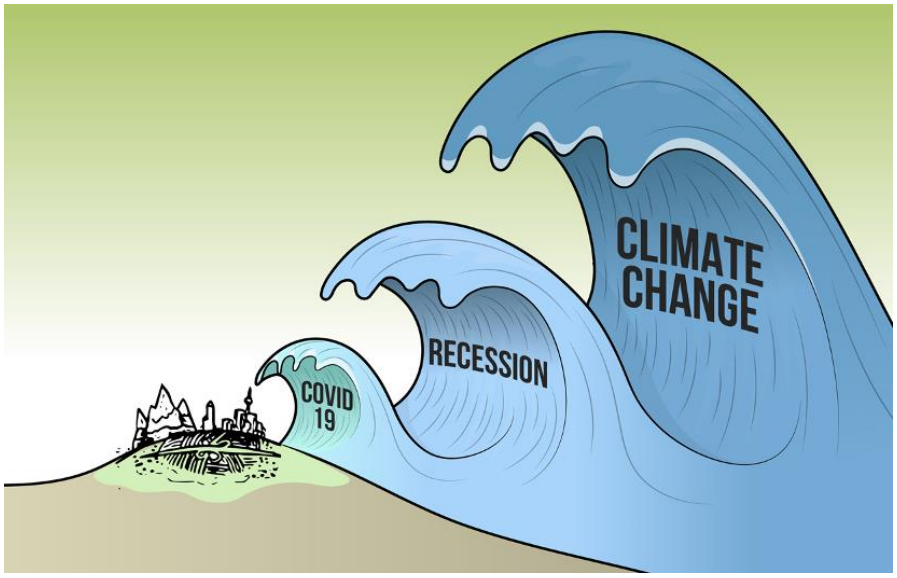
Final Thesis

The Impact of the COVID-19 crisis on the Hydrogen Energy Transition in the Netherlands:

Threat or Opportunity?



MSc International Management / CEMS

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Preface

"Failure is so important. We speak about success all the time. It is the ability to resist failure or use failure that often leads to greater success." – J.K. Rowling

In 2019, I started my first master thesis. The thesis topic that I chose from a predefined list turned out to be too theoretical for me. I did not see how I could provide value to practice by researching this subject, and I could not find a research gap in academic literature, as it had been so widely studied. Therefore, I decided to stop writing this thesis and start over with a fresh topic in 2020. Through conducting an economic internship at the Dutch Consulate General in Antwerp, I was able to identify a contemporary issue that could provide societal relevance: the perceptions of different stakeholders on the impact of COVID-19 on the Dutch hydrogen energy transition in the Netherlands. Firstly, studying this topic is relevant because green and blue hydrogen are essential energy carriers for reaching the national climate objectives. Secondly, investigating this subject is vital because the ongoing COVID-19 pandemic has resulted in an international public health and economic crisis, which could stimulate or impede the hydrogen energy transition in the Netherlands, according to different stakeholder perceptions.

This research subject turned out to be quite challenging for me as it is very technical, complex, and involves various stakeholders. Moreover, studying such an actual topic as the ongoing COVID-19 crisis is demanding because I had to consider recent changes and developments. Writing this thesis has taken me a considerable amount of time and effort. I would like to thank my coach, Prof. Lucas Meijs, for providing me with the additional time and support needed to complete this thesis successfully. I am also grateful that he taught me to keep the bigger picture in mind and not get lost by focusing too much on details. Furthermore, I would like to thank my co-reader, Dr. Marijn Faling, for aiding me to strengthen the theoretical foundation of my study.

Finally, I am proud that I have been able to conduct substantial research that has value to practitioners, as I have been invited by the Dutch Hydrogen and Fuel Cell Association and the Ministry of Infrastructure and Water Management to present this study's findings.

Ishana Ramsaran

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Executive Summary

In the National Climate Agreement of 2019, the Dutch government states its ambition to transition to green and blue hydrogen to meet the national climate objectives of 2030 and 2050 and tackle climate change. Currently, sustainable hydrogen technology is novel, emerging, and not commercially viable yet. Cooperation from multiple stakeholders from the state, market, and the third sector is required to develop sustainable hydrogen technology further and implement blue and green hydrogen on a large-scale. Financial government support is also vital to accomplish the Dutch hydrogen energy transition.

This study investigates stakeholder perceptions on whether the ongoing COVID-19 crisis will stimulate or impede the hydrogen energy transition in the Netherlands. COVID-19 has resulted in an international public health and economic crisis, which could offer a window of opportunity for radical change for stakeholders in the Dutch hydrogen sector, according to academic literature. Hence the following research question is investigated in this study:

How do different hydrogen stakeholders perceive the current and expected implications of the COVID-19 crisis on the hydrogen energy transition in the Netherlands?

To answer this research question, this study first analyzes academic and practical literature to describe the Dutch hydrogen energy transition before the COVID-19. Then, academic literature about past crises is assessed to explore the potential implications of COVID-19. Furthermore, this research uses a qualitative method to explore this novel and complex phenomenon that requires a deep understanding. Semi-structured interviews are used as a data collection tool. Seventeen hydrogen stakeholders from state, market, and the third sector are interviewed about their perspectives on the implications of COVID-19 on the Dutch hydrogen energy transition.

The findings conclude that hydrogen stakeholders from the state, market, and the third sector perceive the current implications of the ongoing COVID-19 crisis as quite limited. Business is mostly conducted as usual, as most stakeholders continue to collectively tackle the largest looming crisis of the 21st century: climate change. Furthermore, stakeholders expect that the Dutch government will financially support the hydrogen energy transition to recover the Dutch economy from the COVID-19 crisis, which offers an opportunity for radical change. This study advises multiple stakeholders to work together as a strong coalition to develop sustainable hydrogen technology further and seize this opportunity, which is threatened by increasing government debt and stakeholders of non-hydrogen sectors that would like to promote their agendas.

Keywords: COVID-19; crisis; energy transition; sustainability transition; hydrogen; the Netherlands; stakeholders.

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1. Introduction

In the National Climate Agreement of 2019, the Dutch government states its ambition to transition to green and blue hydrogen to meet the national climate objectives of 2030 and 2050 and tackle climate change. Green and blue hydrogen are essential energy carriers. They could become more suitable or cost-effective for specific applications in the sectors of Industry, the Built Environment, and Mobility and Transportation than renewable electricity (Ministerie van Economische Zaken en Klimaat, 2020). Currently, sustainable hydrogen technology is novel and emerging (Markard, 2018). Cooperation from multiple stakeholders from the state, market, and the third sector is required to develop sustainable hydrogen technology further and implement blue and green hydrogen on a large-scale. Financial government support is also vital to accomplish the Dutch hydrogen energy transition (Gigler et al., 2020).

This study investigates stakeholder perceptions on whether the ongoing COVID-19 crisis will stimulate or impede the hydrogen energy transition in the Netherlands. In December 2019, the first COVID-19 disease outbreak was identified in China. Due to the worldwide spread of COVID-19, the virus has been declared a pandemic (WHO, 2020). From February 2020 until February 2021, the ongoing COVID-19 outbreak has infected over one million people in the Netherlands. To slow down the spread of the virus, the Dutch government has imposed restrictions on several social and economic activities from March 2020, including a (partial) lockdown, closure of educational institutions and non-essential businesses, bans on public gatherings, and travel restrictions (Rijksoverheid, 2020). Consequently, COVID-19 has resulted in an international public health and economic crisis, which could drastically change the course of the Dutch hydrogen energy transition.

According to academic literature, crises such as COVID-19 could offer a window of opportunity for radical (sustainable) change. A window of opportunity can be defined as a period of larger receptivity of decision-making stakeholders when the proponents of initiatives have a higher possibility of shifting attention to their agendas and their solutions to problems (Keeler, 1993; Kingdon, 1984; Saurugger & Terpan, 2016).

Stakeholders of the hydrogen sector could seize this window of opportunity to promote their agenda to accomplish the hydrogen energy transition. The COVID-19 measures have reduced traffic and industrial activities, which caused a significant temporary decrease in greenhouse gas emissions and improved air quality (Scientias, 2020). When hydrogen stakeholders convince governmental decision-making stakeholders to move forward towards a more sustainable economy and keep reducing these greenhouse gas emissions, this could provide an opportunity for the Dutch hydrogen energy transition.

However, this window of opportunity could be threatened by stakeholders of non-hydrogen sectors who would like to promote their agendas. When decision-making stakeholders of the Dutch government are convinced to adopt a short-term vision and are mainly focused on tackling the public health crisis and its economic consequences, they could put aside sustainability initiatives and the looming climate change crisis.

This study assumes hydrogen stakeholders from the market, state, and the third sector to have different perceptions on whether the ongoing COVID-19 crisis will stimulate or impede the

hydrogen energy transition in the Netherlands, as they have different priorities. Hence, the following research question is investigated in this study:

How do different hydrogen stakeholders perceive the current and expected implications of the COVID-19 crisis on the hydrogen energy transition in the Netherlands?

This study aims to answer this question and give practitioners insights into the current and expected course of the Dutch hydrogen energy transition. Consequently, this research has the following structure:

- Part A describes a review of existing literature about this topic. This part includes chapter 2, describing literature about the Dutch hydrogen energy transition before COVID-19, and chapter 3, which entails academic literature about past crises to assess the implications of COVID-19 on the Dutch hydrogen energy transition from the perceptions of various stakeholders.
- Part B discusses the empirical research of this study. This section entails chapter 4, describing the research methodology, and chapter 5, which discusses the results.
- Part C describes the interpretation of the findings of this research. This part encompasses chapter 6, which interprets and combines the study results with the reviewed literature, and chapter 7, which presents the study's conclusions and the answer to the research question. Section C also includes chapter 8, discussing the implications for theory and practice, this study’s limitations, and future research suggestions.

A. Literature review

2. Dutch hydrogen energy transition before COVID-19 from the perceptions of different stakeholders

2.1 Introduction

This chapter utilizes academic and practical literature to describe the Dutch hydrogen energy transition before the COVID-19 outbreak from various stakeholders' perceptions.

It describes:

- What the characteristics of the Dutch hydrogen energy transition are;
- What stakeholder perceptions are;
- How the hydrogen energy transition trajectory in the Netherlands before the COVID-19 crisis looked like in practice by using (parts of) the Multi-year Programmatic Approach for Hydrogen;
- What the similarities are between hydrogen projects before COVID-19 regarding financing, stakeholder participation, and stakeholder cooperation.
- What the concluding remarks of this chapter are.

2.2 Dutch hydrogen energy transition

This paragraph defines what a hydrogen energy transition in the Netherlands is, as having a deep understanding is essential for this study.

Most energy transitions aim to move towards an energy system based on renewable energy sources and carriers. Consequently, this implies phasing out fossil fuel-based energy systems (Verbong & Loorbach, 2012). As a result, most recent academic studies about energy transitions are aimed at the transition to a renewable energy system (e.g., Ćetković & Buzogány, 2016; Jenniches, 2018; D. Loorbach et al., 2017). This study looks at the hydrogen energy transition in the Netherlands, including both blue and green hydrogen.

There are three main types of hydrogen energy carriers: grey, blue, and green. Grey hydrogen is produced using fossil fuels, which releases significant CO_2. About 10% of Dutch methane is currently used to produce grey hydrogen, which is unsustainable. Blue hydrogen is produced in the same way as grey hydrogen, but the difference is that the released CO_2 is (mostly) captured. Green hydrogen is produced from renewable energy sources, such as solar and wind, and does not release CO_2 (TNO, 2020).

Some stakeholders in practical literature argue that utilizing methane-based blue hydrogen leads to a lock-in of fossil fuels and does not contribute to the shift to a renewable energy system. In contrast, other stakeholders view blue hydrogen as a stepping stone to implement green hydrogen, as the natural gas system can be relatively easily adapted, and significant emission reductions can be achieved relatively quickly (Gigler et al., 2020).

Therefore, this study defines the energy transition as the transition from fossil fuels to a renewable energy system. The hydrogen energy transition in the Netherlands is defined as the transition from fossil fuels to green hydrogen, using blue hydrogen as a means to achieve this.

2.3 Stakeholder perceptions

This paragraph describes what stakeholder perceptions are according to academic literature and which stakeholder groups are active in the Dutch hydrogen sector according to practical literature.

To understand what stakeholder perceptions are, a stakeholder first needs to be defined. A literature review on twenty-five years of stakeholder theory by Littau et al. (2010) identifies three groups of stakeholder definitions. The first group that Littau et al. (2010) identify is the "interest in" or "stake in" definition group. This group defines a stakeholder as an individual, group, or organization with an interest or stake in the outcome. The second is the "impacted by" or "can impact" definition group. This group defines a stakeholder as an individual, group, or organization that is impacted by or can impact the outcome. The third definition group combines these two groups. It defines a stakeholder as an individual, group, or organization that has an interest in the outcome and is impacted by or can impact the outcome. This study adopts the third group's definition as it captures both crucial elements of a stakeholder, and defines the hydrogen energy transition as the outcome. Therefore, a stakeholder is viewed as an individual, group, or organization that has an interest in the hydrogen energy transition and is impacted by or can impact the hydrogen energy transition.

According to Avelino & Wittmayer (2016), stakeholders can be distinguished among four different sector groups of (1) state, (2) market, (3) community, and (4) third sector, which have different sector logics. The state is conceptualized as formal, non-profit, and public; the market as formal, for-profit, and private; the community as informal, non-profit, and private. The third sector is viewed as the intermediary sector in between the three other sectors, which crosses the boundaries between formal and informal, profit and non-profit, and public and private. Moreover, these stakeholder groups can be distinguished among three levels of aggregation of (1) sectors, (2) individual stakeholders, and (3) organizational stakeholders.

Various organizational stakeholders are involved in the sectoral groups of market, state, and third sector in the Dutch hydrogen energy transition. Therefore, this study's stakeholder perceptions are defined as the perceptions from organizational stakeholders from the sectoral groups of market, state, and third sector. This research assumes these stakeholder perspectives to be different from each other as stakeholders have different priorities due to their sector logics.

However, according to a Dutch study conducted by Hupe & Meijs (2000) as part of the John Hopkins Comparative Non-profit Sector Project, the distinctions between governmental, for-profit, and non-profit organizations within the field of environmental affairs have become increasingly blurred in the Netherlands. This implies that stakeholders from market, state, and third sector have more similar sector logics. Several factors can explain this. Firstly, most environmental organizations in the Netherlands are primarily dependent on government subsidies. Secondly, multiple stakeholders believe that they have a shared responsibility to manage environmental affairs, which implies that they have similar priorities. Thirdly, the Netherlands has a strong consensus and consultation culture, resulting in reduced conflicts between stakeholders. Therefore, the distinctions between organizational stakeholders in the

context of the current Dutch hydrogen energy sector could be blurred, and stakeholders could have more similar priorities and sector logics.

So, this study defines a stakeholder as an individual, group, or organization that has an interest in the hydrogen energy transition and is impacted by or can impact the hydrogen energy transition. There are multiple organizational stakeholders active in the hydrogen sector from the groups of state, market, and third sector who are assumed to have different perceptions.

2.4 Dutch hydrogen transition trajectory before COVID-19

This section discusses how the hydrogen energy transition trajectory in the Netherlands before the COVID-19 crisis looked like in practice by using (parts of) the Multi-year Programmatic Approach for Hydrogen (MPAH) of the Top Consortium for Knowledge and Innovation (TKI) New Gas. First, the TKI New Gas, the MPAH report, and the Dutch hydrogen stakeholders are introduced. Then, an overview of the practice demonstration projects from 2020-2030 is given for the sectors of Industry, the Built Environment, and Mobility and Transportation. After that, the similarities between projects of all three sectors are discussed.

In order to accomplish the Dutch hydrogen energy transition, cooperation from multiple stakeholders from the state, market, and third sector is required. In the Top Consortium for Knowledge and Innovation (TKI) New Gas, the Dutch government, companies, universities, and research centers collaborate to strengthen the knowledge and innovation regarding new gases, including hydrogen. The TKI New Gas has more than 350 collaboration partners and stimulates new initiatives that accelerate the transition to sustainable energy (RVO, 2019).

The Multi-year Programmatic Approach for Hydrogen (MPAH) is a report published by the TKI New Gas in January 2020 (Gigler et al., 2020). It outlines a trajectory from 2020-2050 for the required research, demonstration, implementation, and upscaling of hydrogen in the Netherlands for the sectors of Industry, the Built Environment, and Mobility and Transportation.

The Multi-year Programmatic Approach for Hydrogen is elaborated in five separated but interrelated sections: (1) From vision to policy-making, (2) Practice: demonstration projects (pilots, demos and implementation), (3) Creating the conditions, (4) Research for the longer term, (5) Supporting and accompanying activities. This study focuses on section 2 on practice demonstration projects to get an improved understanding of the demonstration, implementation, and upscaling through large-scale practice projects required to achieve the 2030 climate ambitions. Section 4: research for the longer term is not chosen because the developments of COVID-19 are too uncertain to obtain reliable data needed to evaluate this section. Furthermore, this study views the other sections as supportive of section 2.

This study selects the Multi-year Programmatic Approach for Hydrogen report to study the hydrogen energy transition trajectory in the Netherlands before the COVID-19 crisis because its project plans were developed before COVID-19 and, therefore, do not take the pandemic into account. Furthermore, this report is chosen for this study because it represents the aggregation of multiple stakeholders' viewpoints and has a broad support base, as it has been drafted through consulting several stakeholders, according to the report. **Table 1** below assigns the key stakeholders of the Multi-year Programmatic Approach for Hydrogen to the

stakeholder groups of state, market, and third sector. Many companies in the Dutch hydrogen sector are state-owned and have both market and state logics. This research assigned these state-owned companies to the market stakeholder group, as the market logic is viewed as dominating. Furthermore, the community group is not included in the table below because stakeholders from the Dutch hydrogen sector community are more involved at an individual level as citizens and residents. They are not organized on a large scale in clubs and community groups.

Stakeholder group	Involved organizational stakeholders
State	Ministries; Provinces; Municipalities; Cities
Market	Energy companies; Network operators; Industrial companies; Ports; Transportation companies
Third sector	Environmental organizations; Industry associations; Knowledge institutions

Table 1. stakeholder groups and key stakeholders of the Dutch hydrogen energy transition

Now, an overview is given of the practice demonstration projects from 2020-2030 for the sectors of Industry, the Built Environment, and Mobility and Transportation, which are discussed in section 2 of the MPAH report.

Projects for the Industry sector

The Industry is expected to have the highest demand for hydrogen and become the largest market for hydrogen technology applications. Hydrogen in the Industry can be used as a raw material or auxiliary material for several chemical products, such as methanol and ammonia, and in oil and biomass refining processes. Furthermore, hydrogen can be used for the generation of high-temperature heat and steam for industrial applications.
Practice projects in the Industry are aimed at the production of green hydrogen on a large-scale through electrolysis. The long-term objective is to produce hydrogen completely CO_2-free and to utilize sustainable electricity production optimally. Upscaling through higher volumes and system capacities from Megawatt (MW) to Gigawatt (GW) scale will lead to gradual cost reduction. Upscaling is necessary to make the large-scale deployment of green hydrogen possible and profitable, offer more suitable or cost-effective alternatives for specific green electricity applications, and replace the Industry's current methane-based hydrogen usage.

Besides green hydrogen, practice projects in the Industry aim to upscale the production of blue hydrogen, which is deemed necessary to have access to large quantities of CO_2-neutral hydrogen in the short-term.

When comparing Industry projects to the Built Environment and Mobility and Transportation projects, this study states that the Industry sector projects require the most substantial financing because of their most significant scale.

Projects for the Built Environment sector

For the Built Environment, several possible options for sustainability exist. The usage of hydrogen is, besides green gas, appealing in homes and communities in which other energy sources and carriers are not feasible. Possibilities for hydrogen in the Built Environment include mixing hydrogen in the natural gas network in existing buildings, utilizing pure

hydrogen in existing neighborhoods, applications for individual homes, and applications for community heat systems (high-rise buildings and regional grids). Hydrogen does not appear desirable in new construction because sustainable all-electric alternatives seem more suitable, sustainable, and cost-effective.

It is essential to research, test, and demonstrate how hydrogen can be applied in the short-term to realize the desired level of sustainability in the Built Environment. Projects in the Built Environment are developed in several configurations (diverse types of situations, the share of hydrogen, and end-user applications), which is necessary to gain broad experience. Furthermore, these projects are needed to determine the conditions under which reconstruction, application, and possible further deployment after 2030 can occur effectively, efficiently, and safely.

When comparing Built Environment projects to Industry and Mobility and Transportation projects, this research states that the community stakeholder group has the highest level of involvement, as residents and citizens are directly involved in the Built Environment.

Projects for the Mobility and Transportation sector

Mobility and Transportation is an important sector for fuel cells and hydrogen. The Netherlands could play a vital role in developing hydrogen-powered public transportation buses, freight trucks, and special vehicles, such as garbage and sweeping trucks. Moreover, there are several possibilities for application in the shipping sector. The applications in this sector have a varying degree of market and technology readiness. Furthermore, the involvement of the Dutch Industry in the development and production of these applications differs.

Projects in the Mobility and Transportation sector are aimed at the following segments. The first segment is the passenger cars. Personal hydrogen cars are developed and produced abroad and have limited commercial availability.

The next segment is public bus transportation. Fuel-cell public buses are already available in serial production. Cost reduction is possible by purchasing large quantities, which is the goal of a couple of major European projects in which the Netherlands participates. Furthermore, the expansion of hydrogen-powered buses can be supported in concessions where battery-electric buses are not adequate.

Another segment is zero-emissions logistics. Hydrogen-powered freight trucks and delivery vans need to be further developed, tested, and demonstrated. Forklift trucks are already technically available. Moreover, zero-emissions urban cleaning is a relevant segment. Fuel-cell garbage trucks and sweeping trucks will be further developed, tested, and demonstrated.

The following segment is zero-emissions shipping. Fuel-cell ships and onshore power options need to be developed and demonstrated. The Netherlands is the leading inland waterway shipper within the Rhine area. This is partly why hydrogen applications are promising, namely for mobile hydrogen-powered energy containers and batteries. Maritime shipping is, for the time being, dependent on liquid fuels. Finally, filling stations are a relevant segment.

Developing infrastructure with nation-wide coverage is crucial to create different types of hydrogen-based Mobility and Transportation.

When comparing Mobility and Transportation projects to Industry and Built Environment projects, this study states that projects in the Mobility and Transportation sector are aimed at many different segments and cannot be generalized.

2.5 Similarities between hydrogen projects before COVID-19

This paragraph discusses the similarities between the projects of the sectors of Industry, Built Environment, and Mobility and Transportation. It elaborates on the aspects of financing, stakeholder participation, and stakeholder cooperation.

2.5.1 Financing

Projects of all three sectors are generally highly complex and expensive. Several national and European subsidies are available for hydrogen, but the demand is much greater than the supply. Hence, the authors of the MPAH argue that current subsidies are not sufficient to develop hydrogen in the short and long term and implement hydrogen on a large scale.

2.5.2 Stakeholder participation and stakeholder cooperation

Projects of all three sectors have organizational stakeholders from the stakeholder groups of state, market, and third sector. The project plans' dates and scale sizes are considered ambitious by the MPAH report authors. They argue that these high standards are desirable because of the speed of international developments and the necessity to reduce CO_2-emissions quickly. Furthermore, as mentioned before, many stakeholders have been consulted for the MPAH report from the state, market, and third sector, which resulted in a broad support base. Based on this, this research can infer that most stakeholders have a high willingness to participate in hydrogen projects to transition to a renewable energy system. Moreover, it can be inferred that stakeholders generally have a good cooperation.

However, individual stakeholders of the community need to be more involved, as the MPAH report states that societal embeddedness through the involvement of societal actors needs to be increased. This can be achieved by sharing knowledge and providing information packages.

2.6 Concluding remarks

In this study, the hydrogen energy transition in the Netherlands is defined as the transition from fossil fuels to green hydrogen, using blue hydrogen as a means to achieve this. To transition to hydrogen in the Netherlands, practice projects need to be demonstrated, implemented, and upscaled for the sectors of Industry, Built Environment, and Mobility and Transportation. Multiple organizational stakeholders from the market, state, and third sector have an interest in the hydrogen energy transition and can impact or are impacted by these hydrogen projects.

In the Multi-year Programmatic Approach Hydrogen, organizational stakeholders from these three stakeholder groups have stated very ambitious goals to execute these projects and have expressed a broad support base. This study can conclude that before COVID-19, stakeholders

generally had a high willingness to participate in hydrogen projects to transition to a renewable energy system. Furthermore, stakeholders typically had good cooperation. However, projects were expensive and needed more subsidies from the state.

The next chapter assesses academic literature about past crises to assess different stakeholders' perceptions on the implications of COVID-19 on the Dutch hydrogen energy transition.

3. Implications of COVID-19 on Dutch hydrogen energy transition from the perceptions of different stakeholders

3.1 Introduction

This chapter assesses academic literature about past crises to explore the potential implications of COVID-19 on the Dutch hydrogen energy transition from the perceptions of different stakeholders.

It discusses:

- What the COVID-19 crisis is;
- What a sustainability transition is;
- How crises are linked to sustainability transitions;
- What the implications of COVID-19 are on the Dutch hydrogen energy transition regarding financing, stakeholder participation, and stakeholder cooperation, operations, and Mobility and Transportation;
- What the concluding remarks of this chapter are.

3.2 COVID-19 crisis definition

To study the current and expected impact of COVID-19 on the Dutch hydrogen energy transition from different stakeholders' perceptions, this research first needs to define what the COVID-19 crisis is. As mentioned in the introduction, the COVID-19 crisis is both an international public health and economic crisis. This paragraph discusses the previous crises before COVID-19 and establishes definitions of the global public health and economic crisis that are used throughout this study.

First, international public health crises are discussed. Besides the ongoing COVID-19 pandemic, five other major global disease outbreaks have taken place since 2009: the 2009-2010 swine flu pandemic, the 2011-2015 polio declaration, the 2013-2016 Ebola virus epidemic in West Africa, the 2015-2016 Zika virus epidemic, and the 2018-2020 Ebola virus epidemic in the Democratic Republic of Congo and Uganda. These global disease outbreaks have resulted in many infections and fatalities and cost billions of Euros to combat. COVID-19 is expected to be highly damaging for public health globally. This is because humans have never been infected by the virus before, there is no vaccine yet (at the time of the primary data collection in October 2020), and it spreads as easily from person to person as influenza (Chakraborty & Maity, 2020).

The World Health Organization (WHO) has declared each of these six disease outbreaks as a Public Health Emergency of International Concern (PHEIC), which has been developed under the 2005 International Health Regulations (IHR). SARS, human influenza caused by a new subtype, smallpox, and poliomyelitis due to wildtype poliovirus are automatically declared as PHEICs (WHO, 2019).

This study adopts the WHO's PHEIC definition because it is widely used in academic research to study international public health crises. A Public Health Emergency of International Concern (PHEIC) is defined as “an extraordinary event which is determined to constitute a public risk to other States through the international spread of disease and to

potentially require a coordinated international response." A PHEIC is declared when a situation emerges that is "serious, sudden, unusual or unexpected" that "carries implications for public health beyond the affected State's national border" and "may require immediate international action" (WHO, 2019).

Second, international economic crises are elaborated upon. During some of the previous major international crises before COVID-19, the global economy was only partially damaged. During the Latin American debt crisis of the 1980s and the 1997 Asian Financial crisis, most economies in advanced countries experienced growth. Furthermore, during the 2008 global financial crisis, emerging markets, China especially, continued to grow. The last time the entire global economy was severely harmed was during the Great Depression in the 1930s. The current economic collapse caused by COVID-19 is estimated to be similarly sudden and steep because measures to slow down the spread of the virus severely restrict social and economic activities and require Billions of Euros of funding by governments worldwide at an unprecedented level (Reinhart & Reinhart, 2020).

These international economic crises have different causes but are all manifested by a sudden decline in economic activity. Therefore, many studies define these crises through the description of their symptoms (Revyakin, 2017). Consequently, this study defines an economic crisis as "a situation of a sudden, and often unexpected, deterioration of most, or all, key macroeconomic indicators, including GDP growth, unemployment levels, inflation rates, and public debt" (Starke et al., 2011, p. 2). An international economic crisis is an economic crisis experienced simultaneously by many countries globally (Starke et al., 2011).

So, this research can conclude that the COVID-19 crisis is an international public health crisis, which is a sudden and unexpected spread of disease which poses significant risks to the public health of countries worldwide. Furthermore, the COVID-19 crisis is an international economic crisis, which is a sudden and unexpected decline in economic activity that poses significant risks to the economies of countries worldwide. Moreover, this study can conclude that crises, in general, are sudden and unexpected, pose substantial risks, and cause uncertainty.

3.3 Dutch hydrogen transition as a sustainability transition and the link with a crisis

Section 2.2 defines the Dutch hydrogen energy transition as the transition from fossil fuels to green hydrogen, using blue hydrogen as a means to achieve this. To understand how the COVID-19 crisis impacts the Dutch hydrogen energy transition according to academic literature, this section studies literature about sustainability transitions because the hydrogen energy transition concept is too narrow to find useful insights in the existing literature. Furthermore, this section links the sustainability transition and crisis concepts.

Energy transitions have been investigated in various fields of academic research. Within transition research, the energy transition is often conceptualized as an example of a sustainability transition (Markard, 2018). This study uses the definition of sustainability transition presented by Loorbach et al. (2017) as it contains notions that are widely shared across all transition studies. Therefore, a sustainability transition is defined as a large-scale

disruptive non-linear societal change that emerges over decades and is needed to solve significant societal challenges. For the energy transition, climate change is the major societal challenge that needs to be resolved (Loorbach et al., 2017).

To link the concepts of a crisis and sustainability transition, this study utilizes academic literature that states that a crisis could offer a window of opportunity for radical change. Firstly, a window of opportunity can be defined as a period of larger receptivity of decision-making stakeholders when the proponents of initiatives have a higher possibility of shifting attention to their agendas and their solutions to problems. This possibility is created when a crisis threatens the high-priority objectives of the decision-making stakeholders, surprises the decision-making stakeholders, and causes a sense of urgency, and limits the time to respond. Secondly, radical change can be defined as a change beyond minor problem areas and incremental modifications. Consequently, highly severe crises offer opportunities for radical change, and less severe crises create possibilities for incremental change (Keeler, 1993; Kingdon, 1984; Saurugger & Terpan, 2016). Therefore, sustainability transition proponents could utilize the COVID-19 crisis as an opportunity to promote their hydrogen transition agenda to Dutch governmental decision-makers to accomplish disruptive large-scale societal change. However, this window of opportunity could be threatened by stakeholders of non-hydrogen sectors who would like to promote their agendas.

3.4 Implications of COVID-19 on the Dutch hydrogen energy transition

Section 2.5 discussed the similarities between hydrogen projects of all three sectors of Industry, Built Environment, and Mobility and Transportation regarding financing, stakeholder participation, and stakeholder cooperation before COVID-19. Hence, this paragraph studies academic literature about past crises to assess the implications of COVID-19 on financing, stakeholder participation, and stakeholder cooperation. This section also analyzes the implications on operations and Mobility and Transportation, as these are typically induced by public health crises. This paragraph does not distinguish yet between current and expected COVID-19 implications. This distinction is made in empirical research.

3.4.1 Financial implications

The COVID-19 crisis could have positive or negative effects on the financing of hydrogen projects in the Netherlands. These implications can be explained by academic studies about the relationship between past economic crises and sustainability transitions.

Positive financial implications

One stream of academic literature argues that adopting the green growth narrative by the state will positively influence sustainability transitions and help solve economic crises (see Geels, 2013; Perez, 2013; Van Der Ploeg & Withagen, 2013). Green growth is “a new strategic narrative that promises to solve both environmental and economic problems. It frames environmental protection in terms of opportunity and reward rather than additional cost” (Geels, 2013, p. 69).

Academic research distinguishes three main viewpoints on green growth with differing levels of ambition. The first perspective views green growth as slightly greener economic growth,

which can be achieved by green taxes. The second perspective views green growth as greener economic growth, which can be accomplished by creating new jobs in sustainable sectors and increasing government spending on green investments. The third viewpoint sees green growth as significantly greener economic growth, which can be achieved by a green industrial revolution. This revolution entails government investments in novel green technologies, skills, markets, infrastructures, and an extensive socio-institutional change (Bowen & Fankhauser, 2011). Hence, the state stakeholder group's adoption of the green growth narrative could positively impact the Dutch hydrogen energy transition.

Negative financial implications

However, another stream of academic literature argues that economic crises and sustainability transitions compete for attention (see Ashford et al., 2012; Geels, 2013; Penna & Geels, 2012). This can negatively impact the government's financing of sustainability transitions due to changing political and social priorities. Moreover, economic crises typically decrease investor or business confidence, which negatively influences the financing of sustainability transitions by companies (Ashford et al., 2012). Hence, the prioritization of economic issues over sustainability transitions could negatively influence the financing of the Dutch hydrogen energy transition. Additionally, as the COVID-19 crisis is also a public health crisis, which could lead to differing prioritizing of public health issues over the Dutch hydrogen energy transition by stakeholders from the market, state, and third sector.

Therefore, the COVID-19 crisis could have positive or negative effects on the financing of Dutch hydrogen projects depending on the levels of prioritization of sustainability issues by state, market, and third sector stakeholders.

3.4.2 Stakeholder participation implications

The COVID-19 crisis could positively or negatively affect stakeholders' participation in hydrogen projects in the Netherlands. These implications can be explained by academic literature about the relationship between past crises and sustainability transitions. This study views financial implications as an element of stakeholder participation implications.

As mentioned in section 3.4.1, economic crises, public health crises, and sustainability transitions compete for attention. Therefore, the level of stakeholder participation is dependent on the prioritization of sustainability issues. **Figure 2** below describes the key factors that influence the prioritization of sustainability transitions by stakeholder groups during economic and public health crises.

Stakeholder group	Key factors that influence the prioritization of sustainability during crises
State	Public health pressures; economic pressures; public opinion.
Market	Economic pressures; public health pressures; government measures; investor or business confidence.
Third sector	Mix of state, market, and community factors.

Figure 2. key factors that influence the prioritization of sustainability transitions by stakeholder groups during economic and public health crises based on own hypothesis

As mentioned in section 3.2, the state stakeholder group has to deal with tackling the sudden and unexpected spread of disease, which poses significant risks to public health. Therefore, public health pressures are likely to impact the prioritization of sustainability issues by the state strongly. Furthermore, the state has to deal with economic pressures due to the sudden and unexpected decline of economic activity. Hence, economic issues like unemployment could dominate the political debate (Ashford et al., 2012). However, as mentioned in section 3.4.1, when the state adopts the green growth narrative, this could positively affect sustainability transitions. Besides, the state is strongly influenced by the community stakeholder group's public opinion on sustainability issues (Penna & Geels, 2012). Hence, these factors could affect the level of stakeholder participation by the state stakeholder group.

The market stakeholder group also has to deal with strong economic and public health pressures. Additionally, the market's priorities are impacted by the government's measures regarding sustainability transitions and the adoption of the green growth narrative (Geels, 2013). All these factors influence the level of investor or business confidence in sustainability transitions (Ashford et al., 2012). Hence, these factors could affect the level of stakeholder participation by the market stakeholder group. Moreover, the third sector stakeholder group has mixed state, market, and community influencing factors, which could impact its level of stakeholder participation.

Therefore, the COVID-19 crisis could have positive or negative effects on stakeholders' participation in Dutch hydrogen projects depending on the levels of prioritization of sustainability issues by state, market, and third sector stakeholders.

3.4.3 Stakeholder cooperation implications

The COVID-19 crisis could have positive or negative effects on the cooperation of stakeholders in the Dutch hydrogen sector. These implications can be explained by academic studies about past crises and sustainability transitions.

Negative stakeholder cooperation implications

On the one hand, crises could negatively influence the cooperation of stakeholders in sustainability transitions. Transition studies argue that sustainability transitions create challenges for stakeholders as they have a high degree of complexity and uncertainty, are value-laden, and are heavily contested. Therefore, conflicts about the objectives, speed, scope, and direction of the transition characterize sustainability transitions (Markard, 2018).

Crises disrupt current ways of understanding and doing, induce uncertainty regarding future directions, and cause sustainability transitions to be non-linear and unpredictable. Crises are complex phenomena that have competing interpretations of their causes and solutions (Geels, 2013). Consequently, crises could intensify the conflicts about the objectives, speed, scope, and direction of sustainability transitions. Hence, crises could negatively impact the cooperation between stakeholders of state, market, and third sector in the Dutch hydrogen sector.

Positive stakeholder cooperation implications

On the other hand, crises could positively impact the cooperation of stakeholders in sustainability transitions. Solving sustainability challenges requires a high level of collaboration among different stakeholders, as no single organization possesses the knowledge or resources to tackle it by themselves (Gray & Stites, 2013). Strong collaboration is also essential for managing crises, as they create a superior goal whose scale exceeds the coping capacity of any single organization (Nohrstedt et al., 2018). Consequently, when stakeholders reconcile their different priorities to tackle both sustainability issues and crises, their relationship could become stronger. Hence, crises could positively impact the cooperation between stakeholders of state, market, and third sector in the Dutch hydrogen sector.

Therefore, the COVID-19 crisis could have positive or negative effects on the level of stakeholder cooperation in Dutch hydrogen projects depending on whether stakeholders are able to reconcile their different priorities and induce hostility or friendliness.

3.4.4 Operational implications

The COVID-19 crisis could have negative, limited, or no effects on the operations of projects in the Dutch hydrogen sector. These implications can be explained by academic studies about past public health crises. The reviewed literature did not discuss positive operational implications.

Negative operational implications

During public health crises, such as the 2002-2003 SARS epidemic in Asia, various countries have implemented quarantine and isolation measures to limit the disease's spread. These included work and national and international travel measures, impeding the flow of goods, services, and people (Tan & Enderwick, 2006). Similar measures in the case of the Netherlands could affect the operations of projects and cause delays. For instance, when engineers from another country would not be allowed to visit the Netherlands to repair a hydrogen truck. Therefore, COVID-19 could negatively impact the hydrogen sector's operations in the Netherlands according to the stakeholders of state, market, and third sector.

No or limited operational implications

Moreover, sectors that involved regular human contact were directly and heavily affected during SARS. These sectors include the healthcare industry, hospitality, and Mobility and Transportation. However, many organizations that require less regular human contact were not as heavily affected and were able to mainly continue their operations due to the role of information technology. Organizations issued laptops that could access the organization’s intranet and employed technologies, such as video conferencing. Consequently, many employees were able to work from home, and overseas meetings, conferences, and visits were canceled (Tan & Enderwick, 2006).

In 2003, some Industry leaders believed that videoconferencing would be continued to conduct business to save traveling time and money, even when traveling to Asia would proceed (Overby et al., 2004). Over the past years, the global video conferencing market size has increased significantly, and in 2019, it was valued at $3,85 billion (Grand View Research,

2020). Hence, looking at this study's context, public health crises could have no or limited implications on organizations' operations that require less human contact due to information technology deployment. For instance, office workers in the hydrogen sector could also do their jobs from home. Hence, COVID-19 could have no or limited impact on the operations of the hydrogen sector in the Netherlands according to the stakeholders of state, market, and the third sector.

Therefore, the COVID-19 crisis could have negative or no or limited effects on the operations of Dutch hydrogen projects depending on the COVID-19 measures.

3.4.5 Mobility and Transportation implications

The COVID-19 crisis could have negative effects on the Dutch hydrogen projects in the Mobility and Transportation sector particularly. These implications can be explained by academic studies about past public health crises.

Negative Mobility and Transportation implications

As mentioned in section 3.4.4, the Mobility and Transportation sector has been negatively affected by public health crises, such as SARS, due to travel restrictions. Besides these restrictions, people's mobility behavior is affected by fear, which disease outbreaks generate (Smith, 2006). Hence, this has resulted in reduced travel by people in countries with the highest infection rates (Brahmbhatt & Dutta, 2008). However, for some cases, lost economic activity in Mobility and Transportation during the disease outbreak could have been regained when the outbreak was over, which is called the bounce-back effect. For example, consumers could have undertaken postponed personal car purchases. For other cases, the damages might have been permanent, such as reductions in public transportation (Beutels et al., 2009).

So, public health crises negatively impact Mobility and Transportation sectors due to decreased travel by people. Hence, COVID-19 could negatively affect the hydrogen projects in the Mobility and Transportation sector in the Netherlands, as these projects require significant investments in this sector. The level of financing in Mobility and Transportation hydrogen projects is dependent on the priorities of the various stakeholders.

3.5 Concluding remarks

The COVID-19 crisis is an international public health and economic crisis, which is sudden, unexpected, and poses substantial risks. Furthermore, this crisis could offer a window of opportunity for radical change.

This chapter assessed academic literature about past crises to assess the implications of COVID-19 on the Dutch hydrogen energy transition in the Netherlands. This paragraph presents an overview of these implications in **figure 3** below.

	Financial implications	Stakeholder participation implications	Stakeholder cooperation implications	Operational implications	Mobility and Transportation implications
Negative implications	Decreased prioritization of sustainability transitions by stakeholders could negatively influence the financing of hydrogen projects.	Decreased prioritization of sustainability transitions by stakeholders could negatively influence stakeholder participation in the hydrogen transition.	Intensified conflicts between stakeholders could negatively influence stakeholder cooperation.	Imposed work and travel measures that tackle the public health crisis could negatively influence hydrogen operations.	Reduced travel by people could negatively influence hydrogen projects in the Mobility and Transportation sector.
Positive implications	Adopting the green growth narrative by the state stakeholder group could positively impact the financing of hydrogen projects.	Increased prioritization of sustainability transitions by stakeholders could positively impact stakeholder participation in the hydrogen transition.	The reconciliation of different stakeholder priorities could positively impact stakeholder cooperation.	The literature did not discuss positive operational implications.	The literature did not discuss positive Mobility and Transportation implications.
No or limited implications	The literature did not discuss no or limited financial implications.	The literature did not discuss no or limited stakeholder participation implications.	The literature did not discuss no or limited stakeholder cooperation implications.	The imposed work and travel measures could have no or limited impact on hydrogen operations when workers can work from home using information technology.	The literature did not discuss no or limited Mobility and Transportation implications.

Figure 3. Overview of implications of COVID-19 on the Dutch hydrogen energy transition according to theory (e.g., Ashford et al., 2012; Beutels et al., 2009; Geels, 2013; Markard, 2018; Tan & Enderwick, 2006)

After conducting empirical research, this study determines which parts of the literature studied in chapters 2 and 3 do not apply to the Dutch hydrogen energy transition context in chapter 6. The next chapter elaborates on the research methodology of this study.

B. Empirical research

4. Research methodology

4.1 Introduction

This chapter elaborates on the research methodology of this study.

It describes:

- Why this research uses a qualitative method;
- How semi-structured interviews are used as a data collection tool;
- How the interview respondents were selected and interviews were conducted;
- How primary data were analyzed;
- What the concluding remarks of this chapter are.

4.2 Qualitative research

This study uses a qualitative method to explore a novel and complex phenomenon that requires a deep understanding (Creswell, 2007). Firstly, different stakeholders' perceptions on the current and expected impact of the COVID-19 crisis on the Dutch hydrogen energy is a new phenomenon. As far as this study knows, no research conducted before 2020 has analyzed the implications of public health and economic crises on sustainability transitions. Furthermore, sustainable hydrogen technology is particularly novel and immature and cannot compete yet with established technologies (Markard, 2018). Secondly, this novel phenomenon is highly complex because it has multiple analytical layers of three different sectors (Industry, Built Environment, Mobility and Transportation) and stakeholder group perceptions (state, market, third sector).

4.3 Semi-structured interviews

Semi-structured interviews have been conducted to study this novel and complex phenomenon. These interviews enable the researcher to ask questions flexibly depending on the conversation, gain insight into how interviewees interpret the phenomenon and what they find relevant. To ensure the critical areas are still covered, an interview guide has been developed containing more specific questions (see **Appendix A**) (Blumberg et al., 2014). This guide entails questions about the overall hydrogen energy transition and the practice projects of the sectors of the Industry, the Built Environment, and Mobility and Transportation mentioned by the MPAH report. Furthermore, this guide was originally in Dutch but has been translated to English for this thesis.

4.4 Respondents selection and interviews

A purposive sampling method has been mainly used to select this study's interview respondents, which is a non-probability sampling that conforms to specific criteria (Blumberg et al., 2014). For this exploratory study, interviewees must adhere to particular standards of an expert population. Firstly, interviewees must be stakeholders of the hydrogen energy transition. Secondly, interviewees must have knowledge about at least one of the following sectors mentioned by the MPAH report: the Industry, the Built Environment, and Mobility and Transportation. This ensures that they have an understanding of at least one of the sectors

that the interview guide refers to. Thirdly, interviewees must be from the state, market, or third sector stakeholder group, as different stakeholder perceptions are analyzed.

Respondents have been selected by employing two sampling strategies. First, specific stakeholders have been reached out to directly by using purposive sampling. Individuals working for organizations mentioned in the MPAH report have been searched for on LinkedIn and Google to ensure they adhere to the above criteria. Then, they were reached out to via LinkedIn messages, e-mails, or phone calls. Second, respondents have been selected using a snowball sampling technique by asking interviewees who to interview next (Blumberg et al., 2014). This ensured that the next interviewees possessed an adequate level of knowledge to answer the questions.

This research presents an overview of the seventeen respondents that were interviewed between 13 and 30 October in **Appendix B**. The interviews have been conducted via phone or video calls because of the COVID-19 restrictions. Moreover, the concept of data saturation has been taken into account, which means that this study's researcher aims to collect data until a few, if any, new insights were provided (Saunders et al., 2009). Consequently, the researcher aimed to conduct interviews until a sufficient level of diversified perspectives from the state, market, and the third sector about the three different sectors has been reached. Not many new insights were provided during the final interviews, so data saturation has been reached.

4.5 Data analysis

After the interviews have been conducted, transcripts were created and coded using data analysis software MAXQDA. Based on the reviewed literature, the following second-order categories have been developed for all three sectors of Industry, Built Environment, and Mobility and Transportation: financial implications, stakeholder participation implications, and stakeholder cooperation implications, operational implications. Furthermore, for the Mobility and Transportation sector specifically, Mobility and Transportation implications have been identified. Subsequently, first-order categories were created that explain whether the second-order implications are positive, no or limited, or negative.

Appendix C presents the implications that all interviewed stakeholders mention across all three sectors. Consequently, based on **Appendix C**, **Appendices C.1, C.2, and C.3** were developed to understand the implications according to the stakeholder groups of state (C.1), market (C.2), and third sector (C.3).

Furthermore, it was discovered in this analysis that the Mobility and Transportation sector has sector-specific implications because of the changing way of transportation due to COVID-19. Based on this, **Appendix D** was created, where implications are presented that all interviewed stakeholders mention for Mobility and Transportation, particularly. The number of respondents for this appendix is too small to distinguish between state, market, and third sector stakeholders.

The next chapter presents an overview of Appendices C and D's findings and elaborates on these.

4.6 Concluding remarks

This study uses a qualitative method to explore a novel phenomenon that requires a complex understanding. To analyze different stakeholders' perceptions on the current and expected impact of COVID-19 on the Dutch hydrogen energy transition, semi-structured interviews were conducted using an interview guide. This guide entails questions about the overall hydrogen energy transition and the practice projects of the sectors of the Industry, the Built Environment, and Mobility and Transportation mentioned by the MPAH report.

5. Results

5.1 Introduction

This chapter discusses this research's findings by describing the current and expected implications of COVID-19 on the Dutch hydrogen energy transition from the perceptions of different stakeholders according to the collected interview data.

It describes:

- What the financial, stakeholder participation, stakeholder cooperation, operational and Mobility and Transportation implications of COVID-19 on the Dutch hydrogen energy transition are;
- What these implications according to the perspectives of the stakeholder groups of state, market, and the third sector are;
- What the concluding remarks of this chapter are.

5.2 Financial implications

The financing of hydrogen projects is one of the most significant themes of this study. The hydrogen sector is heavily dependent on government support because blue and green hydrogen is not profitable yet. Projects in the Industry sector require the most substantial amount of financing because of their scale.

No or limited financial implications by government

Some stakeholders argue that there is no current impact on hydrogen project financing by the government because the COVID-19 funds for hydrogen have not been granted yet.

Positive financial implications by government

This research found that ten out of seventeen stakeholders expect the Dutch government to support the hydrogen transition financially to recover the Dutch economy. The following quote illustrates this:

"Well, I think that the Dutch government is currently more inclined to put money in the hydrogen market because it generates economic development and employment opportunities in the Netherlands, and it contributes to the sustainable transition of the Netherlands. Therefore, it will support the Netherlands in all positive ways to get back on track after the COVID pandemic." (Interviewee 14: Dutch port, p. 39)

Negative financial implications by government

However, a few stakeholders point out that they expect it will be more difficult for the Dutch government to financially support the hydrogen transition, as they spend a significant amount on COVID-19 support. The following quote exemplifies this:

"Europe and the Netherlands are spending money like crazy to battle the crisis and its implications. However, at a certain point, the bill has to be paid. So yes, I view that as a threat to the energy transition because after a crisis in the years of recovery, usually, there is no abundance of funds, and costs are cut wherever possible." (Interviewee 16: Ekinetix, p. 42)

Negative financial implications by companies
Besides the government, funding from companies is needed as well. This study found that ten out of seventeen stakeholders view that companies currently have a lower willingness to invest in hydrogen and have become more risk-averse. This is particularly problematic for the significant hydrogen investments that are needed in the Industry sector. The following quote illustrates this:

> *"In general, you can state that the economic situation seems to be deteriorating. We are heading towards a recession, especially when COVID will last a while. Consequently, the effect is that generally, companies become more hesitant to invest and are less inclined to make substantial investments. They prefer to take a step back."*
> (Interviewee 4: TKI New Gas, p. 24)

No or limited financial implications by companies
However, Interviewee 2: Groningen Seaports from the market stakeholder group indicates that he currently does not notice a lower willingness to invest by companies. According to Interviewee 9: Province Groningen, this can be explained by the fact that Groningen Seaports has been flooded with new company applications for their hydrogen initiatives.

Sub-conclusion
So, firstly, this study can conclude that currently, some stakeholders argue that there is no current impact on hydrogen project financing by the government because the funds for hydrogen have not been granted yet. Most stakeholders expect that the government will support the hydrogen transition to boost the economy, but there have to be sufficient COVID-19 funds available. When looking at the stakeholder groups of state, market, and third sector, this research can observe that all stakeholder groups follow this line of reasoning. This research argues that the Dutch government needs to view the sustainable transition as a priority to allocate these funds to hydrogen.

Secondly, regarding funding from companies, this study can conclude that most stakeholders observe that companies currently have a lower willingness to invest in hydrogen. When looking at the three stakeholder groups, this research can notice that most stakeholder groups follow this line of reasoning. However, Interviewee 2: Groningen Seaports from the market stakeholder group forms the exception. At the moment, he does not observe a lower willingness to invest by companies, as company applications for their hydrogen initiatives are booming.

5.3 Stakeholder participation implications
The participation of stakeholders in the hydrogen transition is one of the most important themes of this research, overlapping with section 5.2 Financial Implications. This study views financing as an element of stakeholder participation.

No or limited stakeholder participation implications

This study found that eleven out of seventeen stakeholders argue that they currently still want and need to continue with the hydrogen transition, despite COVID-19 because of the ongoing climate issues. The following quote illustrates this:

"I think that currently, COVID-19 will not have such a large effect on the further development of the hydrogen sector because the energy transition and the climate issues are at least equally important or even more important than COVID-19." (Interviewee 17: Natuur en Milieufederatie Zuid-Holland, p. 42)

Positive stakeholder participation implications

Some stakeholders argue that COVID-19 does have an impact and view that currently, the pandemic has a positive effect on the willingness and need to transition to hydrogen because of people's reappraisal for their environment and climate and the ambition for a green financial recovery. The following quote exemplifies this:

"The positive part is that various recovery plans aim for sustainability in both the Netherlands and Europe. So, we see that there is an acceleration in the sustainability approach. We have gotten a reappraisal for a green environment around us and clean air. This holds for companies as well and is not only government-driven. I see that companies want to be frontrunners in hydrogen and other innovative areas to get out of the COVID-19 crisis." (Interviewee 9: Province Groningen, p. 29-30)

Even large oil and gas companies that are heavily affected by COVID-19, such as Shell and BP, have a stronger willingness and need to transition to hydrogen at the moment:

"Companies like Shell and BP are heavily affected by lower oil prices. Consequently, they need to cut costs, but they do not cut costs or relatively cut the least costs on the transition and hydrogen projects. They view hydrogen as an opportunity." (Interviewee 3: Gasunie, p. 14-15)

Negative stakeholder participation implications

However, some stakeholders expect that a few smaller heavily affected organizations, such as NAM (the Dutch natural gas company), will have to drop or lower their level of hydrogen participation:

"Parties that have the largest economic damage seem to drop hydrogen projects. These parties often operate in a specific market, and they are too small to do much risk diversification, unlike large stakeholders [such as Shell and BP]. To give you an example, this morning, it was announced that NAM needs to lay-off staff because of the decreasing price of natural gas. NAM is responsible for the gas extraction in the Netherlands and will have to reduce their activities, which means that they are probably more careful to join various hydrogen projects and make large investments."
(Interviewee 4: TKI New Gas, p. 58-59)

Sub-conclusion
Therefore, this research can conclude that most stakeholders currently view that they still want and need to continue with the hydrogen transition, despite COVID-19 because of the ongoing climate change issues. Some stakeholders view that COVID-19 does have an impact and argue that the pandemic has a positive effect on the willingness and need to transition to hydrogen because of people's reappraisal for their environment and climate and the ambition for a green financial recovery. Even major oil and gas companies that are heavily affected by COVID-19, such as Shell and BP, have a stronger willingness and need to transition to hydrogen. However, some stakeholders expect that a few smaller, heavily affected organizations, such as NAM, will have to drop or lower their hydrogen participation level.

When looking at the stakeholder groups of state, market, and third sector, this study can observe that all stakeholder groups follow the above line of reasoning.

5.4 Stakeholder cooperation implications

The cooperation between stakeholders in the hydrogen sector is a theme that has been impacted limitary by COVID-19.

No or limited stakeholder cooperation implications
This research found that before COVID-19, stakeholders generally had good cooperation. Consequently, twelve out of seventeen interviewees argue that COVID-19 currently has a limited or no impact on stakeholder cooperation. Stakeholders are impacted because their way of cooperating is changed by switching to working online, but there is typically no increased hostility or friendliness between stakeholders. The following quote exemplifies this:

"Well, in general, the cooperation between stakeholders for those specific hydrogen projects was quite good [before COVID-19]. So, they had a common goal. And, I think that besides the fact that it has become more complicated to work together physically, stakeholders still have good cooperation and a shared goal." (Interviewee 15: Government institution, p. 95)

Negative stakeholder cooperation implications
According to the interviewed stakeholders, switching to working online has both positive and negative effects on stakeholder cooperation at the moment. The negative implications are that it is more complicated to: coordinate working online with many different stakeholders, network, communicate informally, physically demonstrate projects, and stimulate innovation and creativity. Moreover, when communicating with non-professional stakeholders, it is more challenging to exchange knowledge with residents in the Built Environment.

Positive stakeholder cooperation implications
The positive effect of switching to working online is that it is easier for stakeholders to plan and conduct appointments because their traveling time has been reduced. Furthermore, online meetings are often more efficient and to the point.

Moreover, as mentioned before, most stakeholders currently do not observe increased hostility or friendliness between stakeholders. However, Interviewee 11: Municipality Arnhem,

expects that stakeholders who will survive the COVID-19 crisis together could have a stronger relationship in the end:

"It could be possible that the current relations between stakeholders will become stronger in the long term. When partners get through a crisis together, they could become stronger partners. They become fellow-sufferers as well as cooperation partners." (Interviewee 11: Municipality Arnhem, p. 87)

Sub-conclusion

So, this study can conclude that before COVID-19, stakeholders generally had good cooperation. This research found that most interviewees argue that COVID-19 currently has a limited or no impact on stakeholder cooperation. Stakeholders are impacted because their way of cooperating is changed by switching to working online, but there is typically no increased hostility or friendliness between stakeholders.

When looking at the stakeholder groups of state, market, and third sector, this research can observe that all stakeholder groups follow the above line of reasoning. However, Interviewee 11: Municipality Arnhem from the state stakeholder group forms the exception. He expects that stakeholders who will survive the COVID-19 crisis together could have a stronger relationship in the end.

5.5 Operational implications

Operations of hydrogen projects is another theme that COVID-19 impacts.

Negative operational implications

Some stakeholders argue that specific hydrogen projects currently experience delays due to national and international work and travel restrictions. The following quote can exemplify this:

"The HEAVENN hydrogen valley project [aimed at the development of a fully functioning green hydrogen chain in the Northern Netherlands] has started up [at the beginning of 2020]. We see that this project has been delayed due to the restrictions of COVID. For instance, delivery times have increased due to lockdowns, etc. So, that is what you see for every project that becomes more tangible. In 2021 and 2022, many things need to be built for these hydrogen projects, and corona is not helping." (Interviewee 9: Province Groningen, p. 33)

Also, some stakeholders state that it has become more difficult at the moment to physically demonstrate hydrogen projects on site because of the COVID-19 restrictions, which is crucial in the demonstration and pilot phase:

"For these European projects, we need to organize events, gatherings, workshops, and we need to show people how our technology works. Therefore, physically attending these activities is crucial and is part of communication and dissemination: to what extent can you disseminate your learning experiences and the things you would like to show to the outside world. And that is, of course, an issue at the moment." (Interviewee 8: WaterstofNet, p. 49)

No or limited operational implications
However, despite the measures, this study found that eight out of seventeen interviewees argue that existing hydrogen projects that started before COVID-19 are currently being continued because office workers are able to work from home.

Sub-conclusion
Therefore, this study can conclude that some stakeholders argue that specific hydrogen projects currently experience delays due to national and international work and travel restrictions. Also, some stakeholders state that it has become more difficult to physically demonstrate hydrogen projects on site at the moment because of the COVID-19 restrictions, which is crucial in the demonstration and pilot phase. However, half of the interviewees argue that existing hydrogen pilot projects that started before COVID-19 are currently being continued despite the measures.

When looking at the stakeholder groups of state, market, and third sector, this research can observe that all stakeholder groups follow the above line of reasoning.

5.6 Mobility and Transportation implications

The Mobility and Transportation sector has sector-specific implications because of the changing way of transportation due to COVID-19. This sector has many different segments, which are impacted differently by COVID-19. Therefore, their impacts cannot be generalized.

Negative Mobility and Transportation implications
Dutch citizens are encouraged to restrict their travel movements to curb the spread of the coronavirus. As a result, Dutch citizens travel less and try to avoid using public transportation. Consequently, some stakeholders argue that public transport and bus companies currently have fewer passengers and a lower willingness to invest in hydrogen projects. Furthermore, some expect fewer passengers and a lower willingness to invest in hydrogen if COVID-19 lasts long:

"In the long-term, it could be that companies become more hesitant and postpone possible investments in hydrogen busses, due to uncertainty about how structural or temporal the lower numbers of bus passengers will be. So, there is an uncertainty which will probably have an impact on the development of hydrogen in the mobility sector."
(Interviewee 10: Ministry of I&W, p. 77)

Moreover, people drive their cars less as well. Consequently, some stakeholders state that purchase investments for (hydrogen) cars are currently delayed.

Positive Mobility and Transportation implications
However, as people restrict their travel movements, they shop more online. Consequently, delivery services have more clients, which presents an opportunity for hydrogen applications, according to Interviewee 10: Ministry I&W:

"What you see now with COVID is that what's bad for one organization is good for another. On the one hand, public transportation companies are heavily impacted as many buses are not driving anymore. On the other hand, delivery services are currently busier than ever. […] Public transportation companies and delivery services could both want to drive hydrogen vehicles to emit fewer emissions." (Interviewee 10: Ministry I&W, p. 116-120)

Sub-conclusion

So, this research can conclude that to curb the coronavirus's spread, Dutch citizens travel less and try to avoid using public transportation. Consequently, some stakeholders argue that public transportation has and expects to have fewer passengers and a lower willingness to invest in hydrogen if COVID-19 lasts long. Moreover, some stakeholders state that purchase investments for (hydrogen) cars are currently delayed, as people drive their cars less. However, delivery services are thriving, which presents an opportunity for hydrogen applications.

5.7 Concluding remarks

Based on this investigation, it can be concluded that there are both no or limited, positive and negative current and expected implications of COVID-19 on the Dutch hydrogen energy transition. Stakeholders have relatively moderate viewpoints and are neither extraordinarily optimistic nor pessimistic.

Furthermore, this study concludes that the no or limited, positive, and negative implications of COVID-19 on the Dutch hydrogen energy transition are dependent on two main factors. The first factor is the duration of COVID-19: the longer COVID-19 will last, the more severe its effects will be. The second factor is the level of prioritization of sustainability by all stakeholders. The majority of stakeholders need to view the hydrogen energy transition and climate issues as at least equally important as COVID-19. However, not all stakeholders are able to act on this prioritization.

When looking at the stakeholder groups of state, market, and third sector, this research can conclude that these groups do not have differing viewpoints and typically follow the same line of reasoning. Some individual stakeholders have divergent views, but these are not dependent on the stakeholder groups they belong to.

The next chapter combines the research results with the discussed literature of chapters 2 and 3.

C. Interpretation of findings

6. Linking literature and results

6.1 Introduction

This chapter combines the research results (chapter 5) with the discussed literature (chapters 2 and 3) and presents interpretations and insights.

It describes:

- What the current and expected financial, stakeholder participation, operational, stakeholder cooperation, and Mobility and Transportation implications of COVID-19 on the Dutch hydrogen energy transition according to theory and empirical research are;
- What the perceptions of various stakeholders on these implications according to theory and empirical research are;
- What the concluding remarks of this chapter are.

6.2 Financial implications

The COVID-19 crisis has positive, no, or limited, and negative financial implications on the Dutch hydrogen energy transition.

No or limited financial implications by government

The results state that some stakeholders argue that there is currently no impact on hydrogen project financing by the government because the COVID-19 funds for hydrogen have not been granted yet (at the time of the primary data collection).

Positive financial implications

The results suggest that ten out of seventeen stakeholders expect the Dutch government to have a high willingness to financially support the hydrogen transition to recover the Dutch economy from the COVID-19 crisis. This finding confirms the literature about the second-level green growth narrative. Hence, most stakeholders adopt the second-level perspective of green growth and prioritize sustainability. They argue that greener economic growth can be accomplished by creating new jobs in the hydrogen sector and increasing government spending on green investments. These investments are crucial, as subsidies for hydrogen projects before COVID-19 were not sufficient, as stated in the MPAH report. Industry projects, in particular, require the most substantial financing because of their scale.

Negative financial implications by government

However, the findings imply that a few stakeholders expect that it will be more difficult for the Dutch government to financially support the hydrogen transition, as they spend a significant amount on COVID-19 support. As mentioned in the literature, economic crises, public health crises, and sustainability transitions compete for attention. Even if the Dutch government has the willingness to prioritize sustainability transitions and establish green

growth, they need to have the ability to do so, as tackling the health crisis and supporting affected businesses requires significant funds.

Negative financial implications by companies
Besides the government, funding from companies is needed as well. This study found that ten out of seventeen stakeholders view that companies currently have a lower willingness to invest in hydrogen and have become more risk-averse. This is particularly problematic for the significant hydrogen investments that are needed in the Industry sector. This finding confirms the literature that states that economic crises typically decrease investor or business confidence, which negatively influences the financing of sustainability transitions by companies and the prioritization of sustainability.

No or limited financial implications by companies
However, Interviewee 2: Groningen Seaports forms the exception. Currently, he does not observe a lower willingness to invest by companies, as company applications for their hydrogen initiatives are booming. The literature section about financial implications (3.4.1) did not describe this no or limited financial implication. However, this finding can be explained by literature from section 3.4.4 about the SARS public health crisis. This section states that sectors that involved regular human contact were directly and heavily affected, such as the medical industry, hospitality, and Mobility and Transportation. However, many organizations that require less regular human contact were not as heavily affected and were able to mainly continue their operations due to the role of information technology. Hence, this study argues that companies that currently do not have a lower willingness to invest in hydrogen initiatives appear to be not that heavily affected by the COVID-19 crisis.

Sub-conclusion
This research can conclude that the COVID-19 crisis has positive, no, or limited, and negative effects on the financing of Dutch hydrogen projects depending on the levels of prioritization of sustainability issues by stakeholders. This study found that this prioritization is mainly driven by willingness and ability. Stakeholders expect that the Dutch government has a high willingness to support hydrogen to boost the Dutch economy financially. However, they need to have the ability to do so, as tackling the health crisis and supporting affected businesses requires significant funds. Furthermore, most companies currently do, and some companies do not have a lower willingness to invest in hydrogen projects. This willingness can partly be explained by these companies' ability to invest, as some are more impacted by the effects of COVID-19 than others.

6.3 Stakeholder participation implications
The COVID-19 crisis has positive, no, or limited, and negative stakeholder participation implications on the Dutch hydrogen energy transition.

No or limited stakeholder participation implications
Before COVID-19, this research argued based on the literature that stakeholders generally had a high willingness to participate in hydrogen projects to transition to a renewable energy system.

The results found that eleven out of seventeen stakeholders argue that they currently still have a high willingness to continue with the hydrogen transition, despite COVID-19 because of the ongoing climate issues. The reviewed literature did not describe this no or limited stakeholder participation implication because it expected the influence of COVID-19 on this implication to be more severe.

Positive stakeholder participation implications

The findings imply that some stakeholders argue that COVID-19 does have an impact and view that the pandemic currently has a positive effect on the willingness to transition to hydrogen because of people's reappraisal for their environment and climate and the ambition for a green financial recovery. This finding confirms literature about the prioritization of sustainability issues, which states that green technologies can be stimulated to boost the economy and relieve economic pressures. Furthermore, people's reappraisal of the environment positively impacts public opinion on sustainability matters and positively influences the prioritization of sustainability.

Moreover, the results found that even large oil and gas companies that are heavily affected by COVID-19, such as Shell and BP, currently have a stronger willingness to transition to hydrogen. This also confirms the literature about the prioritization of sustainability issues. Oil and gas companies face major economic pressures and decreased investor confidence due to the lower oil and gas prices. These pressures could positively impact the prioritization of hydrogen, as it is viewed as an opportunity.

Negative stakeholder participation implications

However, some stakeholders expect that a few smaller, heavily affected organizations, such as NAM, will have to drop or lower their level of hydrogen participation. This is also confirmed by literature about the prioritization of sustainability issues. These smaller organizations do not have the ability to prioritize hydrogen because economic pressures dominate them.

Sub-conclusion

This study can conclude that the COVID-19 crisis has positive, no, or limited, and negative effects on the stakeholder participation of Dutch hydrogen projects depending on the levels of prioritization of sustainability issues by stakeholders. This research found that this prioritization is mainly driven by willingness and ability. Most stakeholders currently still have a high willingness to continue with the hydrogen transition, despite COVID-19 because of the ongoing climate issues. This willingness could be positively impacted by people's current reappraisal for their environment and climate and the ambition for a green financial recovery. However, it is expected that few smaller organizations, such as NAM, do not have the ability to prioritize hydrogen because economic pressures dominate them.

6.4 Stakeholder cooperation implications

The COVID-19 crisis has positive, no, or limited, and negative stakeholder cooperation implications on the Dutch hydrogen energy transition.

Negative and no or limited implications
One stream of literature states that sustainability transitions are characterized by conflicts about the objectives, speed, scope, and direction of the transition. Consequently, crises could intensify these conflicts and negatively impact the cooperation between stakeholders of state, market, and third sector in the Dutch hydrogen sector. However, the results and the MPAH report state that stakeholders generally had good cooperation before COVID-19. Furthermore, the findings imply that most stakeholders argue that they still have good cooperation and that there is currently no increased hostility between them due to COVID-19.

This finding can be explained by the study from Hupe & Meijs (2000), which argues that stakeholders have a low level of conflict due to the strong Dutch consensus and consultation culture. Furthermore, multiple stakeholders believe that they have a shared responsibility to manage environmental affairs. Therefore, stakeholders have good cooperation and have a shared goal and responsibility of establishing the hydrogen transition, which is not negatively affected by the COVID-19 crisis.

So, there is currently no increased hostility between stakeholders, but the results show that their way of cooperating is negatively impacted by switching to working online from home. The negative implications are that it is more complicated to: coordinate working online with various stakeholders, network, communicate informally, physically demonstrate projects, and stimulate innovation and creativity. Moreover, when communicating with non-professional stakeholders, it is more challenging to exchange knowledge with residents in the Built Environment.

Positive and no or limited implications
Another stream of literature states that when stakeholders reconcile their different priorities to tackle both sustainability issues and crises, their relationship could become stronger. This theory confirms the view of Interviewee 11: Municipality Arnhem, who expects that stakeholders who survive the COVID-19 crisis together could have a stronger relationship in the end. However, the findings imply that most stakeholders argue that there is currently no increased friendliness between them due to COVID-19. Stakeholders have good cooperation and have a shared goal and responsibility of establishing the hydrogen transition, which is not positively affected by the COVID-19 crisis.

So, there is currently no increased friendliness between stakeholders, but their way of cooperating can also be positively impacted by working online from home. The positive effect is that it is easier for stakeholders to plan and conduct appointments because their traveling time has been reduced. Furthermore, online meetings are often more efficient and to the point.

Sub-conclusion
This study can conclude that the COVID-19 crisis has positive, no, or limited, and negative effects on the stakeholder cooperation of Dutch hydrogen projects due to the changed way of

working together online. There is no current increased hostility or friendliness between stakeholders, in contrast to the suggestions of the literature. Stakeholders have good cooperation and have a shared goal and responsibility of establishing the hydrogen transition, which is not positively or negatively affected by the COVID-19 crisis.

The literature did discuss that many stakeholders worked from home due to the SARS outbreak, but it did not discuss this in relation to worsened or improved stakeholder cooperation, as increasingly working from home is not limited to the hydrogen sector and is a general trend. However, the results showed hydrogen-specific implications that are valuable to explore further. As hydrogen is an emerging technology, which is tested out through pilot projects, physically demonstrating these projects and stimulating innovation and creativity is particularly difficult while working online from home.

6.5 Operational implications

The COVID-19 crisis has negative and no or limited operational implications on the Dutch hydrogen energy transition.

Negative operational implications

The results showed that some stakeholders argue that specific hydrogen projects currently experience delays due to national and international work and travel restrictions. For instance, delivery times have increased due to lockdowns. This finding confirms the literature stating that national and international work and travel measures impeded the flow of goods, services, and people during the SARS epidemic. Also, this study found that some stakeholders state that it has become more difficult to physically demonstrate hydrogen projects on site at the moment because of the COVID-19 restrictions, which is crucial in the demonstration and pilot phase.

No or limited operational implications

However, despite the measures, this study found that eight out of seventeen interviewees argue that existing hydrogen projects that started before COVID-19 are currently being continued because office workers can work from home. This finding confirms the theory that states that organizations' operations that require less human contact can be continued due to information technology deployment. Already during the SARS outbreak, many workers were able to work from home, and the information technology that enables this has significantly improved and expanded over the years.

Sub-conclusion

This research can conclude that the COVID-19 crisis has negative and no or limited implications on the Dutch hydrogen energy transition operations due to the COVID-19 measures, which are similar to other public health crisis measures. The longer COVID-19 will last, the more severe its measures and implications will be. However, as the hydrogen sector operations require limited human contact, the current implications have been less severe.

6.6 Mobility and Transportation implications

The COVID-19 crisis has negative and positive Mobility and Transportation implications on the Dutch hydrogen energy transition.

Negative Mobility and Transportation implications

The findings show that Dutch citizens are encouraged to restrict their travel movements to curb the coronavirus's spread. As a result, Dutch citizens travel less and try to avoid using public transportation. Consequently, some stakeholders argue that public transport and bus companies currently have fewer passengers and a lower willingness to invest in hydrogen projects. Furthermore, some expect fewer passengers and a lower willingness to invest in hydrogen if COVID-19 will last long. These results confirm literature that argues that travel restrictions and the fear of the virus resulted in reduced travel by people during the SARS outbreak. The reductions in public transportation could have permanent damage.

Moreover, the results state that people drive their cars less, leading to delayed purchase investments for (hydrogen) cars, according to some stakeholders. This result confirms a theory that describes that the loss of car investments could be regained when the outbreak is over, which is called the bounce-back effect.

Positive Mobility and Transportation implications

Furthermore, the results show that as people restrict their travel movements, they shop more online. Consequently, delivery services have more clients, which presents an opportunity for hydrogen applications, according to Interviewee 10: Ministry I&W. This opportunity for hydrogen applications has not been discussed by the selected literature. This research initially did not see the link between online shopping growth and the potential for hydrogen applications. The literature introduced in this paragraph explains that SARS convinced many Chinese citizens who were afraid to go outside to shop online instead. This temporary shift from offline to online might have triggered the long-term structural change in shopping behavior and the increase of delivery services (Fernandes & Tang, 2020).

Sub-conclusion

This study can conclude that the COVID-19 crisis has negative public transportation implications on the Dutch hydrogen energy transition due to the COVID-19 travel measures, which are similar to other public health crisis measures. The expectation is that the longer COVID-19 will last, the more severe its measures and implications will be.

Furthermore, based on the literature in chapter 3, this study did not expect positive Mobility and Transportation implications for hydrogen caused by COVID-19. The findings identified that delivery services present an opportunity for hydrogen applications, as people shop more online to restrict their travel movements. Furthermore, this paragraph explained that online shopping and delivery services also increased during the SARS outbreak.

6.7 Stakeholder perceptions: similar

This study analyzed the current and expected financial, stakeholder participation, stakeholder cooperation, operational, and Mobility and Transportation implications from the perceptions of different stakeholders. The results show that the stakeholder groups of state, market, and third sector do not have differing perceptions and typically follow the same line of reasoning on these implications. Some individual stakeholders have divergent views, but these are not dependent on the stakeholder groups they belong to.

According to the literature by Hupe & Meijs (2000), distinctions between governmental, for-profit, and non-profit organizations within the field of environmental affairs have become increasingly blurred in the Netherlands. Hence, stakeholders from market, state, and third sector in the Dutch hydrogen sector have more similar logics and viewpoints on the implications of COVID-19.

6.8 Concluding remarks

This chapter assessed the current and expected implications of COVID-19 on the Dutch hydrogen energy transition according to theory and empirical research. **Figure 4** below presents an overview of the latter.

	Financial implications	**Stakeholder participation implications**	**Stakeholder cooperation implications**	**Operational implications**	**Mobility and Transportation implications**
Negative implications	Theory: Decreased prioritization of sustainability transitions by stakeholders could negatively influence the financing of hydrogen projects.	Theory: Decreased prioritization of sustainability transitions by stakeholders could negatively influence stakeholder participation in the hydrogen transition.	Theory: Intensified conflicts between stakeholders could negatively influence stakeholder cooperation.	Theory: Imposed work and travel measures that tackle the public health crisis could negatively influence hydrogen operations.	Theory: Reduced travel by people could negatively influence hydrogen projects in the Mobility and Transportation sector.
	Practice: This theory confirms practice.	Practice: This theory confirms practice.	Practice: This theory does not confirm practice. The results found that stakeholders have low conflict and high shared stakeholder responsibility to transition to hydrogen due to	Practice: This theory confirms practice.	Practice: This theory confirms practice.

			the strong Dutch consensus culture.		
Positive implications	Theory: Adopting the green growth narrative by the state stakeholder group could positively impact the financing of hydrogen projects.	Theory: Increased prioritization of sustainability transitions by stakeholders could positively impact stakeholder participation in the hydrogen transition.	Theory: The reconciliation of different stakeholder priorities could positively impact stakeholder cooperation.	Theory: The literature did not discuss positive operational implications.	Theory: The literature did not discuss positive Mobility and Transportation implications.
	Practice: This theory confirms practice.	Practice: This theory confirms practice.	Practice: This theory confirms the view of Interviewee 11, who thinks that stakeholders who survive the COVID-19 crisis together could have a stronger relationship in the end.	Practice: This theory confirms practice.	Practice: This theory does not confirm practice. The results found that the growth of delivery services offers an opportunity for hydrogen applications.
No or limited implications	Theory: The literature did not discuss limited or no financial implications.	Theory: The literature did not discuss limited or no stakeholder participation implications.	Theory: The literature did not discuss limited or no stakeholder cooperation implications.	Theory: The imposed work and travel measures could have no or limited impact on hydrogen operations when workers can work from home using information technology.	Theory: The literature did not discuss limited or no Mobility and Transportation implications.
	Practice: This theory does not confirm practice. The results found that some companies do not have a lower willingness to prioritize and invest	Practice: This theory does not confirm practice. The results found that most stakeholders have a high willingness to prioritize the	Practice: This theory does not confirm practice. The results found that there is currently no increased hostility or friendliness	Practice: This theory confirms practice.	Practice: This theory confirms practice.

	in hydrogen because they appear to be not heavily impacted by COVID-19.	hydrogen transition, despite COVID-19 because of the ongoing climate issues.	between stakeholders. However, stakeholder cooperation can be positively and negatively impacted by the shift to working from home.		

Figure 4. Overview of implications of COVID-19 on the Dutch hydrogen energy transition according to theory and practice

Based on this overview, this study can conclude that most implications that are reviewed in the literature confirm the empirical findings. The main discrepancies between theory and practice are caused by the fact that the reviewed literature expected the implications of COVID-19 on the Dutch hydrogen energy transition to be more severe.

Moreover, this research studied the implications of COVID-19 on the Dutch hydrogen energy transition from the perceptions of different stakeholders. The empirical results showed that the stakeholder groups of state, market, and third sector do not have differing viewpoints and typically follow the same line of reasoning regarding these implications because the boundaries between these stakeholders have become increasingly blurred. Consequently, stakeholders have low levels of conflict and a shared responsibility to tackle sustainability issues.

7. Conclusion

This study answered the research question: *How do different hydrogen stakeholders perceive the current and expected implications of the COVID-19 crisis on the hydrogen energy transition in the Netherlands?*

The findings shows that different hydrogen stakeholders from the state, market, and the third sector have similar viewpoints on the current and expected stakeholder implications because the boundaries between them have become increasingly blurred in the Dutch context.

Stakeholders view that the current implications of the ongoing COVID-19 crisis are quite limited, and business is mostly conducted as usual. Firstly, many organizations in the hydrogen sector that require low regular human contact are not heavily affected and can mainly continue their operations because their office employees can work from home. These organizations face operational issues, such as longer delivery times due to COVID-19 work and travel restrictions. Furthermore, they face online cooperation issues, such as demonstrating hydrogen projects and stimulating innovation and creativity online. However, they also experience the benefits from working online, such as reduced (traveling) time and higher meeting efficiency. Overall, these operational and online cooperation implications have a limited impact on the continuation of hydrogen projects.

Secondly, most Dutch stakeholders have a high willingness to transition to hydrogen and view the hydrogen energy transition and climate issues as at least equally important as the COVID-19 crisis. Consequently, stakeholders have low levels of conflict and a shared responsibility to tackle sustainability issues and transition to hydrogen, which is not significantly altered by the coronavirus. However, market stakeholders in the public transportation sector and small market players in the oil and gas industry have a lower willingness to invest in hydrogen projects because they have been heavily affected by the COVID-19 crisis. Still, these damaged market stakeholders do not significantly lower the overall transition willingness of the hydrogen sector.

Besides these current implications, the stakeholders identified an expected implication that could offer an opportunity for incremental change for hydrogen applications in the Mobility and Transportation sector. Delivery services are thriving as people restrict their travel movements and shop more online, which is a trend that is expected to be continued after the COVID-19 crisis. Furthermore, Dutch municipalities and cities will be able to implement zero-emission zones for delivery trucks from 2025 (Logistiek.nl, 2020). Therefore, developing hydrogen delivery trucks could be very promising.

Moreover, the stakeholders identified one considerable expected implication that could offer a window of opportunity for radical change. The Dutch government has a high willingness to financially support the hydrogen energy transition to recover the Dutch economy from the COVID-19 crisis. This financial support is crucial for developing hydrogen because sustainable hydrogen technology is novel and emerging. Hence, stimulating greener economic growth is the foremost opportunity for the hydrogen sector due to the creation of new jobs and increased government spending on green investments. The hydrogen economy is currently

mentioned on the list of projects eligible for support from the National Growth Fund (Ministerie van Economische Zaken en Klimaat, 2021).

However, this window of opportunity is threatened by the Dutch government's decreased ability to financially support the hydrogen energy transition, as they spend billions of euros on COVID-19 support. The government has borrowed at a negative interest rate in 2020, which limits the severity of national debt, but the public debt still has to be paid off after the COVID-19 crisis (RTL Nieuws, 2020).

Besides, this window of opportunity is threatened by stakeholders of non-hydrogen sectors who would like to promote their agendas. For instance, sustainability opponents could lobby against greener economic growth.

Therefore, to answer the research question: *How do different hydrogen stakeholders perceive the current and expected implications of the COVID-19 crisis on the hydrogen energy transition in the Netherlands?* this study concludes that hydrogen stakeholders perceive the current implications of the ongoing COVID-19 crisis as quite limited. Business is mostly conducted as usual, as most stakeholders continue to collectively tackle the largest looming crisis of the 21st century: climate change. Furthermore, stakeholders expect that the Dutch government will financially support the hydrogen energy transition to recover the Dutch economy from the COVID-19 crisis, which offers a window of opportunity for radical change. Multiple stakeholders have to work together as a strong coalition to develop hydrogen technology further and seize this opportunity, which is threatened by increasing government debt and stakeholders of non-hydrogen sectors that would like to promote their agendas.

8. Discussion

This chapter discusses this study's implications for theory and practice, the limitations of this research, and suggestions for future research.

8.1 Theoretical implications

This section elaborates on the implications of this study on theory.

The first theoretical implication is that Dutch stakeholders in the hydrogen sector still have low conflict and high shared responsibility to tackle sustainability issues during a crisis. The reviewed literature expected that a crisis would intensify conflicts between stakeholders and negatively influence stakeholder cooperation (Geels, 2013). However, this is currently not the case for the unique Dutch context with its strong consensus culture and high shared responsibility for sustainability issues (Hupe & Meijs, 2000). This theoretical implication could be explained by the fact that sustainability and energy transitions have become increasingly important over the past years in the Netherlands, finally resulting in the country's first National Climate Agreement in 2019 (Ministerie van Economische Zaken en Klimaat, 2019). The study by Geels (2013) studied the impact of the 2008 global financial crisis on sustainability transitions, a period in which sustainability issues were considered less important.

Secondly, the theoretical implication is that the negative economic effects of a public health crisis on a sustainability transition appear to be not that severe, as the sectors that are heavily affected involve regular human contact, while most hydrogen operations are being continued. This implication is a novel contribution to theory because (as far as this study knows) no research conducted before 2020 has analyzed the implications of both public health and economic crises on sustainability transitions. This theoretical implication is relevant for practitioners, as sustainability transitions are needed to solve significant societal challenges, and unexpected crises could (severely) change the direction of these transitions (Loorbach et al., 2017; Saurugger & Terpan, 2016).

8.2 Practical implications

This section discusses the implications of this study on practice.

The first practical recommendation is that stakeholders form a strong coalition to convince the Dutch government to financially support the hydrogen energy transition to recover the economy from the COVID-19 crisis. Practitioners are advised to create an alliance with influential stakeholders who have decision-making power on state matters (Saurugger & Terpan, 2016), such as the National Growth Fund and other future COVID-19 funds.

Secondly, this study advises practitioners in the Mobility and Transportation sector to develop hydrogen applications for delivery services. These services are thriving as people restrict their travel movements and shop more online, which is a trend that is expected to be continued after the COVID-19 crisis. Besides, Dutch municipalities and cities will be able to implement zero-emission zones for delivery trucks from 2025 (Logistiek.nl, 2020).

The third recommendation is that practitioners continue to invest in emerging information technologies, which improve business continuity during public health crises because this

study expects novel public health crises to come after COVID-19. In 2004, epidemiologists already warned that the SARS outbreak could be a preview of even more destructive health crises to come due to the growing level of globalization. As economies and countries are increasingly interconnected, viruses like SARS are more easily spread (Overby et al., 2004). Therefore, using enhanced information technology tools during future health crises could optimize creativity and innovation during online cooperation sessions and improve the online demonstration of (pilot) hydrogen projects.

Fourthly, this study's findings are also relevant for other new (sustainable) technologies that need to be further developed and require significant government support, such as technology for using residual heat from data centers.

8.3 Limitations

This section discusses the limitations of this study.

Firstly, the limitation is that this research studies a contemporary topic, which is still changing and developing. When interviews were conducted in October 2020, there was higher uncertainty about the coronavirus and its implications than in February 2021. Consequently, if this study would have interviewed the same stakeholders earlier or later, it might have received quite different responses.

The second limitation is that most interviewed stakeholders are proponents of the green and blue hydrogen energy transition in the Netherlands and collaboration partners. Hence, this also explains why stakeholders have similar viewpoints about the implications of COVID-19 on the Dutch hydrogen energy transition. It would also be valuable to interview more stakeholders that are critical of the transition to reduce selection bias.

The third limitation is the generalizability of the results of this study. This research is focused on the specific context of the hydrogen energy transition in the Netherlands. Hydrogen transitions vary across countries due to, among others, differing policies, societal preferences, and technological developments (Markard, 2018). Therefore, the effects of COVID-19 will be different for hydrogen energy transitions in other countries and other (energy) sectors and transition processes.

Finally, this Master thesis is limited by its scope. For this study, four stakeholders were interviewed from the state, six from the market, and seven from the third sector. In hindsight, this study's researcher would have liked to interview more state stakeholders to create an even distribution of perspectives from all groups. Moreover, the researcher would have preferred to interview more stakeholders from the Mobility and Transportation sector to provide various stakeholders' perceptions on this sector's implications. However, this study has reached data saturation, as not many new insights were provided during the final interviews. Therefore, interviewing more hydrogen proponents would have led to limited novel insights.

8.4 Future research suggestions

This section describes the future research suggestions of this study.

The first suggestion is that future studies could analyze the differences between the expected and actual implications of COVID-19 on the Dutch hydrogen energy transition. When looking back on the COVID-19 crisis in a couple of years, research can determine how the crisis truly affected the course of the Dutch hydrogen energy transition and which stakeholder perceptions turned out to be correct.

The second suggestion is that future research could execute this study in other countries to examine the effects of country-specific conditions on crises and sustainability transitions. This study focused on the specific context of the hydrogen energy transition in the Netherlands and identified that hydrogen stakeholders still have low conflict and shared responsibility for sustainability issues during a crisis. It may be valuable to study the similarities and differences between countries and assess how they can learn from each other.

Thirdly, future studies could investigate how the community stakeholder group views the impact of COVID-19 on the Dutch hydrogen energy transition. This study has excluded this stakeholder group because they are more involved at an individual level as citizens and residents and are not organized on a large scale. The community group could be valuable to study because they can impact and are impacted by the hydrogen energy transition. The government is strongly influenced by the community stakeholder group's public opinion on sustainability issues (Penna & Geels, 2012). Moreover, citizens will decide whether they would like to drive hydrogen cars or heat their houses with hydrogen.

Continuing studying the implications of crises, such as COVID-19, on the hydrogen energy transition is crucial because the Netherlands needs to reach its climate objectives to tackle the largest looming crisis of the 21st century: climate change. Deepened research by theorists gives practitioners the tools to make more informed decisions to stimulate the Dutch hydrogen energy transition. This study aspires to be a starting point for future researchers.

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Appendices

A. Interview guide

Dear Sir/Madam X,

Today, I will interview you for my final research for my Master's degree in International Management/CEMS at the Rotterdam School of Management. My research is about the impact of COVID-19 on the Dutch hydrogen energy transition from different stakeholder perceptions.

This interview will refer to the practice projects in the Industry (see table 6, p. 46-47; table 7, p. 49-50), the Built Environment (see table 9, p. 56), and Mobility and Transportation (see table 8, p. 53-54). These projects are stated in the Multi-year Programmatic Approach Hydrogen report of the TKI New Gas that I have e-mailed to you.

I am curious about your own perspective on the hydrogen energy transition. Therefore, I would encourage you to speak on your own behalf during this interview and not on behalf of your organization.

The duration of this interview will be an hour approximately. If any question is unclear, please feel free to interrupt me. Furthermore, this interview is confidential, and the data will be anonymized. Am I allowed to state your organization's name in this research, or would you like to have complete anonymity?

Would you permit me to record this interview? *starts recording*

Before I start, do you have any other questions?

General questions

1. Who are you?
2. Which functions do you perform that are related to hydrogen?
    a. In which organizations do you perform these functions?
    b. How long have you practiced these functions?
3. Are you knowledgeable about hydrogen practice projects in the Industry that are stated in the Multi-year Programmatic Approach Hydrogen report (see table 6, p. 46-47; table 7, p. 49-50)?
4. Are you knowledgeable about hydrogen practice projects in the Built Environment that are stated in the Multi-year Programmatic Approach Hydrogen report (see table 9, p. 56)?
5. Are you knowledgeable about hydrogen practice projects in Mobility and Transportation that are stated in the Multi-year Programmatic Approach Hydrogen report (see table 8, p. 53-54)?

Overall hydrogen energy transition

1. According to you, what are the largest implications of COVID-19 on the overall Dutch hydrogen energy transition? (e.g., positive or negative)

Sector: Industry

1. About which Industry hydrogen projects of the Multi-year Programmatic Approach Hydrogen report (see table 6, p. 46-47; table 7, p. 49-50), are you knowledgeable?
2. According to you, what were the largest challenges for hydrogen practice projects in the Industry before the COVID-19 outbreak?
    a. According to you, what is the current impact of COVID-19 on these challenges?
    b. According to you, what is the expected impact of COVID-19 on these challenges until 2030?
3. Which stakeholders are involved with these projects?
    a. How was the cooperation between these stakeholders before the COVID-19 outbreak (e.g., positive or negative)
    b. According to you, what is the current impact of COVID-19 on this cooperation? (e.g., positive or negative)
    c. According to you, what is the expected impact of COVID-19 on this cooperation until 2030? (e.g., more/less attention for the environment by stakeholders)
4. What were the goals of these projects before the COVID-19 outbreak?
    a. What were your opinions about these project goals before COVID-19? (e.g., realistic/unrealistic, ambitious/not-ambitious)
    b. According to you, what is the current impact of COVID-19 on these project goals?
    c. According to you, what is the expected impact of COVID-19 on these project goals until 2030?
5. How were these projects financed before the COVID-19 outbreak?
    a. What were your opinions about this project financing before COVID-19? (e.g., sufficient or insufficient financing)
    b. According to you, what is the current impact of COVID-19 on this project financing?
    c. According to you, what is the expected impact of COVID-19 on this project financing until 2030?

Sector: Built Environment

1. About which Built Environment hydrogen projects of the Multi-year Programmatic Approach Hydrogen report (see table 9, p. 56), are you knowledgeable?
2. According to you, what were the largest challenges for hydrogen practice projects in the Built Environment before the COVID-19 outbreak?
    a. According to you, what is the current impact of COVID-19 on these challenges?
    b. According to you, what is the expected impact of COVID-19 on these challenges until 2030?
3. Which stakeholders are involved with these projects?

    a. How was the cooperation between these stakeholders before the COVID-19 outbreak (e.g., positive or negative)
    b. According to you, what is the current impact of COVID-19 on this cooperation? (e.g., positive or negative)
    c. According to you, what is the expected impact of COVID-19 on this cooperation until 2030? (e.g., more/less attention for the environment by stakeholders)
4. What were the goals of these projects before the COVID-19 outbreak?
    a. What were your opinions about these project goals before COVID-19? (e.g., realistic/unrealistic, ambitious/not-ambitious)
    b. According to you, what is the current impact of COVID-19 on these project goals?
    c. According to you, what is the expected impact of COVID-19 on these project goals until 2030?
5. How were these projects financed before the COVID-19 outbreak?
    a. What were your opinions about this project financing before COVID-19? (e.g., sufficient or insufficient financing)
    b. According to you, what is the current impact of COVID-19 on this project financing?
    c. According to you, what is the expected impact of COVID-19 on this project financing until 2030?

Sector: Mobility and Transportation

1. About which Mobility and Transportation hydrogen projects of the Multi-year Programmatic Approach Hydrogen report (see table 8, p. 53-54), are you knowledgeable?
2. According to you, what were the largest challenges for hydrogen practice projects in Mobility and Transportation before the COVID-19 outbreak?
    a. According to you, what is the current impact of COVID-19 on these challenges?
    b. According to you, what is the expected impact of COVID-19 on these challenges until 2030?
3. Which stakeholders are involved with these projects?
    a. How was the cooperation between these stakeholders before the COVID-19 outbreak (e.g., positive or negative)
    b. According to you, what is the current impact of COVID-19 on this cooperation? (e.g., positive or negative)
    c. According to you, what is the expected impact of COVID-19 on this cooperation until 2030? (e.g., more/less attention for the environment by stakeholders)
4. What were the goals of these projects before the COVID-19 outbreak?
    a. What were your opinions about these project goals before COVID-19? (e.g., realistic/unrealistic, ambitious/not-ambitious)

    b. According to you, what is the current impact of COVID-19 on these project goals?
    c. According to you, what is the expected impact of COVID-19 on these project goals until 2030?
5. How were these projects financed before the COVID-19 outbreak?
    a. What were your opinions about this project financing before COVID-19? (e.g., sufficient or insufficient financing)
    b. According to you, what is the current impact of COVID-19 on this project financing?
    c. According to you, what is the expected impact of COVID-19 on this project financing until 2030?

Wrap-up

These were my questions for you. Would you like to add anything to your answers? Furthermore, do you have any questions for me?

Thank you for your time and cooperation. I will share the results of my research with you.

Ends recording

B. Overview of interviewees

This table provides an overview of all interviews. The seventeen interviewed stakeholders provide their own viewpoints and do not speak on behalf of their organizations.

Interviewee	Organization	Information about the organization	Stakeholder group	Interviewed sectors	Interview date	Interview duration
1.	Dutch Hydrogen & Fuel cell Association	Association for hydrogen and fuel cells in the Netherlands	Third sector	Industry; Built Environment; Mobility and Transportation	13-10-2020	46:00
2.	Groningen Seaports	Dutch port and state-owned company	Market	Industry; Mobility and Transportation	15-10-2020	52:00
3.	Gasunie	Dutch energy network operator and state-owned company	Market	Industry; Mobility and Transportation	16-10-2020	43:00
4.	TKI New Gas	Top consortium for knowledge and innovation aimed at sustainable and climate-neutral gas	Third sector	Industry; Built Environment; Mobility and Transportation	16-10-2020	50:00
5.	WattIsDuurzaam	Non-profit news and media website about (sustainable) energy	Third sector	Industry; Built Environment; Mobility and Transportation	19-10-2020	45:00
6.	Netbeheer Nederland	Branch organization for electricity and gas network operators	Third sector	Built Environment	21-10-2020	46:00
7.	Shell	A global group of energy and petrochemical companies	Market	Industry; Built Environment; Mobility and Transportation	21-10-2020	29:00
8.	WaterstofNet	Knowledge and collaboration platform for hydrogen in Flanders and the Netherlands	Third sector	Mobility and Transportation	22-10-2020	38:00
9.	Province Groningen	Province in the Netherlands	State	Industry; Built Environment	22-10-2020	51:00
10.	Ministry of Infrastructure and Water management	Dutch Ministry	State	Mobility and Transportation	22-10-2020	01:00:00
11.	Municipality Arnhem	Municipality in the Netherlands	State	Industry; Mobility and Transportation	22-10-2020	01:03:00
12.	Natuur & Milieu	Environmental organization	Third sector	Industry; Built Environment; Mobility and Transportation	23-10-2020	44:00
13.	Resato	Dutch provider of smart high-pressure solutions	Market	Mobility and Transportation	23-10-2020	33:00
14.	Dutch port	Dutch port and state-owned company	Market	Industry; Mobility and Transportation	27-10-2020	47:00

15.	Government institution	Dutch government institution	State	Industry; Built Environment; Mobility and Transportation	30-10-2020	39:00
16.	Ekinetix	Consulting and engineering bureau specialized in energy transitions	Market	Industry	30-10-2020	01:17:00
17.	Natuur en milieufederatie Zuid-Holland	Environmental organization	Third sector	Industry; Mobility and Transportation	30-10-2020	51:00

C. Overview of all stakeholders: Implications on overall hydrogen transition

Second order category	First-order category	Code	Definition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Financial implications	No or limited overall financial implications	Limited impact on financing	There is a limited impact on financing.				4 ~		6 ~			9 ~	10 ~							
Financial implications	No or limited overall financial implications	Expect limited impact on financing	The expectation is that there is a limited impact on financing.				4 ~						10 ~							
Financial implications	No or limited overall financial implications	No impact on financing	There is no impact on financing.	1 ~	2 ~											13 ~				
Financial implications	No or limited overall financial implications	Expect no impact on financing	The expectation is that there will be no impact on financing.		2 ~										12 ~					
Financial implications	No or limited financial implications by government	No impact on financing by government	There is no impact on financing by the government because the COVID-19 funds for hydrogen have not been granted (yet).	1 ~		3 ~					8 ~			11 ~		13 ~		15 ~		
Financial implications	No or limited financial implications by companies	No impact on willingness to invest by companies	There is no impact on willingness to invest by companies due to COVID-19.		2 ~															
Financial implications	Negative overall financial implications	Expect large economic damage for stakeholders	The expectation is that stakeholders will have large economic damage, which results in less financing for hydrogen.			3 -				7 -		9 -	10 -			13 -				
Financial implications	Negative overall financial implications	If COVID will last long: large economic damage for stakeholders	If COVID lasts long, stakeholders will have large economic damage, which results in less financing for hydrogen.				4 -													17 -
Financial implications	Negative overall financial implications	Less financing for new projects	There is less financing for new hydrogen projects.													13 -				
Financial implications	Negative overall financial implications	Expect less financing for new projects	The expectation is that there will be less financing for new hydrogen projects.													13 -				
Financial implications	Negative financial implications by government	More difficult for government to financially support h2	It is more difficult for the Dutch government to financially support hydrogen because they spend a lot on COVID-19 support.															15 -	16 -	
Financial implications	Negative financial implications	Expect more difficult for government to	The expectation is that it will be more difficult for the Dutch				4 -								12 -				16 -	

	by government	financially support h2	government to financially support hydrogen because they spend a lot on COVID-19 support.																	
Financial implications	Negative financial implications by government	If government not financially support h2: negative	If the Dutch government does not financially support hydrogen, this will have a negative impact on the hydrogen transition.			3 -											14 -			
Financial implications	Negative financial implications by government	If COVID will last long: more difficult for gvnment to finance	If COVID lasts long, it will be more difficult for the government to support hydrogen financially.																	17 -
Financial implications	Negative financial implications by companies	Lower willingness to invest by companies	Companies have a lower willingness to invest in hydrogen and have become more risk-averse.	1 -		3 -	4 -	5 -		7 -	8 -	9 -		11 -		13 -		15 -		
Financial implications	Negative financial implications by companies	Expect lower willingness to invest by companies	The expectation is that companies will have a lower willingness to invest in hydrogen and will become more risk-averse.	1 -			4 -													
Financial implications	Negative financial implications by companies	Lower demand fossil fuels > cheaper than green and blue h2	Because of the lower demand for fossil fuels, fossil fuels and grey hydrogen have become cheaper than green and blue hydrogen.			3 -				7 -										
Financial implications	Positive financial implications by government	Expect EU to financially support h2: green growth	The expectation is that the European Union will financially support hydrogen to get out of the COVID-19 crisis.			3 +						9 +		11 +			14 +		16 +	
Financial implications	Positive financial implications by government	Expect government to financially support h2: green growth	The expectation is that the Dutch government will financially support hydrogen to get out of the COVID-19 crisis.	1 +	2 +	3 +		5 +		7 +	8 +	9 +		11 +	12 +		14 +			
Financial implications	Positive financial implications by government	If government financially supports h2: positive	If the Dutch government financially supports hydrogen, that will positively impact the hydrogen transition.	1 +	2 +	3 +					8 +						14 +		16 +	
Financial implications	Positive financial implications by government	Sustainability requirement for COVID subsidies	In some cases, companies, such as KLM, have to meet requirements to become more sustainable to receive COVID-19 subsidies from the Dutch government.		2 +													15 +		
Stakeholder participation implications	No or limited stakeholder participation implications	Still need/want to continue with h2 transition	Despite COVID-19, people still need/want to continue with the hydrogen transition.	1 ~	2 ~		4 ~		6 ~			9 ~		11 ~	12 ~	13 ~	14 ~	15 ~		17 ~

Stakeholder participation implications	No or limited stakeholder participation implications	More new projects	Despite COVID-19, more new hydrogen projects have started.			3 ~			6 ~						12 ~					
Stakeholder participation implications	Negative stakeholder participation implications	Lower demand for fossil fuels > problems fossil fuel stakeholders	The lower demand for fossil fuels causes problems for fossil fuel stakeholders.	1 -			4 -			7 -		9 -				13 -				
Stakeholder participation implications	Negative stakeholder participation implications	Expect lower demand fossil fuels > problems fossil stakeholders	The expectation is that there will be a lower demand for fossil fuels that will cause problems for fossil fuels stakeholders.	1 -			4 -													
Stakeholder participation implications	Negative stakeholder participation implications	If COVID will last long: lower willingness to participate in h2	If COVID lasts long, stakeholders will have a lower willingness to participate in the hydrogen transition.				4 -		6 -		8 -									
Stakeholder participation implications	Negative stakeholder participation implications	Few heavily affected stakeholders drop/lower h2	Few heavily affected stakeholders, such as the NAM, will drop or lower their level of hydrogen participation.				4 -		6 -	7 -			10 -		12 -					
Stakeholder participation implications	Negative stakeholder participation implications	Expect few heavily affected stakeholders to drop/lower h2	The expectation is that few heavily affected stakeholders, such as the NAM, will drop or lower their level of hydrogen participation.				4 -		6 -				10 -							
Stakeholder participation implications	Positive stakeholder participation implications	Lower demand fossil fuels > shift to h2 participation	The lower demand for fossil fuels could increase the phasing out of fossil fuels and increase the transition to sustainable alternatives, including hydrogen.			3 +				7 +		9 +						15 +		
Stakeholder participation implications	Positive stakeholder participation implications	Need/want to continue with h2 transition more	The need and the want to transition to hydrogen has increased.			3 +				7 +		9 +				13 +		15 +		
Stakeholder participation implications	Positive stakeholder participation implications	Expect need/want to continue with h2 transition more	The expectation is that the need and the want to transition to hydrogen will increase.																16 +	
Stakeholder participation implications	Positive stakeholder participation implications	Most new members for h2 branch organization this year	During this COVID-19 year, the Dutch Hydrogen and Fuel cell Association has attracted the most novel members.	1 +																
Stakeholder participation implications	Positive stakeholder participation implications	Reappraisal for own environment and climate	People have experienced an improved environment and climate due to a.o. lower CO_2 emissions. As a result, people have a reappraisal for their environment and climate.			3 +						9 +				13 +			16 +	

Stakeholder participation implications	Positive stakeholder participation implications	If sustainability will be a priority: positive impact	If sustainability is viewed as a priority, there will be a positive impact on the hydrogen transition.								8 +									
Stakeholder participation implications	Positive stakeholder participation implications	More ambitious climate goals oil companies	Oil companies, such as BP and Shell, have more ambitious climate goals because of COVID-19.							7 +										
Stakeholder participation implications	Positive stakeholder participation implications	More ambitious sustainability goals EU	The European Union has increased their sustainability goals. (It is unclear whether this is because or despite COVID-19)									9 ~			12 ~					
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	Limited impact on cooperation	COVID-19 has a limited impact on stakeholder cooperation. Stakeholders have to switch to working online, but that has a limited effect.	1 ~			4 ~		6 ~	7 ~	8 ~		10 ~	11 ~				15 ~		17 ~
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	Expect limited impact on cooperation	The expectation is that COVID-19 will have a limited impact on stakeholder cooperation.	1 ~			4 ~	5 ~		7 ~	8 ~				12 ~	13 ~				
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	No impact on cooperation	COVID-19 has no impact on stakeholder cooperation. There is no increased hostility or friendliness because of the COVID-19 crisis.	1 ~	2 ~							9 ~				13 ~				17 ~
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	Expect no impact on cooperation	The expectation is that COVID-19 will have no impact on stakeholder cooperation.		2 ~							9 ~								
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online cooperation more difficult	It is challenging to switch to working entirely online.							7 -		9 -		11 -			14 -	15 -		17 -
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online more difficult to network	It is online more difficult to network with others.						6 -								14 -		16 -	
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Expect online more difficult to network	The expectation is that it will be online more difficult to network with others.						6 -											
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online less informal communication	There is online less informal communication.						6 -					11 -	12 -	13 -				
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Expect online less informal communication	The expectation is that there will be online less informal communication.						6 -											
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Offline gatherings are cancelled	Offline gatherings are cancelled.	1 -				5 -							12 -				16 -	17 -

Stakeholder cooperation implications	Negative stakeholder cooperation implications	Expect challenge for online innovation/ creative sessions	The expectation is that it will be challenging to innovate and have creative sessions online.		2 -								11 -							
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online more difficult to exchange knowledge with residents BEV	It is more difficult to exchange knowledge with residents in the Built Environment.					5 -	6 -			9 -						15 -		
Stakeholder cooperation implications	Positive stakeholder cooperation implications	Online easier to plan/conduct appointments	As people work from home and communicate online, it is easier for them to plan and conduct appointments because their traveling time has reduced, and online meetings are often more to the point.	1 +			4 +		6 +			9 +				13 +	14 +		16 +	
Stakeholder cooperation implications	Positive stakeholder cooperation implications	Expect stronger relationship between stakeholders	The expectation is that when hydrogen stakeholders will survive the COVID-19 crisis together, that they will have a stronger relationship.										11 +							
Operational implications	No or limited operational implications	Existing projects are continued	Existing hydrogen projects are being continued.	1 ~			4 ~	5 ~	6 ~					12 ~	13 ~	14 ~	15 ~			
Operational implications	No or limited operational implications	No stakeholders quit projects so far	No stakeholders have quit hydrogen projects so far.		2 ~									12 ~						
Operational implications	Negative operational implications	Delays due to work and travel restrictions	Due to international and national work and travel restrictions, hydrogen projects experience delays.	1 -						7 -	8 -	9 -	10 -							
Operational implications	Negative operational implications	Employees working with h2 get COVID	Employees in the hydrogen sector contract COVID-19 and cannot work.						6 -					11 -						
Operational implications	Negative operational implications	More difficult to demonstrate h2 on site	It is more difficult to demonstrate hydrogen projects on site because of the COVID-19 restrictions.				4 -		6 -		8 -					14 -				

C.1 Overview of state stakeholders: Implications on overall hydrogen transition

Second order category	First-order category	Code	Definition	9. Province Groningen	10. Ministry of I&W	11. Municipality Arnhem	15. Government institution
Financial implications	No or limited overall financial implications	Limited impact on financing	There is a limited impact on financing.	9~	10~		
Financial implications	No or limited overall financial implications	Expect limited impact on financing	The expectation is that there is a limited impact on financing.		10~		
Financial implications	No or limited overall financial implications	No impact on financing	There is no impact on financing.				
Financial implications	No or limited overall financial implications	Expect no impact on financing	The expectation is that there will be no impact on financing.				
Financial implications	No or limited financial implications by government	No impact on financing by government	There is no impact on financing by the government because the COVID-19 funds for hydrogen have not been granted (yet).			11~	15~
Financial implications	No or limited financial implications by companies	No impact on willingness to invest by companies	There is no impact on willingness to invest by companies due to COVID-19.				
Financial implications	Negative overall financial implications	Expect large economic damage for stakeholders	The expectation is that stakeholders will have large economic damage, which results in less financing for hydrogen.	9-	10-		
Financial implications	Negative overall financial implications	If COVID will last long: large economic damage for stakeholders	If COVID lasts long, stakeholders will have large economic damage, which results in less financing for hydrogen.				
Financial implications	Negative overall financial implications	Less financing for new projects	There is less financing for new hydrogen projects.				
Financial implications	Negative overall financial implications	Expect less financing for new projects	The expectation is that there will be less financing for new hydrogen projects.				
Financial implications	Negative financial implications by government	More difficult for government to financially support h2	It is more difficult for the Dutch government to financially support hydrogen because they spend a lot on COVID-19 support.				15-
Financial implications	Negative financial implications	Expect more difficult for government to	The expectation is that it will be more difficult for the Dutch				

	by government	financially support h2	government to financially support hydrogen because they spend a lot on COVID-19 support.				
Financial implications	Negative financial implications by government	If government not financially support h2: negative	If the Dutch government does not financially support hydrogen, this will have a negative impact on the hydrogen transition.				
Financial implications	Negative financial implications by government	If COVID will last long: more difficult for gvnment to finance	If COVID lasts long, it will be more difficult for the government to support hydrogen financially.				
Financial implications	Negative financial implications by companies	Lower willingness to invest by companies	Companies have a lower willingness to invest in hydrogen and have become more risk-averse.	9-		11-	15-
Financial implications	Negative financial implications by companies	Expect lower willingness to invest by companies	The expectation is that companies will have a lower willingness to invest in hydrogen and will become more risk-averse.				
Financial implications	Negative financial implications by companies	Lower demand fossil fuels > cheaper than green and blue h2	Because of the lower demand for fossil fuels, fossil fuels and grey hydrogen have become cheaper than green and blue hydrogen.				
Financial implications	Positive financial implications by government	Expect EU to financially support h2: green growth	The expectation is that the European Union will financially support hydrogen to get out of the COVID-19 crisis.	9+		11+	
Financial implications	Positive financial implications by government	Expect government to financially support h2: green growth	The expectation is that the Dutch government will financially support hydrogen to get out of the COVID-19 crisis.	9+		11+	
Financial implications	Positive financial implications by government	If government financially supports h2: positive	If the Dutch government financially supports hydrogen, that will positively impact the hydrogen transition.				
Financial implications	Positive financial implications by government	Sustainability requirement for COVID subsidies	In some cases, companies, such as KLM, have to meet requirements to become more sustainable to receive COVID-19 subsidies from the Dutch government.				15+
Stakeholder participation implications	No or limited stakeholder participation implications	Still need/want to continue with h2 transition	Despite COVID-19, people still need/want to continue with the hydrogen transition.	9~		11~	15~

Stakeholder participation implications	No or limited stakeholder participation implications	More new projects	Despite COVID-19, more new hydrogen projects have started.				
Stakeholder participation implications	Negative stakeholder participation implications	Lower demand for fossil fuels > problems fossil fuel stakeholders	The lower demand for fossil fuels causes problems for fossil fuel stakeholders.	9-			
Stakeholder participation implications	Negative stakeholder participation implications	Expect lower demand fossil fuels > problems fossil stakeholders	The expectation is that there will be a lower demand for fossil fuels that will cause problems for fossil fuels stakeholders.				
Stakeholder participation implications	Negative stakeholder participation implications	If COVID will last long: lower willingness to participate in h2	If COVID lasts long, stakeholders will have a lower willingness to participate in the hydrogen transition.				
Stakeholder participation implications	Negative stakeholder participation implications	Few heavily affected stakeholders drop/lower h2	Few heavily affected stakeholders, such as the NAM, will drop or lower their level of hydrogen participation.		10-		
Stakeholder participation implications	Negative stakeholder participation implications	Expect few heavily affected stakeholders to drop/lower h2	The expectation is that few heavily affected stakeholders, such as the NAM, will drop or lower their level of hydrogen participation.		10-		
Stakeholder participation implications	Positive stakeholder participation implications	Lower demand fossil fuels > shift to h2 participation	The lower demand for fossil fuels could increase the phasing out of fossil fuels and increase the transition to sustainable alternatives, including hydrogen.	9+			15+
Stakeholder participation implications	Positive stakeholder participation implications	Need/want to continue with h2 transition more	The need and the want to transition to hydrogen has increased.	9+			15+
Stakeholder participation implications	Positive stakeholder participation implications	Expect need/want to continue with h2 transition more	The expectation is that the need and the want to transition to hydrogen will increase.				
Stakeholder participation implications	Positive stakeholder participation implications	Most new members for h2 branch organization this year	During this COVID-19 year, the Dutch Hydrogen and Fuel cell Association has attracted the most novel members.				
Stakeholder participation implications	Positive stakeholder participation implications	Reappraisal for own environment and climate	People have experienced an improved environment and climate due to a.o. lower CO_2 emissions. As a result, people have a reappraisal for their environment and climate.	9+			

Stakeholder participation implications	Positive stakeholder participation implications	If sustainability will be a priority: positive impact	If sustainability is viewed as a priority, there will be a positive impact on the hydrogen transition.				
Stakeholder participation implications	Positive stakeholder participation implications	More ambitious climate goals oil companies	Oil companies, such as BP and Shell, have more ambitious climate goals because of COVID-19.				
Stakeholder participation implications	Positive stakeholder participation implications	More ambitious sustainability goals EU	The European Union has increased their sustainability goals. (It is unclear whether this is because or despite COVID-19)	9~			
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	Limited impact on cooperation	COVID-19 has a limited impact on stakeholder cooperation. Stakeholders have to switch to working online, but that has a limited effect.		10~	11~	15~
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	Expect limited impact on cooperation	The expectation is that COVID-19 will have a limited impact on stakeholder cooperation.				
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	No impact on cooperation	COVID-19 has no impact on stakeholder cooperation. There is no increased hostility or friendliness because of the COVID-19 crisis.	9~			
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	Expect no impact on cooperation	The expectation is that COVID-19 will have no impact on stakeholder cooperation.	9~			
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online cooperation more difficult	It is challenging to switch to working entirely online.	9-		11-	15-
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online more difficult to network	It is online more difficult to network with others.				
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Expect online more difficult to network	The expectation is that it will be online more difficult to network with others.				
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online less informal communication	There is online less informal communication.			11-	
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Expect online less informal communication	The expectation is that there will be online less informal communication.				
Stakeholder cooperation implications	Negative stakeholder	Offline gatherings are cancelled	Offline gatherings are cancelled.				

	cooperation implications						
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Expect challenge for online innovation/ creative sessions	The expectation is that it will be challenging to innovate and have creative sessions online.			11-	
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online more difficult to exchange knowledge with residents BEV	It is more difficult to exchange knowledge with residents in the Built Environment.	9-			15-
Stakeholder cooperation implications	Positive stakeholder cooperation implications	Online easier to plan/conduct appointments	As people work from home and communicate online, it is easier for them to plan and conduct appointments because their traveling time has reduced, and online meetings are often more to the point.	9+			
Stakeholder cooperation implications	Positive stakeholder cooperation implications	Expect stronger relationship between stakeholders	The expectation is that when hydrogen stakeholders will survive the COVID-19 crisis together, that they will have a stronger relationship.			11+	
Operational implications	No or limited operational implications	Existing projects are continued	Existing hydrogen projects are being continued.				15~
Operational implications	No or limited operational implications	No stakeholders quit projects so far	No stakeholders have quit hydrogen projects so far.				
Operational implications	Negative operational implications	Delays due to work and travel restrictions	Due to international and national work and travel restrictions, hydrogen projects experience delays.	9-	10-		
Operational implications	Negative operational implications	Employees working with h2 get COVID	Employees in the hydrogen sector contract COVID-19 and cannot work.			11-	
Operational implications	Negative operational implications	More difficult to demonstrate h2 on site	It is more difficult to demonstrate hydrogen projects on site because of the COVID-19 restrictions.				

C.2 Overview of market stakeholders: Implications on overall hydrogen transition

Second order category	First-order category	Code	Definition	2. Groningen Seaports	3. Gasunie	7. Shell	13. Resato	14. Dutch port	16. Ekinetix
Financial implications	No or limited overall financial implications	Limited impact on financing	There is a limited impact on financing.						
Financial implications	No or limited overall financial implications	Expect limited impact on financing	The expectation is that there is a limited impact on financing.						
Financial implications	No or limited overall financial implications	No impact on financing	There is no impact on financing.	2~			13~		
Financial implications	No or limited overall financial implications	Expect no impact on financing	The expectation is that there will be no impact on financing.	2~					
Financial implications	No or limited financial implications by government	No impact on financing by government	There is no impact on financing by the government because the COVID-19 funds for hydrogen have not been granted (yet).		3~		13~		
Financial implications	No or limited financial implications by companies	No impact on willingness to invest by companies	There is no impact on willingness to invest by companies due to COVID-19.	2~					
Financial implications	Negative overall financial implications	Expect large economic damage for stakeholders	The expectation is that stakeholders will have large economic damage, which results in less financing for hydrogen.		3-	7-	13-		
Financial implications	Negative overall financial implications	If COVID will last long: large economic damage for stakeholders	If COVID lasts long, stakeholders will have large economic damage, which results in less financing for hydrogen.						
Financial implications	Negative overall financial implications	Less financing for new projects	There is less financing for new hydrogen projects.				13-		
Financial implications	Negative overall financial implications	Expect less financing for new projects	The expectation is that there will be less financing for new hydrogen projects.				13-		
Financial implications	Negative financial implications by government	More difficult for government to financially support h2	It is more difficult for the Dutch government to financially support hydrogen because they spend a lot on COVID-19 support.						16-
Financial implications	Negative financial implications	Expect more difficult for government to	The expectation is that it will be more difficult for the Dutch						16-

	by government	financially support h2	government to financially support hydrogen because they spend a lot on COVID-19 support.						
Financial implications	Negative financial implications by government	If government not financially support h2: negative	If the Dutch government does not financially support hydrogen, this will have a negative impact on the hydrogen transition.		3-			14-	
Financial implications	Negative financial implications by government	If COVID will last long: more difficult for gvnment to finance	If COVID lasts long, it will be more difficult for the government to support hydrogen financially.						
Financial implications	Negative financial implications by companies	Lower willingness to invest by companies	Companies have a lower willingness to invest in hydrogen and have become more risk-averse.		3-	7-	13-		
Financial implications	Negative financial implications by companies	Expect lower willingness to invest by companies	The expectation is that companies will have a lower willingness to invest in hydrogen and will become more risk-averse.						
Financial implications	Negative financial implications by companies	Lower demand fossil fuels > cheaper than green and blue h2	Because of the lower demand for fossil fuels, fossil fuels and grey hydrogen have become cheaper than green and blue hydrogen.		3-	7-			
Financial implications	Positive financial implications by government	Expect EU to financially support h2: green growth	The expectation is that the European Union will financially support hydrogen to get out of the COVID-19 crisis.		3+			14+	16+
Financial implications	Positive financial implications by government	Expect government to financially support h2: green growth	The expectation is that the Dutch government will financially support hydrogen to get out of the COVID-19 crisis.	2+	3+	7+		14+	
Financial implications	Positive financial implications by government	If government financially supports h2: positive	If the Dutch government financially supports hydrogen, that will positively impact the hydrogen transition.	2+	3+			14+	16+
Financial implications	Positive financial implications by government	Sustainability requirement for COVID subsidies	In some cases, companies, such as KLM, have to meet requirements to become more sustainable to receive COVID-19 subsidies from the Dutch government.	2+					
Stakeholder participation implications	No or limited stakeholder participation implications	Still need/want to continue with h2 transition	Despite COVID-19, people still need/want to continue with the hydrogen transition.	2~			13~	14~	

Stakeholder participation implications	No or limited stakeholder participation implications	More new projects	Despite COVID-19, more new hydrogen projects have started.		3~				
Stakeholder participation implications	Negative stakeholder participation implications	Lower demand for fossil fuels > problems fossil fuel stakeholders	The lower demand for fossil fuels causes problems for fossil fuel stakeholders.			7-	13-		
Stakeholder participation implications	Negative stakeholder participation implications	Expect lower demand fossil fuels > problems fossil stakeholders	The expectation is that there will be a lower demand for fossil fuels that will cause problems for fossil fuels stakeholders.						
Stakeholder participation implications	Negative stakeholder participation implications	If COVID will last long: lower willingness to participate in h2	If COVID lasts long, stakeholders will have a lower willingness to participate in the hydrogen transition.						
Stakeholder participation implications	Negative stakeholder participation implications	Few heavily affected stakeholders drop/lower h2	Few heavily affected stakeholders, such as the NAM, will drop or lower their level of hydrogen participation.			7-			
Stakeholder participation implications	Negative stakeholder participation implications	Expect few heavily affected stakeholders to drop/lower h2	The expectation is that few heavily affected stakeholders, such as the NAM, will drop or lower their level of hydrogen participation.						
Stakeholder participation implications	Positive stakeholder participation implications	Lower demand fossil fuels > shift to h2 participation	The lower demand for fossil fuels could increase the phasing out of fossil fuels and increase the transition to sustainable alternatives, including hydrogen.		3+	7+			
Stakeholder participation implications	Positive stakeholder participation implications	Need/want to continue with h2 transition more	The need and the want to transition to hydrogen has increased.		3+	7+	13+		
Stakeholder participation implications	Positive stakeholder participation implications	Expect need/want to continue with h2 transition more	The expectation is that the need and the want to transition to hydrogen will increase.						16+
Stakeholder participation implications	Positive stakeholder participation implications	Most new members for h2 branch organization this year	During this COVID-19 year, the Dutch Hydrogen and Fuel cell Association has attracted the most novel members.						
Stakeholder participation implications	Positive stakeholder participation implications	Reappraisal for own environment and climate	People have experienced an improved environment and climate due to a.o. lower CO_2 emissions. As a result, people have a reappraisal for their environment and climate.		3+		13+		16+

Stakeholder participation implications	Positive stakeholder participation implications	If sustainability will be a priority: positive impact	If sustainability is viewed as a priority, there will be a positive impact on the hydrogen transition.						
Stakeholder participation implications	Positive stakeholder participation implications	More ambitious climate goals oil companies	Oil companies, such as BP and Shell, have more ambitious climate goals because of COVID-19.			7+			
Stakeholder participation implications	Positive stakeholder participation implications	More ambitious sustainability goals EU	The European Union has increased their sustainability goals. (It is unclear whether this is because or despite COVID-19)						
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	Limited impact on cooperation	COVID-19 has a limited impact on stakeholder cooperation. Stakeholders have to switch to working online, but that has a limited effect.			7~			
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	Expect limited impact on cooperation	The expectation is that COVID-19 will have a limited impact on stakeholder cooperation.			7~	13~		
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	No impact on cooperation	COVID-19 has no impact on stakeholder cooperation. There is no increased hostility or friendliness because of the COVID-19 crisis.	2~			13~		
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	Expect no impact on cooperation	The expectation is that COVID-19 will have no impact on stakeholder cooperation.	2~					
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online cooperation more difficult	It is challenging to switch to working entirely online.			7-		14-	
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online more difficult to network	It is online more difficult to network with others.					14-	16-
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Expect online more difficult to network	The expectation is that it will be online more difficult to network with others.						
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online less informal communication	There is online less informal communication.				13-		
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Expect online less informal communication	The expectation is that there will be online less informal communication.						
Stakeholder cooperation implications	Negative stakeholder	Offline gatherings are cancelled	Offline gatherings are cancelled.						16-

	cooperation implications								
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Expect challenge for online innovation/ creative sessions	The expectation is that it will be challenging to innovate and have creative sessions online.	2-					
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online more difficult to exchange knowledge with residents BEV	It is more difficult to exchange knowledge with residents in the Built Environment.						
Stakeholder cooperation implications	Positive stakeholder cooperation implications	Online easier to plan/conduct appointments	As people work from home and communicate online, it is easier for them to plan and conduct appointments because their traveling time has reduced, and online meetings are often more to the point.				13+	14+	16+
Stakeholder cooperation implications	Positive stakeholder cooperation implications	Expect stronger relationship between stakeholders	The expectation is that when hydrogen stakeholders will survive the COVID-19 crisis together, that they will have a stronger relationship.						
Operational implications	No or limited operational implications	Existing projects are continued	Existing hydrogen projects are being continued.				13~	14~	
Operational implications	No or limited operational implications	No stakeholders quit projects so far	No stakeholders have quit hydrogen projects so far.	2~					
Operational implications	Negative operational implications	Delays due to work and travel restrictions	Due to international and national work and travel restrictions, hydrogen projects experience delays.			7-			
Operational implications	Negative operational implications	Employees working with h2 get COVID	Employees in the hydrogen sector contract COVID-19 and cannot work.						
Operational implications	Negative operational implications	More difficult to demonstrate h2 on site	It is more difficult to demonstrate hydrogen projects on site because of the COVID-19 restrictions.					14-	

C.3 Overview of third sector stakeholders: Implications on overall hydrogen transition

Second order category	First-order category	Code	Definition	1. Dutch h2 & fuel cell association	4. TKI New Gas	5. WattIs Duurzaam	6. Netbeheer NL	8. WaterstofNet	12. Natuur & Milieu	17. Natuurenmilieufederatie ZH
Financial implications	No or limited overall financial implications	Limited impact on financing	There is a limited impact on financing.		4~		6~			
Financial implications	No or limited overall financial implications	Expect limited impact on financing	The expectation is that there is a limited impact on financing.		4~					
Financial implications	No or limited overall financial implications	No impact on financing	There is no impact on financing.	1~						
Financial implications	No or limited overall financial implications	Expect no impact on financing	The expectation is that there will be no impact on financing.						12~	
Financial implications	No or limited financial implications by government	No impact on financing by government	There is no impact on financing by the government because the COVID-19 funds for hydrogen have not been granted (yet).	1~				8~		
Financial implications	No or limited financial implications by companies	No impact on willingness to invest by companies	There is no impact on willingness to invest by companies due to COVID-19.							
Financial implications	Negative overall financial implications	Expect large economic damage for stakeholders	The expectation is that stakeholders will have large economic damage, which results in less financing for hydrogen.							
Financial implications	Negative overall financial implications	If COVID will last long: large economic damage for stakeholders	If COVID lasts long, stakeholders will have large economic damage, which results in less financing for hydrogen.		4-					17-
Financial implications	Negative overall financial implications	Less financing for new projects	There is less financing for new hydrogen projects.							
Financial implications	Negative overall financial implications	Expect less financing for new projects	The expectation is that there will be less financing for new hydrogen projects.							
Financial implications	Negative financial implications by government	More difficult for government to financially support h2	It is more difficult for the Dutch government to financially support hydrogen because they spend a lot on COVID-19 support.							

Financial implications	Negative financial implications by government	Expect more difficult for government to financially support h2	The expectation is that it will be more difficult for the Dutch government to financially support hydrogen because they spend a lot on COVID-19 support.		4-				12-	
Financial implications	Negative financial implications by government	If government not financially support h2: negative	If the Dutch government does not financially support hydrogen, this will have a negative impact on the hydrogen transition.							
Financial implications	Negative financial implications by government	If COVID will last long: more difficult for gvnment to finance	If COVID lasts long, it will be more difficult for the government to support hydrogen financially.							17-
Financial implications	Negative financial implications by companies	Lower willingness to invest by companies	Companies have a lower willingness to invest in hydrogen and have become more risk-averse.	1-	4-	5-		8-		
Financial implications	Negative financial implications by companies	Expect lower willingness to invest by companies	The expectation is that companies will have a lower willingness to invest in hydrogen and will become more risk-averse.	1-	4-					
Financial implications	Negative financial implications by companies	Lower demand fossil fuels > cheaper than green and blue h2	Because of the lower demand for fossil fuels, fossil fuels and grey hydrogen have become cheaper than green and blue hydrogen.							
Financial implications	Positive financial implications by government	Expect EU to financially support h2: green growth	The expectation is that the European Union will financially support hydrogen to get out of the COVID-19 crisis.							
Financial implications	Positive financial implications by government	Expect government to financially support h2: green growth	The expectation is that the Dutch government will financially support hydrogen to get out of the COVID-19 crisis.	1+		5+		8+	12+	
Financial implications	Positive financial implications by government	If government financially supports h2: positive	If the Dutch government financially supports hydrogen, that will positively impact the hydrogen transition.	1+				8+		
Financial implications	Positive financial implications by government	Sustainability requirement for COVID subsidies	In some cases, companies, such as KLM, have to meet requirements to become more sustainable to receive COVID-19 subsidies from the Dutch government.							

Stakeholder participation implications	No or limited stakeholder participation implications	Still need/want to continue with h2 transition	Despite COVID-19, people still need/want to continue with the hydrogen transition.	1~	4~		6~		12~	17~
Stakeholder participation implications	No or limited stakeholder participation implications	More new projects	Despite COVID-19, more new hydrogen projects have started.				6~		12~	
Stakeholder participation implications	Negative stakeholder participation implications	Lower demand for fossil fuels > problems fossil fuel stakeholders	The lower demand for fossil fuels causes problems for fossil fuel stakeholders.	1-	4-					
Stakeholder participation implications	Negative stakeholder participation implications	Expect lower demand fossil fuels > problems fossil stakeholders	The expectation is that there will be a lower demand for fossil fuels that will cause problems for fossil fuels stakeholders.	1-	4-					
Stakeholder participation implications	Negative stakeholder participation implications	If COVID will last long: lower willingness to participate in h2	If COVID lasts long, stakeholders will have a lower willingness to participate in the hydrogen transition.		4-		6-	8-		
Stakeholder participation implications	Negative stakeholder participation implications	Few heavily affected stakeholders drop/lower h2	Few heavily affected stakeholders, such as the NAM, will drop or lower their level of hydrogen participation.		4-		6-		12-	
Stakeholder participation implications	Negative stakeholder participation implications	Expect few heavily affected stakeholders to drop/lower h2	The expectation is that few heavily affected stakeholders, such as the NAM, will drop or lower their level of hydrogen participation.		4-		6-			
Stakeholder participation implications	Positive stakeholder participation implications	Lower demand fossil fuels > shift to h2 participation	The lower demand for fossil fuels could increase the phasing out of fossil fuels and increase the transition to sustainable alternatives, including hydrogen.							
Stakeholder participation implications	Positive stakeholder participation implications	Need/want to continue with h2 transition more	The need and the want to transition to hydrogen has increased.							
Stakeholder participation implications	Positive stakeholder participation implications	Expect need/want to continue with h2 transition more	The expectation is that the need and the want to transition to hydrogen will increase.							
Stakeholder participation implications	Positive stakeholder participation implications	Most new members for h2 branch organization this year	During this COVID-19 year, the Dutch Hydrogen and Fuel cell Association has attracted the most novel members.	1+						
Stakeholder participation implications	Positive stakeholder participation implications	Reappraisal for own environment and climate	People have experienced an improved environment and climate due to a.o. lower CO_2 emissions.							

			As a result, people have a reappraisal for their environment and climate.							
Stakeholder participation implications	Positive stakeholder participation implications	If sustainability will be a priority: positive impact	If sustainability is viewed as a priority, there will be a positive impact on the hydrogen transition.					8+		
Stakeholder participation implications	Positive stakeholder participation implications	More ambitious climate goals oil companies	Oil companies, such as BP and Shell, have more ambitious climate goals because of COVID-19.							
Stakeholder participation implications	Positive stakeholder participation implications	More ambitious sustainability goals EU	The European Union has increased their sustainability goals. (It is unclear whether this is because or despite COVID-19)						12~	
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	Limited impact on cooperation	COVID-19 has a limited impact on stakeholder cooperation. Stakeholders have to switch to working online, but that has a limited effect.	1~	4~		6~	8~		17~
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	Expect limited impact on cooperation	The expectation is that COVID-19 will have a limited impact on stakeholder cooperation.	1~	4~	5~		8~	12~	
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	No impact on cooperation	COVID-19 has no impact on stakeholder cooperation. There is no increased hostility or friendliness because of the COVID-19 crisis.	1 ~						17~
Stakeholder cooperation implications	No or limited stakeholder cooperation implications	Expect no impact on cooperation	The expectation is that COVID-19 will have no impact on stakeholder cooperation.							
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online cooperation more difficult	It is challenging to switch to working entirely online.							17-
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online more difficult to network	It is online more difficult to network with others.				6-			
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Expect online more difficult to network	The expectation is that it will be online more difficult to network with others.				6-			
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online less informal communicatio n	There is online less informal communication.				6-		12-	
Stakeholder cooperation implications	Negative stakeholder	Expect online less informal	The expectation is that there will be online less				6-			

	cooperation implications	communication	informal communication.							
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Offline gatherings are cancelled	Offline gatherings are cancelled.	1 -		5-			12-	17-
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Expect challenge for online innovation/ creative sessions	The expectation is that it will be challenging to innovate and have creative sessions online.							
Stakeholder cooperation implications	Negative stakeholder cooperation implications	Online more difficult to exchange knowledge with residents BEV	It is more difficult to exchange knowledge with residents in the Built Environment.			5-	6-			
Stakeholder cooperation implications	Positive stakeholder cooperation implications	Online easier to plan/conduct appointments	As people work from home and communicate online, it is easier for them to plan and conduct appointments because their traveling time has reduced, and online meetings are often more to the point.	1+	4+		6+			
Stakeholder cooperation implications	Positive stakeholder cooperation implications	Expect stronger relationship between stakeholders	The expectation is that when hydrogen stakeholders will survive the COVID-19 crisis together, that they will have a stronger relationship.							
Operational implications	No or limited operational implications	Existing projects are continued	Existing hydrogen projects are being continued.	1~	4~	5~	6~		12 ~	
Operational implications	No or limited operational implications	No stakeholders quit projects so far	No stakeholders have quit hydrogen projects so far.						12~	
Operational implications	Negative operational implications	Delays due to work and travel restrictions	Due to international and national work and travel restrictions, hydrogen projects experience delays.	1-				8-		
Operational implications	Negative operational implications	Employees working with h2 get COVID	Employees in the hydrogen sector contract COVID-19 and cannot work.				6-			
Operational implications	Negative operational implications	More difficult to demonstrate h2 on site	It is more difficult to demonstrate hydrogen projects on site because of the COVID-19 restrictions.		4-		6-	8-		

D. Overview of all stakeholders: Implications for Mobility and Transportation

Mobility and transport implications	Negative mobility and transport implications	Changed travel behaviour: negative for mobility stakeholders	The changed travel behaviour is negative for Mobility and Transportation stakeholders.					5 ~								13 ~				17 ~
Mobility and transport implications	Negative mobility and transport implications	Buses: less passengers	Buses have fewer passengers.										10 ~					15 ~			
Mobility and transport implications	Negative mobility and transport implications	Buses: expect less passengers	The expectation is that buses will have fewer passengers.	1 ~									10 ~								
Mobility and transport implications	Negative mobility and transport implications	Public transportation: expect less passengers	The expectation is that public transportation will have fewer passengers.										10 ~								
Mobility and transport implications	Negative mobility and transport implications	Buses: lower willingness to invest	Buses have a lower willingness to invest.					5 ~					10 ~								
Mobility and transport implications	Negative mobility and transport implications	Buses: expect lower willingness to invest	The expectation is that buses will have lower willingness to invest.					5 ~					10 ~								
Mobility and transport implications	Negative mobility and transport implications	Public transportation: lower willingness to invest	Public transportation has a lower willingness to invest.															15 ~			
Mobility and transport implications	Negative mobility and transport implications	Public transportation: expect lower willingness to invest	The expectation is that public transportation will have a lower willingness to invest.										10 ~								
Mobility and transport implications	Negative mobility and transport implications	If COVID-19 will last long: public transport: lower willingness to invest	IF COVID-19 lasts long, there will be a lower willingness to invest for public transportation.																	17 ~	
Mobility and transport implications	Negative mobility and transport implications	If COVID will last long: filling stations: lower willingness to invest	If COVID-19 lasts long, there will be a lower willingness to invest for filling stations.																	17 ~	
Mobility and transport implications	Negative mobility and transport implications	Vehicles: delayed purchase investments	People delay their purchase investments for vehicles.										10 ~								
Mobility and transport implications	Negative mobility and transport implications	Cars: delayed purchase investments	People delay their purchase investments for cars.	1 ~	2 ~											13 ~					
Mobility and transport implications	Negative mobility and transport implications	Cars: expect lower willingness to invest	The expectation is that there will be a lower willingness to invest for cars.	1 ~																	
Mobility and	Negative mobility and	Ships: expect lower	The expectation is that there will be a lower	1 ~																	

transport implications	transport implications	willingness to invest	willingness to invest for ships.																	
Mobility and transport implications	Negative mobility and transport implications	Ships: heavily affected	The shipping sector is heavily affected.	1 ~																
Mobility and transport implications	Negative mobility and transport implications	Cruise ships: heavily affected	Cruise ships are heavily affected.	1 ~																17 ~
Mobility and transport implications	Negative mobility and transport implications	Buses: heavily affected	Buses are heavily affected.										10 ~							
Mobility and transport implications	Negative mobility and transport implications	Public transportation expect heavily affected	The expectation is that public transportation will be heavily affected.					5 ~						11 ~						
Mobility and transport implications	Negative mobility and transport implications	If COVID will last long: public tr: lower willingness h2	If COVID lasts long, public transportation will have a lower willingness to participate in hydrogen projects.																	17 ~
Mobility and transport implications	Negative mobility and transport implications	Strong interdependence of projects: one down others down	Mobility and Transportation projects have strong interdependence: if one project goes down, others go down as well.					5 ~												17 ~
Mobility and transport implications	Negative mobility and transport implications	Strong competition from electric vehicles development	There is strong competition from electric vehicles.					5 ~												
Mobility and transport implications	Negative mobility and transport implications	Buses: expect electric investments	The expectation is that bus companies will invest in electric buses instead of hydrogen buses.					5 ~												
Mobility and transport implications	Positive mobility and transport implications	Delivery services: more clients	Delivery services have more clients.										10 +							
Mobility and transport implications	Positive mobility and transport implications	Expect changed travel behaviour: more sustainable travelling	The expectation is that people will travel more sustainably.														14 +			
Mobility and transport implications	Positive mobility and transport implications	Delivery services: expect opportunities for h2	Delivery services are an opportunity for hydrogen applications.										10 +							