Master of Environmental and Energy Management

Thesis Report

Natural Gas-Produced Electricity as a Green Energy Resource

Consequences of the 2022 European Delegated Regulation on the Dutch Energy Transition

By: Arash Kamali

1st Supervisor: Dr. Athanasios Votsis

2nd Supervisor: Dr. Dasom Lee

AUGUST-2022

UNIVERSITY OF TWENTE.

Table of Content

1. Introduction 1
   1.1 Background and Context 1
   1.2 Problem Statement 2
   1.3 Research Questions 3
   1.4 Thesis Outline 4
2. Literature Review 5
   2.1 Energy Reliability and Affordability 5
   2.2 Environmental Impacts 5
   2.3 Sociotechnical Consequences 6
   2.4 Research Theory 7
3. Research Design and Methods 9
   3.1 Conceptual Framework 9
   3.2 Data Collection 10
   3.3 Data Analysis Methodology 12
   3.4 Qualitative Causality Assessment 14
   3.5 Quantification of the FCM 21
   3.6 Building the FCM 23
   3.7 Considering Time Dependency of the Causalities 23
   3.8 FCM calculating tool 24
   3.9 Scenarios 25
4. Results and Discussion 28
   4.1 Final values 29
      4.1.1 Scenario 1 30
      4.1.2 Scenarios 2, 3, and 4 30
      4.1.3 Scenario 5 31
   4.2 Transition path 31
      4.2.1 Long Term Scenarios 31
      4.2.2 Short Term Scenarios 32
   4.3 Theoretical Remarks 34
5. Conclusion 36
6. References 40
7. Appendix 1 (Interview Transcripts) 48
8. Appendix 2 (FCM results) 109

List of Tables

Table 1. Contexts and sub-contexts of the research. 9
Table 2. Research framework 10
Table 3. List of interviews 11
Table 4. Questionnaire justifications 12
Table 5. Concepts deduced for the FCM 13
Table 6. Legend of the causality weight matrix 14
Table 7. Concepts' pseudonyms 15
Table 8. Qualitative causality matrix 16
Table 9. Qualitative weight matrix (+H filtered) 21
Table 10. Quantified result of Table 9 21
Table 11. The quantitative causality weight matrix 22
Table 12. Concepts with meaningful negative values 23
Table 13. Sign criteria for dummy nodes 24
Table 14. Longer than short-term connections 24
Table 15. The techniques are used to simulate different scenarios. 27
Table 16. Short-term results. 30
Table 17. Figures of scenario 1 109
Table 18. Figures of scenario 2 109
Table 19. Figures of scenario 3 109
Table 20. Figures of scenario 4 110
Table 21. Figures of scenario 5 110

List of Figures

Figure 1. CO_2 emission reduction rate according to 1990 level (Andrew & Peters, 2021) 1
Figure 2. Total primary energy supply by source, 2000-18 (Energy Agency, 2020) 2
Figure 3. Mind map to be covered throughout this research. 4
Figure 4. Short-term connection 24
Figure 5. Medium-term connection 24
Figure 6. Long-term connection 24
Figure 7. The fuzzy cognitive map 25
Figure 8. Scenario 1 results. 28
Figure 9. Scenario 2 results. 28
Figure 10. Scenario 3 results. 28
Figure 11. Scenario 4 results. 29
Figure 12. Scenario 5 results. 29
Figure 13. Legend 29
Figure 14. Small natural gas producers 33
Figure 15. Extraction from Groningen 33
Figure 16. CO_2 emission 33
Figure 17. NOx and SOx emissions 33
Figure 18. GDP per capita 33
Figure 19. Energy prices 33
Figure 20. Energy security 33
Figure 21. Natural gas import 33
Figure 22. Social concerns and panics 34
Figure 23. Legend for Figure 14 to Figure 22. 34

1. Introduction

1.1 Background and Context

Adopted by 196 parties at the Conference of the Parties (COP) 21, though still not sufficient to many, some believed the Paris Agreement was a goodnight kiss to fossil fuels (Paris Agreement, 2015). Followed by the European Green Deal, to tackle global warming and its consequences, European Commission set 2050 as a net-zero greenhouse gas emissions target (The European Green Deal, 2019). The Dutch governments, consequently, aligned themselves by setting rules to comply with the agreement within the EU domain. Similar to the EU, they targeted 2050 as the final date to achieve a circular and climate-neutral economy all in comparison with 1990 emission levels (The Government of the Netherland, n.d.).

Over the years, it has been shown that electricity and heat producers have the dominant portion of CO_2 emissions (Our World in Data, 2022). Hence, focusing on the energy production sector makes sense in order to achieve the Paris Agreement goals. Even though a rapid decrease is observed in both curves in Figure 1 from 2019 onward, no one will be blamed if being skeptical about this drop. Because many believe energy demand has dropped as a result of the COVID-19 pandemic (Liu et al., 2020).

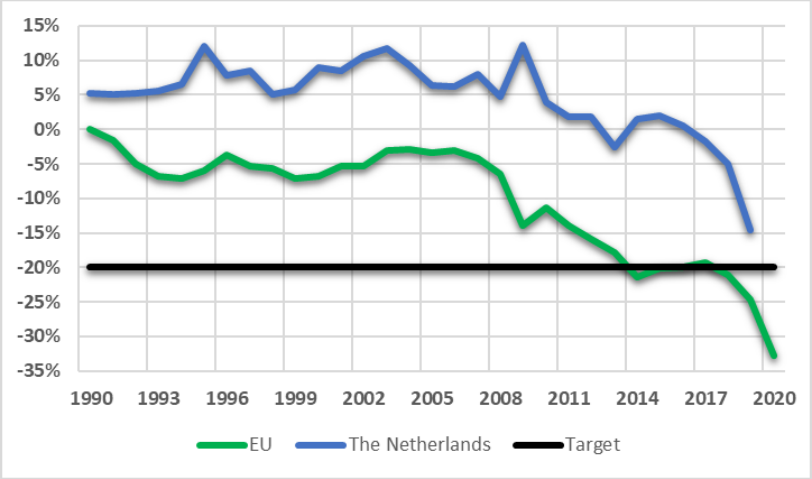

Figure 1. CO_2 emission reduction rate according to 1990 level (Andrew & Peters, 2021)

Nevertheless, considering the *Do No Significant Harm* principle the European Union's most recent taxonomy for sustainable activities (European Commission Delegated Regulation, 2022), which was issued after more than a year of debate (Abnett, 2022), announced that the electricity produced from a gas/coal powerplant would be labeled green if it emits less than 262g of equivalent CO_2 per kWh or the annual emission is kept below 550kg CO_2 per kWh over 20 years (TEG, 2020)[1]. Albeit these standards do not include conventional natural gas burning powerplants (EIA, 2021), they have brought various arguments to the agenda, including conspiracy theories like the oil and gas cartels lobbying to wake up the devil of fossil fuel that many tried to chain in the past.

Considering natural gas as the transitional source toward sustainable energy resources has been discussed for many years (Bessi et al., 2021; Boersma & Jordaan, 2017; R. Li & Su, 2017), and up till now, there is no general consensus on whether it facilitates the transition or hampers it. Understanding the concept of *no energy, no life*, one can formulate the trade-off between obliterating fossil fuel and environmental considerations, particularly at the present moment

[1] In their recent circumstantial taxonomy, European Union has put more products of gas-based energy conversion products under green category. However, this research only focuses on the electricity from natural gas and neglect the rest.

when renewables struggle with various obstacles such as intermittency. Hence, instead of trying to wipe out the heavy fuels in one direct step, the EU targets to replace them with natural gas.

According to these challenges, this research has tried to find what are the consequences of the recent EU's decision on labeling electricity from natural gas green.

1.2 Problem Statement

The governments of The Netherlands successfully shut down five coal-fired power plants as had been decided by the end of 2017 (The Government of the Netherlands, n.d.) and another one in 2019 (NOS, 2019) out of a total of 10 powerplants.

However, shutting down a power plant does not eliminate the electricity demands it has been supplying. That is to say, in the energy supply chain, other suppliers should fill in the vacancy and produce more. Therefore, a trade-off between going deep into environmental protection actions and underrating the needs, necessities, and infrastructures can be reasoned. In the best-case scenario, the deficit is expected to be filled by renewable energy resources, solar and wind energy in the short term, and hydrogen in a long run. Hitherto, however, not only the production from these resources is insufficient, but also, technical difficulties accompanying renewables have brought many hitches such as electricity grid congestion. This trade-off shows that the interrelatedness of the energy supply/demand components should be seen not as a system context in which "[an] *interacting set of elements conserving a set of relations among them*" (Whitney et al., 2015) but also as a sociotechnical system, where some interactions are non-linear and often unpredictable (G. H. Walker et al., 2008).

According to an IEA report (Energy Agency, 2020), The Netherland has always seemed to be a passionate fossil fuel consumer. As depicted in Figure 2, one can see despite all the measures considered, the Dutch energy system still heavily relies on carbon-based energy resources, surprisingly, oil and even coal, though gas dependency appears to be reasonable due to the large natural gas reservoir in The Netherlands.

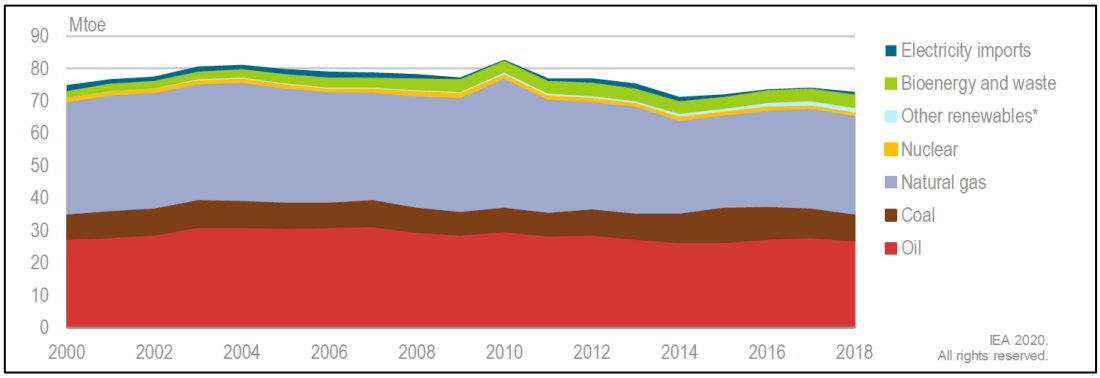

Figure 2. Total primary energy supply by source, 2000-18 (Energy Agency, 2020)

Altogether, how the newly formed Dutch energy system answers the energy affordability and reliability concerns in the face of the energy transition, and particularly, as a result of the EU's regulations remains a fundamental question almost no academic research has answered yet. Moreover, dwelling too long in the transition period is a pitfall, resulting in natural gas becoming an easily accessible source of energy and crowding out the investment in renewables[1]. These are the concepts this research[2] has aimed to figure out by employing fuzzy

[1] The author believes (and hopes with all his heart) that the struggle between Russia and Ukraine is a temporary situation, which, of course, has influenced the energy market in Europe. However, this study has kept the impacts of that (hopefully) momentary conditions out.

[2] Due to the similar nature of research, study, and this thesis, these words are used interchangeably throughout this report.

cognitive mapping which is believed to deal with sociotechnical complex systems perfectly (Nair et al., 2019).

Above all, huge natural gas reservoirs in The Netherlands on the one hand, and the pressure from the governments and social activists to phase out fossil fuels, on the other hand, make this country an interesting case study in which the results of the EU's regulations may impact the whole energy system significantly.

1.3 Research Questions

To bound the research area in addition to preventing the research track from being lost, one foremost question is developed to postulate all the research area corners and its components being affected by the recent EU delegated regulation.

Electrification of the power sector to tackle its GHG emission and reduce the direct consumption of fossil fuels by the consumers has long been considered the first step toward a carbon-neutral energy supply (Bogdanov et al., 2021; Sakamoto et al., 2021). In this quest, the European Union believes natural gas plays a crucial role (Abnett, 2022). Hence, to motivate heavy hydrocarbon-based electricity producers, coal-firings, for instance, to switch to a less pollutant fuel rapidly, they labeled the electricity produced from natural gas green. Due to the hierarchical structure of EU legislation, the Dutch governments have to comply with the EU's regulations, though they have already started phasing out the coal powerplants (NOS, 2019). This brings the general question of how this regulation shakes the current conditions in the Dutch energy system. Consequently, the main research question can be read as:

How does categorizing natural gas-produced electricity as a green energy resource by the EU affect the energy transition in the Netherlands?

The overall research question is being answered with the help of four sub-questions, which have been defined as follows:

- **Who/what will be affected the most by this delegated regulation, and how?**

  It is presumed that the Dutch energy supply/demand market can be seen as a complex (adaptive) system in which many components are influenced by a human's decisions, making it a sociotechnical complex system (G. H. Walker et al., 2008). Therefore, any provocation from outside the system, or even internally initiated, will inevitably affect other parts. Also, this question addresses the method which will be used to analyze the magnitude of those effects, i.e., fuzzy cognitive mapping developed to "*capture and model the behavior of qualitative system dynamics*" (Nair et al., 2019).

- **What complementary regulations are necessary for limiting the possible damages?**

  FCMs, as a predictive tool, help to explore the future consequences of changes imposed on a system, according to predefined goals (Nair et al., 2019). Hence, they discover whether the goals will have been achieved or not, following a scenario. Or, whether other policies must be applied to achieve the targets. In other words, this study is going to identify the possible necessity of supportive/preventative leverages on the Dutch national level.

- **How does this regulation promote the phasing out of heavy fuels; moreover, will lower carbon costs crowd out renewable investment?**

  As a sociotechnical system, the Dutch energy market is under the influence of its (ir)rational anthropogenic actions. It has been argued constantly that human rationality, undoubtedly, plays the leading role in a sociotechnical system like this study's foci (Kebede, 2014; Quackenbush, 2004). Accordingly, if a green light is given to natural

gas, labeling it socially and economically harmless, unlike the original targets, rationality will inevitably push toward more natural gas utilization.

- **What does this regulation imply for eventually managing to escape from a carbon locked-in society?**

  One subsequent to the last question is the imposed risks to the possibility of escaping from a perpetuating carbon locked-in society (Unruh, 2000). That is to say, the infrastructures for natural gas to be used will be developed regarding the regulation. Thus, this time, society will be restrained by natural gas.

In response to those questionings, this thesis looks at the problem from three different angles, namely, Energy Reliability and Affordability, Environmental Impacts, and Sociotechnical Effects. In brief, these viewpoints were selected to address almost all the different agents of a complex system like the Dutch energy system, however, more details are elaborated in 3.1.

The dominant angles this thesis will cover with their branches to be explored are illustrated in Figure 3. However, others can argue for more to be involved. For instance, due to the consequences of the recent Russian-Ukraine crisis on the energy price in the EU, a geopolitical perspective, if not only political, is very much debatable. As war is generally a temporary state, though its effects may last for a long time, this study does politely disregard focusing on this aspect, only to monitor its consequences on the actors' objectives.

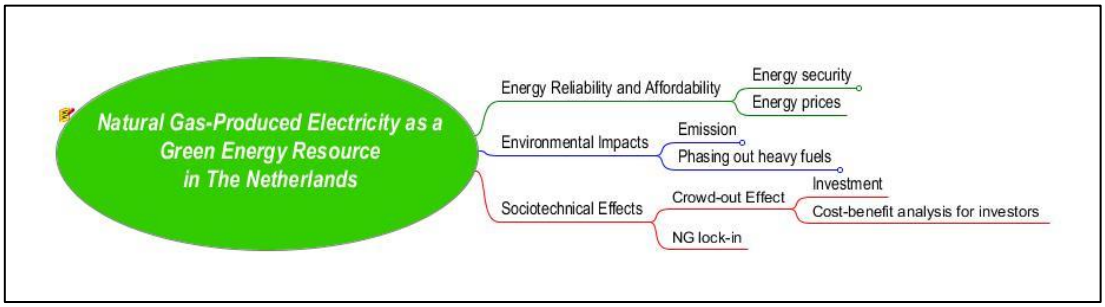

Figure 3. Mind map to be covered throughout this research.

Once more, one can speculate other subclasses for every three main pillars, biodiversity in the environmental impacts, for example. However, from the author's perspective, those mentioned in Figure 3 were believed to be of the most importance.

1.4 Thesis Outline

Many have expressed fears that the European Commission's recent decision will bring a halt to the energy transition (Abnett, 2022). This research explores from an academic viewpoint whether that fear sustains. Furthermore, this study seeks to identify the most vulnerable actors and sociotechnical system elements at the Dutch national level in the face of the regulation.

In the first step, according to an extensive literature review, previous projects and research about the role of natural gas in the energy transition have been perceived. Simultaneously, the macro actors are identified according to the analogous cases. Then by applying sociotechnical systems theory as well as complex adaptive systems theory, through semi-structured interviews with the dominant stakeholders, sets of qualitative data have been gathered.

Upon data collection, a Fuzzy Cognitive Map (FCM) has been built; and the business-as-usual scenario has been analyzed to explore the most probable future outcomes of the delegated regulation. Having observed the results from the model, and its entailed hypothetical scenarios, recommendations have been introduced to help the government facilitate the energy transition while protecting vulnerable stakeholders.

2. Literature Review

Scholars still debate whether natural gas promotes the transition toward sustainable energy production in the future or hinders it. There are different opposite opinions across the scientific society; each focuses on a particular point of view. For instance, Gürsan et al. (2021) developed a systematic approach to all the articles advocating diverse impacts natural gas may have. In fact, they divided the effects of natural gas into positive direct effects, positive indirect effects, negative indirect effects, and uncertain effects. However, because this thesis uses fuzzy cognitive mapping as a tool for model/scenario building and data analysis, it is of no benefit to divide works of literature into those four categories. In contrast, since fuzzy cognitive maps work with real numbers between -1 to +1 to represent the range of interaction between two system elements, the articles have been split into two main divisions, namely, positive consequences and negative consequences.

Moreover, to review the works of literature as per section 1.2, among all the possible perspectives for literature review, only three standpoints have been selected to study.

2.1 Energy Reliability and Affordability

Sustainable Development Goal 7 (SDG 7) aims for giving reliable, affordable, and sustainable energy access to all. In alignment with this, Dutch authorities have intensively focused on the electrification of almost everything (*Energy Report Transition to Sustainable Energy*, 2016). Consequently, electricity transmission and grid stability have become salient issues. Colombo et al. (2016) believe that natural gas could give us enough time to satisfy our energy demand until commercially viable electricity storage technologies are introduced.

Furthermore, Foreest et al. (2010), having predicted energy supply stability issues, state that natural gas-burned electricity producers are the best option to stabilize the grid, particularly in countries rich in natural gas reservoirs (Costello, 2017; de Gooyert et al., 2014). As a result, the natural gas price would become competitive with sustainable energy resources (Baron et al., 2013).

The role of natural gas in demand stability is predicted to be substantial (Scheepers et al., 2022). Those pro-natural gas scholars also believe that the gas market in Europe is resilient enough to manage harsh fluctuations of demand even in politically contaminated supply chains (Bartelet & Mulder, 2020). Deeper excavations regarding energy affordability reveal that while there are apprehensions about energy prices upsurging as a result of rapid shifts to renewables, the money saved in this regard can be invested to reduce renewable energy prices in the future (Harris & Roach, 2016).

In contrast, the recent war between Russia and Ukraine has created suspicion about the latter statement. Perhaps, Colombo et al. (2016) prophesized that natural gas in the European market is highly politicized. Particularly Boersma et al. (2017) argue that due to the high price of gas transportation, natural gas as a source of energy might not be available to countries that have no reservoir or are not located in the vicinity of one. Accordingly, coal may become economically beneficial for the latter countries, ensuing in a more carbon-intense fuel energy market (Colombo et al., 2016).

2.2 Environmental Impacts

Burning fossil fuels, natural gas, in particular, have undoubtedly negative environmental impacts. Although greenhouse gas emission is not the only adverse effect of that, this track has been discussed massively in the literature. Generally, in using natural gas, greenhouse gas emission is referred to as the indicator of environmental impacts. More precisely, based on the strength of the greenhouse effect, each of the greenhouse gases produced by burning fossil fuels

is determined by equivalent CO_2 (Helmers et al., 2019). There is a mix of views on the role of natural gas as a transitional fuel among scholars. For instance, despite natural gas being a carbon-based fuel, parts of the academic society are optimistic believing that it emits less carbon dioxide than heavy hydrocarbons, namely, coal and oil (Costello, 2017; Hekkert et al., 2005; Safari et al., 2019; van der Linde, 2015).

Researchers particularly emphasized the role of natural gas in reducing carbon dioxide in the electricity generation section (Baron et al., 2013; Bhander et al., 2019). Indeed, a study by Wilson et al. (2018) showed that CO_2 emissions in Britain had fallen in 2016 due to a drastic switch from coal to natural gas in the electricity production sector. In another investigation, Burnham et al. (2012) proved that each kWh of electricity generated by natural gas emits 50% less GHG. However, for countries that have already converted the main part of their electricity green, the remaining room for natural gas to perform the transitional fuel role is gasoline in the transportation section (Safari et al., 2019).

It is not only the CO_2 emission that has been compared to the use of natural gas instead of heavier fuels. That is to say, comparing air pollution of natural gas with heavy hydrocarbons, one should note that natural gas burning facilities emit less NOx, SOx, and particulate matters responsible for urban smog, acid rain, and visibility problems, respectively (Bhander et al., 2019; Boersma & Jordaan, 2017; Colombo et al., 2016).

Above all, a hot debate regarding the policies on controlling emissions has been found among researchers. It says policymakers should contribute to limiting the emission by implementing precise mechanisms, as they have been trying to do. For example, the carbon pricing mechanism through Emission Trading System and Carbon Taxes was supposed to reduce total emissions (Boersma & Jordaan, 2017), which evidently failed (Colombo et al., 2016).

Even so, not all believe in the positive environmental impacts of natural gas, particularly when unconventional gas sources like shale gas comes into account (Howarth et al., 2011). They think the carbon footprint of shale gas is at least 20% more than coal. Therefore, in the long run, shale gas deteriorates the environment more than coal would have done. Furthermore, Costello (2017) articulates a threshold as a rule of thumb that if only the leakage rate in the natural gas burning boiler exceeds 3.2%, utilizing natural gas instead of coal does not contribute to global warming prevention. He also believes that using natural gas entailing no carbon-capturing system is not actual decarbonization whatsoever (Costello, 2017). Still, in another study, Arent et al. (2015) were hopeful that responsible utilizing shale gas "*could play a significant role in realizing a more sustainable energy future*." Additionally, Li et al. (2017) predicted that employing natural gas as a transitional fuel would bring negative impacts on carbon dioxide emissions. That also has been highlighted explicitly for the following two decades (Costello, 2017).

Another point of view against natural gas as a transitional fuel is the worries about having weak targets in using natural gas. Undeniably, without a meaningful cap for CO_2 emission, delays toward a zero-carbon future would be inevitable (Knittel et al., 2016). Besides, Zhang et al. (2016) argue that a lengthy period of transition is going to delay the move to renewables, if not stop it at all.

2.3 Sociotechnical Consequences

Like the environmental impacts, sociotechnical consequences of using natural gas have various sub-categories. However, the most relevant topics to this research have been covered in this section. Putting on a scale, concerns about the negative sociotechnical consequences of using natural gas as transitional fuel outweighs optimists' arguments. Among optimists, Foreest et al. (2010) believe less CO_2 emission from combined cycle gas turbines running at higher efficiency than a coal-fired power plant would not bring much opposition. Similarly, Guidolin et al. (2019)

showed the pressure renewables in collaboration with natural gas exert on coal. However, Gooyert et al. (2014) believe "*the energy transition asks for an explicit exit strategy for the fossil industry*." Likewise, Szabo (2022) argues that incumbents deploy their power to extend the status quo in order to remain on natural gas rather than finally skip over it.

From another perspective, Howarth et al. (2011) believe that due to the high infrastructure cost of gas transportation, it does not make sense to invest in natural gas rather than leapfrog the transition period. Similarly, Stephenson et al. (2012) worried about greenwashing, proposed to omit the transition and move directly toward renewables.

Interestingly, the carbon lock-in argument that started early this century is still being debated. Unruh (2000) explained how a carbon-based society keeps swirling down into itself due to the solid structures of a carbon-based energy system. He demonstrates a carbon locked-in society in which technology tries to ease the path of carbon. Recently, Bessi et al. (2021), mentioning natural gas' collaborative role, have found that it still has a competitive role with renewables. This demonstrates the crucial role of natural gas in the energy transition, though warns of a carbon locked-in society on the other hand.

Additionally, The Netherlands as an owner of a significantly large natural gas reservoir has faced an exceptional social problem. Despite small earthquakes in the province of Groningen being precedent (Verdoes & Boin, 2021), it is believed that the frequency and magnitude of these quakes have been constantly rising (Vlek, 2019). According to the study by Vlek (2019), stepwise production reduction from the Groningen field was not sufficient, thus, many residents have been suffering from the direct impacts of the earthquakes like damage to their properties, as well as indirect consequences such as diminishing property value. Being ignored at the beginning, all the pressure exerted by inhabitants' social expectations made it difficult for the governments to incentivize the investment in natural gas as a transitional fuel (Boersma, 2016). However, some believe the problem has not been found a real crisis "*because of a social dependency on the extraction of gas*" (Verdoes & Boin, 2021).

2.4 Research Theory

While giving them a meaningful role, theories act like the string in a prayer bead, preventing them from being lost, hence, playing a substantial role in research (Venable, 2006). Besides, as was discussed earlier in 1.3, this research assumes the Dutch energy production/consumption market as a sociotechnical system as it has all the specifications of a system (G. H. Walker et al., 2008). Thus, the relevant theories, such as complex systems theories, are applicable (Chan, 2002).

To elaborate more, Mitchell et al. (2001) defined a complex system as a group comprised of many interacting parts they called "*components*" or "*agents*". They also explained that the interactions, whether they are symmetric or asymmetric, "*in such a system often lead to large-scale behaviors which are not easily predicted from a knowledge of the behavior of the individual agents."*

The above approach to a complex system is expanded by Svítek (2015) who believes information and knowledge enrich a complex system. In his article (Svítek, 2015) self-actions in addition to the mutual interactions between the different components of a system were articulated in a way to show how the information flow from various agents impacts each other and ends in an information resonance. This, particularly, is probable in the non-hierarchical system architectures where information goes back and forth throughout the system via the same-level interlinkages (Svítek, 2015). In a more practical approach, Li et al. (2021) addressed the regional energy system containing different energy producers and consumers acting together. Although they emphasize the reliability of the energy network, their idea of employing

complex system theory on an energy system can be applied to the Dutch energy system in which some agents are supposedly being impacted by the EU's recent regulation.

There is yet another point in looking at the Dutch energy system through the complex system theory's glasses; which is the method used to analyze the collected data. Fuzzy cognitive mapping is amongst the tools to evaluate the behaviors of a complex system. This method which has been chosen to assess the system is elaborated in 0. Additionally, Walker (2015) states: "*If people made the kind of rational choices tacitly designed […], a fair slice of humanity's grand challenges would probably disappear sociotechnical systems.*" He then concludes Sociotechnical Systems (STS) theories were developed to address such manners and how systems react to externalities.

With that in mind, one can conclude the Dutch energy system is not a simple complex system. Decentralized governing rules as a result of distributed and interacting components that adapt themselves to the surroundings are the explicit features of a Complex Adaptive System (CAS) where each part responds to a stimulus individually (Eidelson, 1997; Holland, 1992). In such a self-organizing and anti-chaos system, the If/Then reactions along with "*regular innovation and perpetual novelty*" of the agents form a nonlinear set of mathematical equations which needs sophisticated mathematics to simulate the behavior of the system (Holland, 2006; Lansing, 2003). Not to forget that to apply the concept of CAS to a sociotechnical system, diversity and resiliency are studied on a macro-scale, while evolution takes place at the agent level (Levin, 2002). In this regard, the agents in a CAS may move on an evolutionary, revolutionary, or transformative pathway (Fraedrich et al., 2015). That means the reactions of concepts to the stimulus will be either gradual changes, sharp drastic responses, or totally transform the playground to adapt to the initial pulse. With a slightly different angle, Foxon's study (2013) put three key categories of concepts, namely, market, governments, and civil society, in the shoe of the protagonist to analyze different outcomes of each scenario in the face of low-carbon electricity in the UK.

From another perspective, Walker et al. (2008) believe STSs take the concept of system theory to "*describe, analyze, and design*" purposeful systems embodying their environment. That, unquestionably, fits this research's framework as it ensues objectives in specific contexts. Because this study aims to produce recommendations at the end, one can bring more benefits from employing STS theories, as they are found to address more accurately the complexity and dynamism of a system rather than a traditional military command and control governance (G. H. Walker et al., 2008).

Altogether, understanding the role and influence of each macro component in a complex socio-technical system like the Dutch energy market will contribute to understanding the consequences of the delegated regulation.

3. Research Design and Methods

The purpose of research design is to guide the researcher answer the research questions. Due to the topic's novelty, not much was found in the literature directly answering the research questions. Thus, this study tries to fulfill the gap for a prospective EU regulation analysis. Accordingly, in this chapter, research typology, conceptual framework, means of data gathering, and data analysis methodology is elaborated.

Additionally, this thesis magnifies macro actors as the focal point rather than concentrating on a household level. However, one concept advocating the household level interests is considered in the final model to protect them from being sandwiched between the industries' gears. Based on the nature of the research and means of data gathering, a qualitative method of data analysis should be selected to analyze the collected data. That complies with the chosen method of data analysis, which will be explained later in this section.

3.1 Conceptual Framework

The developed framework by Jakob et al. (2020) will be used to address all the corners of the research area. The framework they developed, called Actor, Objectives, Context (AOC), looks for interactions between actors in a complex system considering their objectives in different contexts. However, unlike the original framework, in the present study, actors' objectives will be asked in the context of the new EU regulation. In other words, this thesis looks into the influences each actor will have on the whole system of the Dutch energy transition. Therefore, upon categorizing the contexts, the objectives of each actor that previously have been identified will be inquired about.

In addition to the headlines of chapter 2, seven so-called sub-contexts were discussed in the body text of that chapter. Subsequently, the contexts implemented in this study is like shown in Table 1.

Table 1. Contexts and sub-contexts of the research.

Context	**Socio-technical Effects**	**Environmental Impacts**	**Energy Supply**
Sub context	Investment and Subsidies	Phasing out heavy fuels	Energy Security
	Crowd out effect	Emission	Energy Affordability
	Carbon lock-in		

Moreover, nine actors have been spotted related to this study; classified into two categories as shown in Table 2.

Table 2. Research framework

Actors	1. Industrial sites: a. Natural gas providers, b. Natural gas burning electricity producers, c. Coal-burning electricity producers, d. Hydrogen producers, e. Intensive energy consumers, f. Renewable energy providers, g. Carbon capturing companies.		
	2. Policymaker: a. Ministry of Economic Affairs and Climate Policy.		
Context	Socio-technical Effects	Environmental Effects	Energy Supply
Sub context	Investment and Subsidies	Phasing out heavy fuels	Security
Sub context	Carbon lock-in	Emission	Affordability
	Crowd out effect		
Objectives	To be specified by the actors' interview	To be specified by the actors' interview	To be specified by the actors' interview

Still, only a few objectives could be figured out through academic literature. Due to that, this row was left unknown only to be completed according to the actors' responses in the data collection phase.

3.2 Data Collection

This research is looking for figuring out the effects of a newly passed delegated regulation on the Dutch energy system. Hence, the best data is still hidden in the actors' minds. In this regard, interviews and surveys can play the leading role. As has been stated before in this chapter, this thesis only focuses on the macro-level actors; thus, peer-to-peer semi-structured interviewing with the macro actors was recognized to be the most important instrument to extract the data. However, their probable biased opinions, unwillingness to answer accurately due to less anonymity, and last but not least, inaccessibility to perfectly suited respondents are among the difficulties in an interview (Bailey, 2008). Unfortunately, the reluctance of the interviewees to reveal what their entity may do was a nightmare that came through in this research.

Consequently, the work of literature to find the agents of the system, as well as the causal interrelations, were used to strengthen the gathered data's credibility. Especially considering that energy transition is a movement started decades ago in The Netherlands, one can conclude that scientific articles discussing that subject may certainly shed light on the recently tilted balance of transition's chariot. Hence, Scopus has been used intensively as well as Google Scholars to find more studies relevant to this research subject. However, since the topic is still new, gray literature such as news reports was also used. To justify that, the author was advised by an energy-producing company to study their website to understand their past performance and future visions. This was also recommended by an expert at the University of Twente. Hence, many references were made according to the information stated on the official websites of the relevant stakeholders. The outcome of this step was to discover all the macro actors/concepts, spot who will be impacted by whom in the Dutch energy sector, and what is the magnitude of the influence.

All in all, ten interviews were performed with experts from different sub-sectors of the Dutch energy system which are summarized in Table 3. The chronology of the interviews was based on the availability of the respondents, however, the last interview with the Ministry of Economic Affairs and Climate Policy was deliberately held in the end to discuss parts of the results perceived from the other interviewees and the FCM.

To keep the anonymity of the participants, their names and companies are not shown, but the expertise they were affiliated with is written to make the gathered data meaningful.

Table 3. List of interviews

No.	Date	Duration	Interviewee's affiliation
1	20-May-2022	32' 32"	Green hydrogen expert
2	24-May-2022	21' 02"	Business development agent at an energy-producing company
3	31-May-2022	29' 37"	Engineering manager at an energy-producing company
4	01-June-2022	19' 08"	Energy expert at an energy-producing company
5	01-June-2022	26' 34"	Public affairs advisor at a natural gas supplier company
6	03-June-2022	24' 10"	Regulatory & government affairs at an energy infrastructure company
7	03-June-2022	26' 46"	Renewable energy expert at a renewable energy company
8	10-June-2022	23' 30"	Energy efficiency consultants at a heavy energy-consuming company
9	14-June-2022	19' 32"	Manager at a carbon-capturing company
10	22-June-2022	28' 47"	Energy advisor at the Ministry of Economic Affairs and Climate

The interviews had been planned to last approximately 45 minutes, however, due to the direct and exact answers received from the interviewees, they became much shorter. Nevertheless, as a result of all the difficulties in finding the right person to talk to, and accordingly, diverting the focus of the data-gathering phase from interviews-only to other means, a total of approximately 260 minutes of questions and answers has formed a practical pool of data.

Eleven questions were designed in two sections with an extra question at the beginning of the interview to play the role of an ice breaker and unravel the interviewee's prejudice toward the regulation. As has been mentioned, the rest of the questions were divided into two categories, general and specific. In the general questions section, the interviewee was supposed to address different angles of the problem stated on 1.3, while specific questions were after understanding the future vision of the respondent (particularly if they could speak for their company), as well as building the FCM. Table 4 shows the detailed description and intentions behind each question.

Table 4. Questionnaire justifications

Question	Reasoning
In general, how do you see the consequences of the regulation?	This ice-breaking question tries to find the respondent's bias, whether (s)he is an optimist or pessimist.
What is your prediction when this regulation is put into practice? Do you see the energy as more affordable and reliable?	To address the consequences of the regulation on energy affordability and reliability as per page 6.
How do you believe this regulation promotes/hinders the energy transition?	To understand if the energy transition might be affected at all.
In your opinion, how successful will this regulation be in phasing out heavy fuels like coal? As a result, how do you think GHG emissions will be in the near future?	To address the environmental impacts and heavy fuel phase out.
How much do you think this regulation contributes to natural gas (in)dependency?	To magnify gas locked-in society probability.
How do you see the investments outflow from renewables as a result of this regulation?	To understand the risks imposed on investment in renewables.
Do you have plans to take advantage of this regulation? If yes, would you please name some of them? If not, why?	To comprehend if the company whom the interviewee speaks after sees any business opportunities. This would be ended up in understanding underpin concepts in the FCM.
As a [actor's category], on a scale of -10 to +10, how much do you think your business will be affected if not affected yet?	To know how great the impact will be. This would make the weight matrix of the FCM.
What are your specific objectives to promote/alleviate the consequences of the influence?	To consider time in the FCM, this needs to be known how long it will take for both harms or benefits to affect a business, and how they will react to that.
What policies do you think should be implemented to promote/alleviate the consequences of the influence on your business?	For the recommendation section of this study, the best ideas can be derived from the stakeholders/actors who are involved.
How many other stakeholders can you see whom might be affected? On a scale of -10 to +10, how much do you think each will be affected if not affected yet?	To find out if other concepts might be neglected or ignored.
How do you think economic indicators change, GDP per capita, and unemployment rate, in specific, in the Netherlands?	To ask specifically about the economic impact of the regulation, as there are some economy-related concepts in the FCM.

3.3 Data Analysis Methodology

FCMs are employed in this study as a way to represent sociotechnical systems as complex adaptive systems, model the interactions between the various sociotechnical components, produce alternative policy scenarios, and ultimately provide policy recommendations. Nair et al. (2019) note that qualitative human interactions in complex social systems are problematic and challenging to model in a linear manner. They proposed fuzzy cognitive mapping to analyze

the data drawn in the interviews. A cognitive map is a qualitative model to show how a system operates (Özesmi & Özesmi, 2004). Each part of the system, named concept/actor, can be physically measured or be as abstract as a political point of view (Özesmi & Özesmi, 2004). Also, Aravindakshan et al. (2021) showed how the actors' perceptions could be captured using fuzzy cognitive mapping while the impacts of external interventions are assessed. However, the subtle art in employing these maps is to define the causality direction, along with quantifying the strength of influence to a real number between -1 to +1.

The primitive types of cognitive maps date back to graph theory by Euler (Biggs et al., 1986). Kosko (1986) applied fuzzy causal functions first; made those graphs known as FCM. Since then, FCM has been used in a variety of fields, from the physiology of appetite to organizational behavior (Özesmi & Özesmi, 2004) and recently in energy transition studies (Kokkinos et al., 2020).

Özesmi & Özesmi (2004) proposed four different ways to construct a cognitive map, i.e., questionnaires, data extraction from text, "*drawing from data that shows causal relationships*," and concluding from interviews with people. All approaches have been considered, bearing in mind that the interviews were meant to be only one part of the data gathering in this study.

Conferring from the interviews, literature, the author's perception, and the supervisors' recommendations, 21 concepts were identified to impact or be impacted as a result of the regulation. These 21 concepts/actors were identified to address the three contexts mentioned in Table 2. Hence, they can be categorized like in Table 5.

Table 5. Concepts deduced for the FCM

Socio-technical Effects	**Environmental Effects**	**Energy Supply-Demand Chain**
Subsidies to renewables	CCS companies	NG-based electricity producers
Investing in renewables	CO_2 emissions	Coal-based electricity producers
Coal import	NOx and SOx emissions	Hydrogen production
Natural gas import		Wind and solar energy providers
GDP per capita		Minor energy consumers
Unemployment rate		Energy-intensive consumers
Renewables accessibility		Energy prices
Social concerns and panics		Energy security
		Extraction from Groningen field
		Small NG producers

It is worth mentioning that tiny important subjects have been considered when defining these concepts. For instance, it is believed that renewable energy resources like wind and solar are already being used in households and industries, while hydrogen as a source of energy is not directly used in households and is not very common in manufacturing sites. Thus, instead of "Hydrogen producers", "Hydrogen production" was recognized as a more concrete concept. Additionally, despite being said previously that this study does not aim to focus on the household level, the dominant portion of the concept "Minor energy consumers" was considered to represent this group. In other words, this concept advocates for households more or less.

Besides, attention has to be paid to the "Extraction from Groningen gas field" and the "Small natural gas producers" concepts. It is more than obvious that the Dutch government has decided to stop producing from Groningen facilities. However, deeper thinking about the energy price as well as the Ukraine-Russia conflicts, though the latter is only (hopefully) momentary, in the

face of energy security has led the author to consider extraction from Groningen as an alternative. Surprisingly, later during the interview phase, it was observed that this option was indeed speculated in the media, although not very likely to happen (Dutch News, 2022).

Another feature of Table 5 is that it made a distinction between the source of the fossil fuels pollutants, namely, CO_2, SOx, and NOx. To be precise, dependent on the type of the fuel and the process of burning them, different pollutants may be emitted. For example, NOx and SOx are the results of burning coal in addition to CO_2, while natural gas is (almost) only responsible for CO_2. Consequently, two separate concepts were considered to make the FCM more accurate. To elaborate more, one should note that in terms of causality, the "NG-based electricity producers" concept only relates to "CO_2 emissions" but the "Coal-based electricity producers" affect both "CO_2 emissions" and "NOx and SOx emissions". Furthermore, "CCS companies" can only contribute to lowering the "CO_2 emissions" while they have no causality relationship with "NOx and SOx emissions". These features serve significantly to receive a more accurate and trustworthy FCM.

Finally, the two concepts of "GDP per capita" and "Unemployment rate" were considered to represent the economic consequences.

3.4 Qualitative Causality Assessment

Once all the concepts are defined, to use an FCM, the causality interrelations together with the strength each connection has, shall be determined. The causality here stands for the degree of influence each concept may have on other concepts. For instance, what happens to concept "B" if its related concept "A" increases may result in three alternatives, i.e., positive, negative, and no causality. A positive causality ends in concept "B" increase, whereas a negative causality concept means concept "B" decrease. Lastly, if nothing happens to concept "B", it means there is no (or zero) causality. Besides the sign, these relationships may differ regarding *how much* is the degree of influence.

To create the causality weight matrix, a Microsoft Excel spreadsheet was developed in the form of a matrix in which the first row and the first column demonstrate the concept names. Then, the causality strength for each connection was assigned according to the relevant references. However, in order to create the causality weight matrix, qualitative criteria were generated to act as a screen as shown in Table 6.

Table 6. Legend of the causality weight matrix

Symbol	Meaning	Quantitative range
+ H	Positive high causality	+10 = and = +8
+ MH	Positive moderate high causality	+8 > and = +6
+ M	Positive moderate causality	+6 > and = +4
+ ML	Positive moderate low causality	+4 > and = +2
+ L	Positive low causality	+2 > and > 0
N	No causality	0
- L	Negative low causality	0 > and = -2
- ML	Negative moderate low causality	-2 > and = -4
- M	Negative moderate causality	-4 > and = -6
- MH	Negative moderate high causality	-6 > and = -8
- H	Negative high causality	-8 > and = -10

It was planned to ask for specific weight numbers of causalities in the interviews. However, it was ascertained that little was known about FCM among the interviewees. In addition to the time shortage in the interviews, this led to the method of deducing the weights as followed.

For ease of illustration, all the concepts in Table 5 were renamed to pseudonyms Ci, i being a counter index. Thus, the concepts' names became like in Table 7.

Table 7. Concepts' pseudonyms

C1	NG-based electricity producers	C8	Subsidies to renewables	C15	Social concerns and panics
C2	Coal-based electricity producers	C9	Investing in renewables	C16	Groningen field production
C3	Hydrogen production	C10	Energy prices	C17	Small NG producers
C4	Wind and solar energy providers	C11	Energy security	C18	NOx and SOx emissions
C5	CCS companies	C12	CO2 emissions	C19	GDP per capita
C6	Minor energy consumers	C13	Coal import	C20	Unemployment
C7	Energy intensive consumers (steel and refineries)	C14	Natural gas import	C21	Renewables' accessibility

Eventually, the qualitative weight matrix was formed as in Table 8.

Table 8. Qualitative causality matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21
C1		- H (1)	N (2)	N (3)	+ H (4)	- L (5)	+ L (6)	N	- L (7)	+ L (8)	+ ML (9)	- H (10)	N	+ ML (11)	+ MH (12)	+ L (13)	+ M (14)	- H (10)	- L (15)	N	N
C2	- M (1)		N (2)	N (2)	N (16)	- L (5)	N (6)	N	N	- ML (17)	+ M (18)	+ H (19)	+ H (20)	N	+ H (21)	N	- L (14)	+ H (19)	+ L (22)	+ L (22)	N
C3	- L (23)	- L (23)		N (2)	+ M (24)	N (25)	+ M (26)	N	N	+ MH (27)	+ L (18)	- M (28)	N	+ L (28)	- MH (29)	N	N	- H (30)	N	N	+ M (31)
C4	- MH (32)	- H (1)	N		N	+ ML (33)	+ M (34)	N	N	N	+ L (35)	- H	N	N	- H (36)	N	N	- H	N (37)	N	+ H
C5 (38)	N	N	N	N		N	N	N	N	+ L	N	- H	N	N	- L	N	N	N	N	N	N
C6	+ L (39)	N	+ L (40)	+ ML (41)	N (38)		N	N	+ ML (42)	N (43)	- L (44)	+ L (45)	N	+ L (46)	N	N	+ ML (45)	N	- L (47)	+ L (47)	- L (44)
C7 (48)	N	N	+ ML	N	+ H (38)	N		N	+ MH	+ L	N	+ M	N	N	N	N	N	+ ML	+ M	N	N
C8	N	N	+ H	+ H	N (38)	+ H (49)	+ M (49)		+ H (49)	- ML (50)	N	N	N	N	- L (51)	N	N	N	+ L (52)	- L (53)	+ H
C9	N	N	+ MH (54)	+ H (54)	N	N	N	N		- L	+ M (55)	N	N	N	N	N	N	N	N (37)	N (37)	+ H
C10	+ L (56)	+ L (56)	+ L (56)	+ L (56)	N	+ H	+ M (57)	N	- L		N	N	N	N	+ H	N	+ L (56)	N	N (37)	+ L (58)	N
C11	- M (59)	- H (59)	N	N	N	+ ML	+ M (48)	N	N	N		N	N	N	- MH	N	N	N	N (60)	- L (61)	N
C12	N	N	N	N	+ H (38)	N	N	+ L (49)	N	+ M (62)	N		N	N	+ M	N	N	N	N	N	N
C13	N	+ L (63)	N	N	N	N	+ L (63)	N	N	- L (63)	N	N		N	+ L	N	N	N	N	N	N
C14	+ L (64)	N	+ L (64)	N	N	N (65)	+ L (64)	N	N	- L (64)	+ M (64)	N	N		- L	N	- MH (64)	N	+ L (66)	N	N
C15	- L (12)	- H (12)	+ L (67)	+ MH (68)	N	N	- M (69)	+ M (70)	N	N	N	N	N	N		- H (71)	- L (12)	N	N	N	N
C16	+ L (64)	N	+ L (64)	N	N	N (65)	+ L (64)	N	N	- L (64)	+ M (64)	N	N	- MH (64)	+ H (72)		- MH (64)	N	+ M (73)	- M (73)	N
C17 (74)	+ L	N	+ L	N	N	N	+ L	N	N	- L	+ M	N	N	- MH	- L	N		N	+ L	- L	N
C18	N	N	N	N	N	N	N	+ L (49)	N	+ M (62)	N	N	N	N	+ M	N	N		N	N	N
C19 (75)	+ L	N	N	+ ML	N	N	N	N	+ L	N	N	+ L	N	+ L	- M	N	N	N		- H	N
C20 (76)	N	N	N	N	N	N	N	N	N	N	N	N	N	N	+ H	N	N	N	N		N
C21	- MH (1)	- H (1)	N	+ H	N	+ ML (33)	+ MH (48)	N	N	+ L (77)	+ L	- H	N	N	- H (21)	N	N	- H	N (58)	N	

According to the legend in Table 6, a qualitative causality weight matrix was developed like in Table 8 considering the acronyms in Table 7. Attentions have to be paid that the references and justifications from which the weights were reasoned have been pointed out next to the symbols which are explained as follows. Nevertheless, in some cases, conflicting opinions were observed between various references. In such cases, an aggregation was made considering the weight of reference and its importance in the energy market.

(1). By assuming that the total demand from the grid is constant, different electricity producers act like a seesaw (RWE, 2022a).

(2). Although hydrogen as a source of energy is very much competitive with natural gas, according to interviewee 2, huge investments have made hydrogen production less competitive. Additionally, energy providers' list of current projects shows less hope for hydrogen production (RWE, 2022b).

(3). Again, as mentioned above, a connection was expected. However, interviewees 2 and 7 expressed different opinions. For instance, according to interviewee 2, the weight could be + L, but, interviewee 7 pointed out a – L relationship because he believed solar and wind energy will not play the base load role due to their intermittency problems. Hence, on average, N causality was assigned.

(4). Both interviewees 4 and 9 were very much optimistic, only because they think the taxonomy's criteria enforce natural gas burning electricity providers to establish carbon-capturing assets to their generators.

(5). Almost all of the interviewees believed that due to gas price rise in recent months, minor energy consumers will be negatively affected. Among them, interviewees 1 to 4 emphasized this issue more than the others.

(6). As an intensive energy consumer, interviewee 8 mentioned the regulation and its consequences on the electricity from natural gas will definitely impact them, but not very much. He also stated that the policy of "*less coal*" will result in neutrality to coal-based electricity.

(7). Although interviewee 7 saw a high risk to renewables if gas-based electricity increased, interviewee 4 believed all the decisions had been made and nothing can redirect the path to renewables. In addition to (RWE, 2022b), it was decided to assign – L for this connection.

(8). There was a conflict between interviewees 1 and 4 to this connection. On the one hand, interviewee 1 stated that he could see a moderately positive causality. On the other hand, interviewee 4 mentioned a negative low weight. Thus, on aggregate, + L was assigned.

(9). As a backup for renewable electricity (RWE, 2022a), interviewees 4, 5, and 6 believed natural gas in electricity production plays the crucial role of stabilizer.

(10). Many references were found that discuss the role of natural gas as a substitute for coal to reduce the air pollutant emission (Baron et al., 2013; Bhander et al., 2019; Costello, 2017; Hekkert et al., 2005; RWE, 2022b; Safari et al., 2019; Wilson & Staffell, 2018).

(11). (CBS, 2022a).

(12). Interviewee 5 strongly mentioned a campaign against natural gas.

(13). To supply the need for natural gas feed for the electricity providers it is believed that extraction from the Groningen field may be increased, though very unlikely (Dutch News, 2022).

(14). In addition to abovesaid and statements of interviewee 10, the best replacement for Groningen gas or coal are minor gas fields (ONE-Dyas, 2021).

(15). Although interviewee 3 could hardly see any relationship here, it is officially said that there is a negative low connection (CBS, 2022a).

(16). Despite the belief that coal-based powerplants growth may be an opportunity for CCS companies, interviewee 9 sees none as well as interviewee 10.

(17). Surprisingly, interviewee 4 mentioned if needed, he can buy coal anywhere at a cheaper price rather than natural gas, though he had no intention to do so.

(18). Same as what was said in (9), but with a lower tendency.

(19). Like in (10) but in opposite direction.

(20). Because The Netherlands is a net coal importer country (Worldometers, 2016).

(21). (Gardumi, 2017).

(22). (Hill & Associates, n.d.).

(23). Interviewee 1 believed that due to the massive energy demand to produce hydrogen, the impact will be low. He also pointed out that the necessary energy at the moment cannot be supplied by renewables. The latter statement was confirmed by interviewee 2.

(24). Both interviewees 1 and 9 mentioned that in the case of gray hydrogen production, a connection as mentioned is expected.

(25). (Rosen & Koohi-Fayegh, 2016).

(26). Interestingly, opinions on this connection were diverse. For instance, interviewee 1 believed in a positive moderate weight, while interviewee 8 stated a stronger relationship (+ H), and Rosen et al. (2016) could see no relation at all. Therefore, in aggregate + M was selected.

(27). Again, there was a contradiction between interviewee 1 and Rosen et al. (2016). The former believed in + M, whereas, the latter saw + H.

(28). According to both interviewees 1 and 2, depending on the source of hydrogen and the energy for producing it, there can be a connection.

(29). Conclusion of interviews 1 and 2.

(30). (Bhander et al., 2019; Boersma & Jordaan, 2017; Colombo et al., 2016; Ishwaran et al., 2017).

(31). Interview 1, in addition to (RWE, 2022d, 2022b). But not at the household level.

(32). There was a consensus between interviewees 1, 2, 4, and 7 that something like in (1) happens, though with a lower weight.

(33). Piekut (2021) and Kam et al. (2018) believed in a lower weight, however, interviewee 7 gave a heavier weight.

(34). Both interviewees 7 and 8 stated so.

(35). Both interviewees 6 and 7 believed in such a relationship. As a justification, interviewee 7 pointed to the local grid congestion as a result of solar panel private wind turbines.

(36). (Gardumi, 2017).

(37). (R. Li & Leung, 2021).

(38). All the causality weights for the concept C5 were deduced from the interview with interviewee 9.

(39). It is believed that the excess gas available in the market makes a good opportunity to generate more electricity (CBS, 2022b).

(40). (RWE, 2022a, 2022b).

(41). Interviewee 6 believed that minor energy consumers could be the dominant solar panel customers.

(42). Ameli & Brandt (2015b) showed that there is positive causality between the number of minor energy consumers. Additionally, they proved that the relationship is not strong (Ameli & Brandt, 2015a).

(43). In contrast to the demand/supply relationship, Battistini et al. (2022) and Sgaravatti et al. (2022) stated no causality.

(44). In a developed country like The Netherlands, it is hardly possible that by increasing the minor energy consumers a huge impact on energy security is observed.

(45). Because most of the households burn natural gas in The Netherlands, more CO_2 emission is expected as a result of increasing the minor energy consumers.

(46). (CBS, 2021).

(47). The denominator of the mathematical formula will increase.

(48). All the causality weights for the concept C7 were deduced from the interview with interviewee 8.

(49). (RVO, n.d.).

(50). (Fischer, 2010).

(51). (Sweeney, 2018).

(52). (Bulavskaya & Reynès, 2018; Organisation for Economic Co-operation and Development, 1998).

(53). (Bulavskaya & Reynès, 2018).

(54). It is more than obvious that investments in renewables will increase renewables. However, this was specifically mentioned by interviewees 5 and 6.

(55). Especially if the investments flow to the storage technologies by which the problem of intermittency can be rectified.

(56). When the energy price increases, all the energy providers can earn a good profit. Thus, their businesses expand.

(57). Both interviewees 1 and 8 believed that the energy consumers had been taking advantage of the subsidized energy price.

(58). (Byström & Bostedt, 2019).

(59). Once the level of energy security rises, the lower use of fossil fuels as the backup energy source is expected. Yet, the impact on carbon-intensive fuels is higher.

(60). (Szustak et al., 2022).

(61). (Naqvi et al., 2022).

(62). (Peelen et al., 2020).

(63). If coal is imported more than the current need, the coal price will drop, and subsequently, electricity from coal becomes financially competitive.

(64). Same as (63) but for natural gas.

(65). No new connection to the gas grid is permitted in The Netherlands.

(66). (Berk & Cem Berk, 2015).

(67). Both interviewees 1 and 2 saw a bright future for hydrogen production. Particularly if accompanied by pressure from social concerns. Moreover, this has been pointed to by Stigka et al. (2014).

(68). In a democratic society, facilitating the exploitation of renewables is catalyzed by citizens' participation in policy-making (Stigka et al., 2014).

(69). (van Berkel, 2019).

(70). (Becker, 1983).

(71). (NAM, 2022).

(72). Apart from obvious, this connection was explicitly addressed by interviewees 3, 4, and 5.

(73). It is presumed that by increasing the production from the Groningen field, not only some recently lost-their-jobs laborers may be employed again, but also as a result of more production the numerator in the GDP per capita formula will rise.

(74). Same as the justifications for C16, but with lower weights.

(75). It is generally believed that by increasing the GDP per capita, social welfare increases as well, thus, the economy will push its boundaries by investing more (Fleurbaey & Blanchet, 2013).

(76). C20 is almost a receiver concept which means cannot drive other concepts, except for C15.

(77). (Brown & Reichenberg, 2021).

3.5 Quantification of the FCM

The state-of-the-art approach to building the causality weight matrix started in 3.4 provides a homogenous number assignment. In detail, once Table 8 was developed, through the filtering capabilities of Microsoft Excel all the relationships with the same qualitative strength can be compared to one another to allocate the most appropriate number to each connection. For instance, as can be seen in Table 9, it had been concluded that 11 connections have the same qualitative weight of + H. Then, according to the references and in comparison, to other connections with the same strength as well as considering Table 6, suitable numbers were dedicated to each connection like in Table 10.

Table 9. Qualitative weight matrix (+H filtered)

+ H	NG-based electricity producers	Coal-based electricity producers	Hydrogen production	Wind and solar energy providers	CCS companies	Minor energy consumers	Energy intensive consumers (steel and refineries)	Subsidies to renewables	Investing in renewables	Energy prices	Energy security	CO2 emissions	Coal import	Natural gas import	Social concerns and panics	Groningen field production	Small NG producers	NOx and SOx emissions	GDP per capita	Unemployment	Renewables' accessibility
NG-based electricity producers					+ H																
Coal-based electricity producers												+ H	+ H		+ H			+ H			
Hydrogen production																					
Wind and solar energy providers																					
CCS companies																					
Minor energy consumers																					
Energy intensive consumers (steel and refineries)					+ H																
Subsidies to renewables						+ H			+ H												
Investing in renewables				+ H																	
Energy prices																					
Energy security																					
CO2 emissions					+ H																
Coal import																					
Natural gas import																					
Social concerns and panics																					
Groningen field production															+ H						
Small NG producers																					
NOx and SOx emissions																					
GDP per capita																					
Unemployment																					
Renewables' accessibility																					

Table 10. Quantified result of Table 9

· H	NG-based electricity producers	Coal-based electricity producers	Hydrogen production	Wind and solar energy providers	CCS companies	Minor energy consumers	Energy intensive consumers (steel and refineries)	Subsidies to renewables	Investing in renewables	Energy prices	Energy security	CO2 emissions	Coal import	Natural gas import	Social concerns and panics	Extraction form Groningen field	Small NG producers	NOx and SOx emissions	GDP per capita	Unemployment	Renewables' accessibility
NG-based electricity producers					9																
Coal-based electricity producers												10	9		9.5			9.5			
Hydrogen production																					
Wind and solar energy providers																					
CCS companies																					
Minor energy consumers																					
Energy intensive consumers (steel and refineries)					8																
Subsidies to renewables						8.5			9.5												
Investing in renewables					8																
Energy prices																					
Energy security																					
CO2 emissions					9																
Coal import																					
Natural gas import																					
Social concerns and panics																					
Groningen field production															10						
Small NG producers																					
NOx and SOx emissions																					
GDP per capita																					
Unemployment																					
Renewables' accessibility																					

Although in an FCM, the weights should be between -1 to +1, the range was assumed to be between -10 to +10, in order to, first, magnify the impacts, second, fine-tune the connection strengths with 0.5 discrete steps.

This procedure to produce the final causality weight matrix was carried on until Table 11 was formed. However, in the end, the quantified matrix was dot-divided by 10 to make it understandable for the software. This resulted in a weight matrix with two decimal point numbers.

Table 11. The quantitative causality weight matrix[1]

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21
C1		-1.00			0.90	-0.10	0.15		-0.05	0.15	0.35	-0.85		0.35	0.70	0.05	0.55	-0.95	0.05		
C2	-0.60					-0.05				-0.30	0.55	1.00	0.90		0.95		-0.15	0.95	0.05	0.05	
C3	-0.10	-0.15			0.40		0.50			0.75	0.10	-0.50		0.05	-0.80			-1.00			0.40
C4	-0.70	-0.95				0.35	0.45				0.10				-1.00						
C5										0.10		-0.85			-0.15						
C6	0.15		0.05	0.25					0.30		-0.10	0.10		0.10			0.20		-0.05	0.05	-0.10
C7			0.25		0.80				0.75	0.05		0.50						0.20	0.40		
C8						0.85	0.45		0.95	-0.40					-0.15				0.10	-0.05	
C9			0.60	0.80						-0.15	0.55										
C10	0.05	0.05	0.15	0.10			0.40		-0.10								0.10			0.05	
C11	-0.55	-0.95				0.35	0.55								-0.80					-0.05	
C12					0.90			0.15		0.50											
C13		0.05					0.05			-0.15											
C14	0.05		0.05				0.15			-0.05	0.55						-0.70		0.05		
C15	-0.10	-1.00	0.10	0.70			-0.50	0.50								-1.00	-0.10				
C16	0.15		0.10				0.15			-0.15	0.55			-0.80	1.00		-0.75		0.40	-0.45	
C17	0.15		0.10				0.15			-0.10	0.45			-0.65					0.10	-0.05	
C18								0.15		0.50											
C19	0.05			0.30					0.15			0.10		0.10							
C20																					
C21	-0.65	-0.95				0.35	0.70			0.05	0.05				-0.90						

[1] No causality connection or, in terms of FCM science, zero-weight relationships were omitted for the ease of reading. However, the software does not accept blank cells and consequently, number 0 was inserted in all the blank cells.

3.6 Building the FCM

Fuzzy cognitive mapping is not a black box. In fact, there are several mathematical equations behind the scene that perform the calculations. In employing the fuzzy cognitive mapping method, two concepts, namely, activation rule and transfer function shall be fully understood, if the researcher wants to receive accurate and reliable results. Scrutinizing those in this report is absolutely not a target, however, it is worthy to look at the first chapter of the book by Prasad (2008) to get familiar with the basic concepts which are necessary to better understand this chapter.

Regardless of their mathematical formula, three activation rules are known to be famous, i.e., Standard Kosko's activation rule, Kosko's activation rule with self-memory, and rescaled activation rule with self-memory. In short, the first is used as the basic rule, the second is used where concepts are influenced by their history, and the last one is utilized where no information about the initial conditions of concepts is known (Nápoles et al., 2018). Consequently, Kosko's activation rule with self-memory was chosen for this study, due to the fact that the dynamics of the Dutch energy system make it self-impacted.

Moreover, there are a couple of transfer functions, namely, bivalent function, trivalent function, hyperbolic function, and sigmoid function. Briefly, the two foremost act like discrete step functions which make the final results exact numbers -1, 0, and +1. However, the two latter are continuous functions and are the most relevant to this study considering both the logicality and stability of the map (Bueno & Salmeron, 2009; Harmati et al., 2021). There is yet a substantial difference between the sigmoid and hyperbolic functions based on their mathematical formula. As easy as possible, it can be said that the sigmoid function should be used for concepts whose value can only be a positive number, whereas, the hyperbolic function is used for those concepts with logically acceptable negative numbers (Nápoles et al., 2018). Therefore, the problem here is that one-size-fits-all does not return credible answers as there are concepts that can hold negative numbers, while for others a negative number does not make sense. As a result, the concepts on which a hyperbolic function is applicable are shown in Table 12.

Table 12. Concepts with meaningful negative values

Pseudonym	Concept	Remark
C9	Investing in renewables	Negative numbers represent investment outflow from renewables
C13	Coal import	Negative numbers show export
C14	Natural gas import	Negative numbers show export
C20	Unemployment	Negative numbers stand for a labor shortage

3.7 Considering Time Dependency of the Causalities

Due to their nature, FCMs look at all the concepts regardless of time. In other words, when two concepts have a direct connection, each step of calculations figures out their value without considering how long, in reality, it takes to observe such an impact. For example, one can recognize that the time needed to see the effects of increasing the number of minor energy consumers on wind and solar energy providers differ from hydrogen production since hydrogen has a long way ahead to be utilized as a source of energy for the minor energy consumers (mostly households). Whereas, the needs of minor energy consumers' need for energy besides the gas-based houses in The Netherlands, affects CO_2 emission in a much shorter time.

To tackle the mentioned problem and obtain more sensible results from the FCM, Carvalho (2013) proposed to consider time lags on the weights. That means, for instance, a lower weight to be assigned to connections with larger time lags. However, the method of Park et al. (1995)

was adopted in this study. They proposed to add "*dummy nodes*" in between the concepts which have time lag dependency considering the delay period. Precisely, according to the step-wise nature of the FCM calculations, these in-between-dummy-nodes prevent the instantaneous impact of one concept on another. As can be seen in Figure 5, "D_1" prevents the simultaneous impact of concept "A" on concept "B". Therefore, it simulates one time-step.

To put into practice, in this research, time dependencies were divided into three periods, i.e., short-term, medium-term, and long-term (Hayes, 2021). It was assumed that medium-term takes twice as short-term, and long-term thrice as short-term. In this way, having no dummy node means a short-term impact, while one dummy node represents one medium-term, and two dummies represent a long-term period. Therefore, in relationships with a medium-term time lag, one dummy node was added instead of the direct connection. Figure 4 to Figure 6 illustrate this methodology.

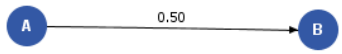

Figure 4. Short-term connection

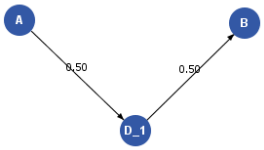

Figure 5. Medium-term connection

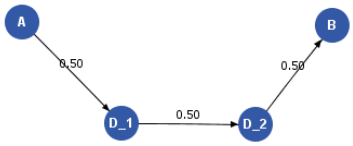

Figure 6. Long-term connection

Besides the weights remaining the same for each added dummy node, the criteria to assign the sign of the causalities are as follows. Attentions have to be paid that each dummy node shall use the same transfer function as its parent concepts use.

Table 13. Sign criteria for dummy nodes

Number of dummies	**Sign of the causality**	
0 (Timeless initial relationship)	+	-
1	Both new connections: +	First new connection: - Second new connection: +
2	All three new connections: +	All three new connections: -

Back to the FCM of this research, 12 causality relationships were determined medium and long-term. These connections are shown in Table 14. Hence, 18 dummy nodes shall be added to the map.

Table 14. Longer than short-term connections

C6 → C4	Medium-term	C3 → C1	Long-term
C6 → C19	Medium-term	C3 → C2	Long-term
C9 → C10	Medium-term	C3 → C12	Long-term
C10 → C9	Medium-term	C3 → C14	Long-term
C21 → C10	Medium-term	C6 → C3	Long-term
		C14 → C19	Long-term

3.8 FCM calculating tool

There are several tools and software for performing fuzzy calculations and each has specific features (Nápoles et al., 2018). One commonly used web-based software named MentalModeler (https://www.mentalmodeler.com/) with a very user-friendly interface handles the calculations

and only returns the final results. However, in FCM analysis, the path toward the final values each concept stabilizes is as important as the final values themselves. From an energy transitions perspective, this is important as well as the policymakers are interested in the pathway parameters in addition to the end-of-the-road results. In other words, toward the end of the calculations, the values at the end of each step may exceed a tolerance criterion. Or, like in this study, the researcher may be looking for the results after a specific number of iterations (time steps). Hence, the FCM Expert software (Nápoles et al., 2018) was specifically used to address the transient steps of the calculations.

Upon importing the causality matrix with the dummy nodes to the software, the FCM became as illustrated in Figure 7.

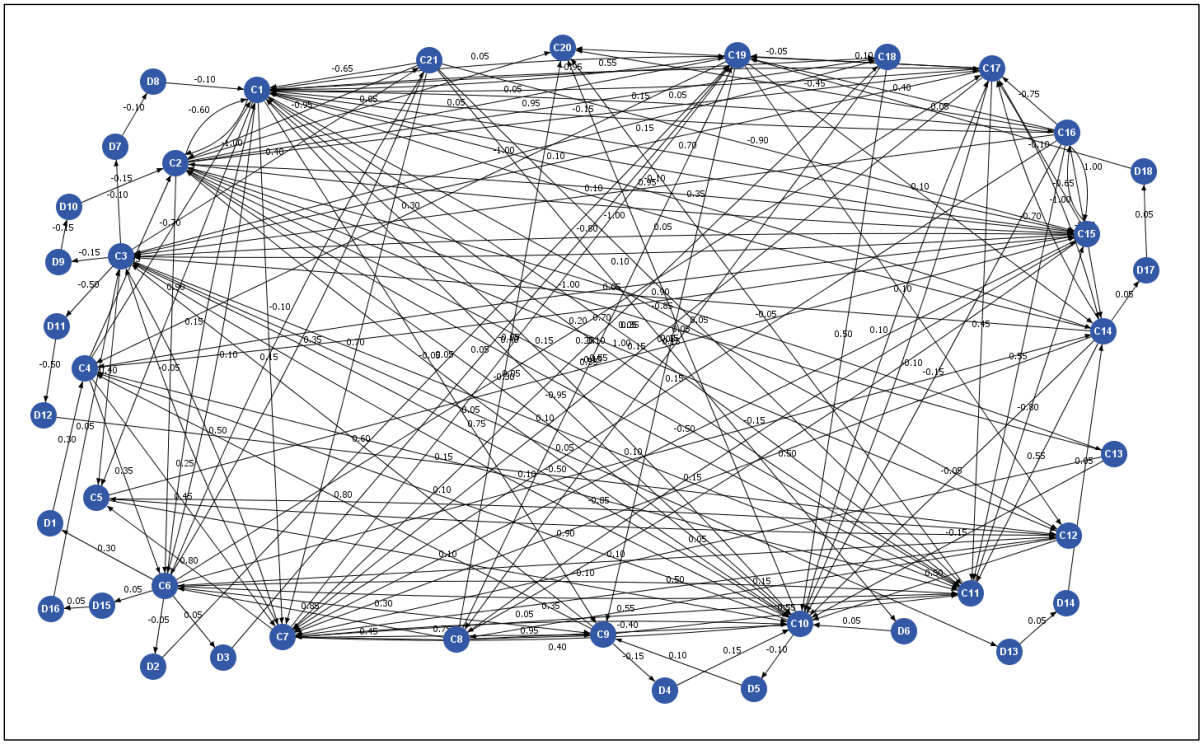

Figure 7. The fuzzy cognitive map

3.9 Scenarios

Scenarios not only predict the future; but also shape it (de Jouvenel, 2000). Therefore, in addition to how they are built, scenarios substantially have been vital among scholars (Riahi et al., 2017). In chapter 1, this report started by arguing the consequences of the recent EU delegated regulation to the goals of the Paris Agreement since "*climate change is the greatest market failure the world has ever seen*" (Stern, 2006). Indisputably, energy issues are tangled with environmental problems, which leads the research to the concept of Shared Socioeconomic Pathways (SSPs). According to Riahi et al. (2017), the climate change research community defined these pathways to ease the future "*climate impacts, vulnerabilities, adaptation, and mitigation.*" Built on five different narratives, in fact, these SSPs try to describe "*alternative socioeconomic development*" (Riahi et al., 2017). With indices 1, that is to say, a sustainable "*taking the green road*" to 5, fossil fuel development or, "*taking the highway*", those SSPs draw different futures (Riahi et al., 2017).

Although SSP1 is believed to lead us to heaven, in climbing the ladder of SSPs from SSP5 up to SSP1, some predict a lengthy dwell on SSP4 that produces many inequalities, particularly in environmental and energy aspects as a result of the delegated regulation. Accordingly, the

foremost scenario is the Business-As-Usual or keeping the status quo as interviewee 3 emphasized.

However, the current energy market chaos which is a direct result of the COVID-19 era and the struggle between Russia and Ukraine, changed the game significantly, at least in short term. Thus, in accordance with the statements of interviewee 10, two substantially different scenarios are defined, namely, short-term and long-term, which themselves can be divided into different plans. At first, it is believed that in short term and due to the energy demand in The Netherlands, relaxation would be given to the limits and targets previously set to achieve the Paris Agreement's goals. This particular scenario by itself can be divided into three plans. In the first plan, coal-burning powerplants would increase their production capacity to save gas for the coming winter (Pascoe, 2022). This plan can be accompanied by forcefully attempting to shut down the Groningen field facilities as promised or letting the interactions in the FCM decide what happens to the production from the Groningen field if no suppressing force is exerted. Consequently, scenarios two and three form respectively. Additionally, another presumable plan in a short period of time is that the governments temporarily break their pledge about rolling out the Groningen field in the favor of less air pollution. Hence, instead of compensating for the gas shortage with coal-based electricity, they let the production from Groningen facilities increase. At last, it is supposed that the critical energy situation in The Netherlands happily will have passed and the governments resume pushing the policies in the favor of sustainable energy resources. It is worth mentioning that in the first four scenarios, it was assumed that small natural gas producers are encouraged to produce more, as interviewee 10 proposed.

The goal here is to compare these five scenarios, foresee their results after an equal amount of time, and finally, find and recommend the optimum scenario in the short- and long-term period. To do so and following the concept explained on page 23, each calculation step was considered to represent a period between 1.5 to 2 years. That is to say, to predict the values for a short run (around 5 years), three iterations have to be performed. The techniques used to manipulate the relevant variables in each scenario are explained in Table 15.

Table 15. The techniques are used to simulate different scenarios.

Scenario	Time span	Technique	Remark
1	7 iterations to simulate 10 to 15 years.	No intervention. The FCM was run straight forward as it was built.	To show BAU results.
2	3 iterations to simulate 4 to 6 years.	The initial value for C2 was set to 1.	To represent the promotion of coal-firing electricity.
		Set C16 as a constant concept with the value of 0.	To show no gas will come from Groningen to compensate for the gas shortage.
		The initial value for C17 was set to 1.	To express the idea of more production from small gas producers.
3	3 iterations to simulate 4 to 6 years	The initial value for C2 was set to 1.	To represent the promotion of coal-firing electricity but let the FCM decide on Groningen production.
		The initial value for C17 was set to 1.	The initial value for C17 was set to 1.
4	3 iterations to simulate 4 to 6 years	Set C2 as a constant concept with the value of 0.	To see what happens if the governments decide to replace coal-based with gas-based electricity.
		The initial value for C17 was set to 1.	To express the idea of more production from small gas producers.
5	7 iterations to simulate 10 to 15 years.	The initial value for C2 was set to 1.	To represent the promotion of coal-firing electricity.
		Set C16 as a constant concept with the value of 0.	To show no gas will come from Groningen to compensate for the gas shortage.

4. Results and Discussion

In using fuzzy cognitive maps to simulate a complex system, the path toward that final state of each component is as important as the final value itself. Thus, the results in this chapter are presented in two categories. In the first, only the final situations are elaborated, and in the second, the transition path is explained. However, to provide the reader with a clear view of the outcomes at each step of the calculation, the curves resulting from the calculations are illustrated in Figure 8 to Figure 12, given that Figure 13 is a common legend for all the figures. For more scrutinizing the results, the relevant tables are enclosed in appendix 2.

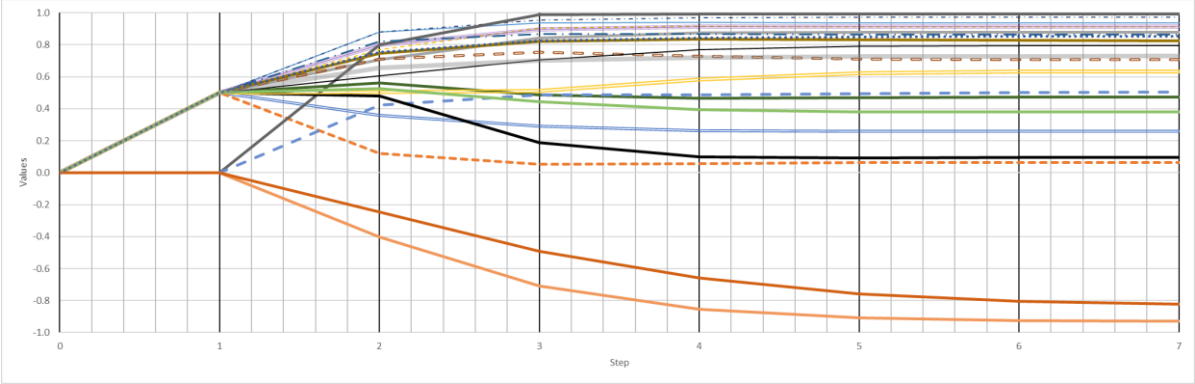

Figure 8. Scenario 1 results.

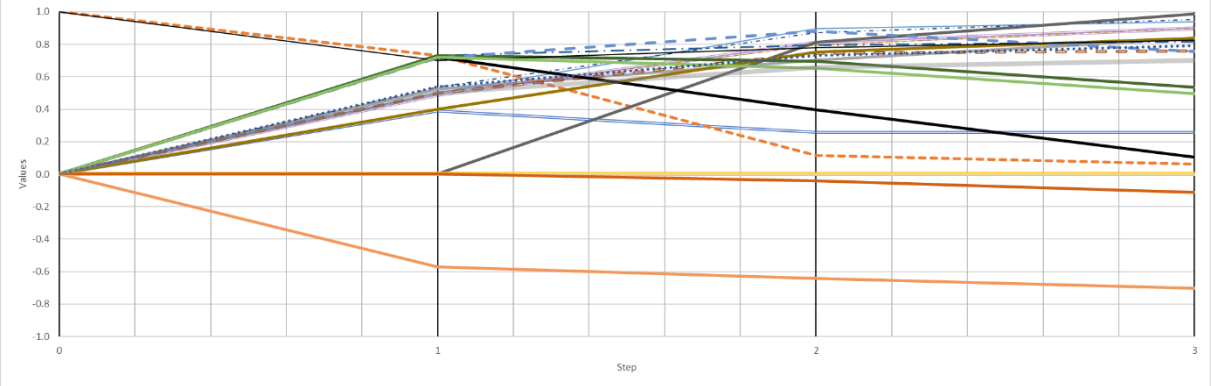

Figure 9. Scenario 2 results.

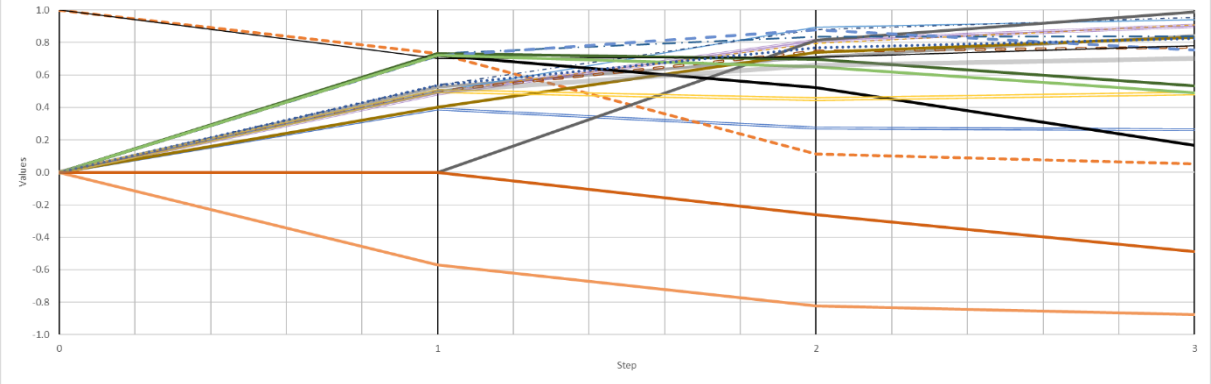

Figure 10. Scenario 3 results.

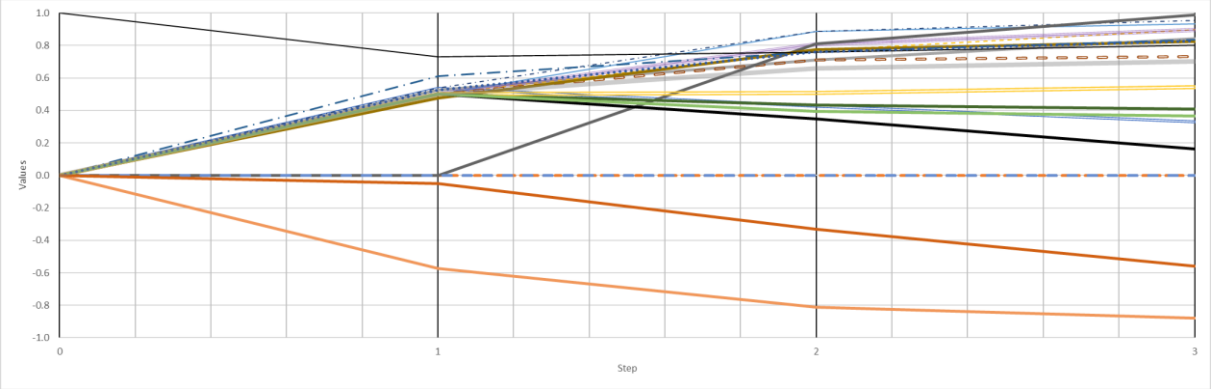

Figure 11. Scenario 4 results.

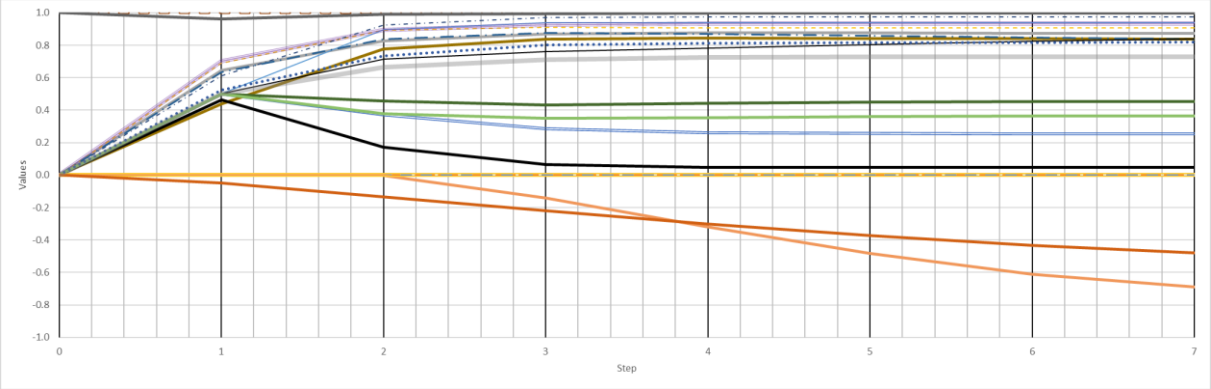

Figure 12. Scenario 5 results.

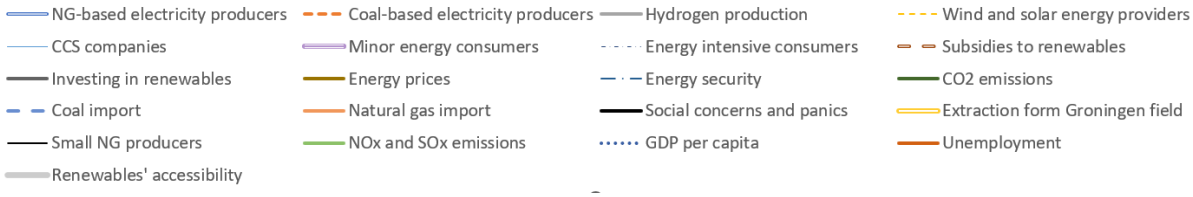

Figure 13. Legend

In general, as can be observed in Figure 8 to Figure 12, two of the four concepts with a hyperbolic transfer function, namely, unemployment and natural gas import demonstrate negative numbers. That means the Dutch energy system will face a lack of labor in the market, while as a result of the measurements the governments have taken, The Netherlands can become a net natural gas exporter. The time and magnitude of the latter depend on how they manage the Groningen facilities. Fortunately, on the other hand, investment in renewable shows positive numbers in all five scenarios which means no risk of investment outflow is predicted for renewables.

4.1 Final values

To give a better understanding of how the energy system in The Netherlands has been built, scenario 1 as the BAU case is the foremost scenario to investigate in this section. Then, the consequences of the (possibly) taken measures in the form of scenarios 2, 3, and 4 in front of each other are discussed. Lastly, the results from scenario 5 are explained.

4.1.1 Scenario 1

As illustrated in Figure 8, the Dutch energy system seems very robust and goal-oriented. That means, if the system had been left to itself, based on the concepts'/actors' interrelations, a set of positive outcomes could have been expected. For instance, a sharp decrease in coal-based electricity can be observed which shows the correct direction of in-place policies. This movement does not only contribute to sustainable resources of energy and their accessibility but also halves the natural gas-based electricity. At the same time, this scenario shows a decent reduction of non-carbon-based pollutants as a direct result of the coal phase-out; and accordingly, social concerns almost remain unchanged. Besides, no investment outflow from renewables is observed.

However, all of that happens only under the shadow of uprising energy prices. Perhaps, this makes a relatively slight increase in gas extraction from Groningen and a moderate increase in production of smaller fields logical; to first, supply the energy and increase the energy security; and second, cut the natural gas import. That is why the "natural gas imports" becomes a negative number which means The Netherlands would have become a net exporter, due to excess production and phasing out the carbon-based energy resources in a long run. Although the market would have suffered from the lack of experienced labor more, both economic indicators would have risen.

4.1.2 Scenarios 2, 3, and 4.

The differences between these scenarios were elaborated in 3.9. However, as a reminder, scenario 2 was the one the government looks forward to permitting coal-based electricity to increase while persuading the small natural gas producers to expand and keeping the promise of "no Groningen gas". In a hypothetical situation it was assumed that above the coal-electricity allowance, let the FCM decide on Groningen gas (scenario 3), while in another hypothetical situation (scenario 4), the third scenario would be accompanied by forcefully shutting down the coal-based powerplants.

According to Table 16 in which the values of each concept after 3 steps of calculation (to resemble a 5-year span) are demonstrated, one can see the results are diverse.

Table 16. Short-term results.[†]

	Scenario 2	**Scenario 3**	**Scenario 4**		**Scenario 2**	**Scenario 3**	**Scenario 4**
C1	0.26	0.26	0.33	C12	0.53	0.53	0.41
C2	0.06	0.05	0.00	C13	0.75	0.75	0.00
C3	0.84	0.84	0.84	C14	-0.70	-0.88	-0.88
C4	0.90	0.91	0.90	C15	0.10	0.17	0.16
C5	0.94	0.94	0.93	C16	0.00	0.49	0.55
C6	0.90	0.90	0.89	C17	0.83	0.78	0.80
C7	0.95	0.95	0.96	C18	0.50	0.49	0.37
C8	0.76	0.77	0.73	C19	0.79	0.83	0.83
C9	0.99	0.99	0.99	C20	-0.11	-0.49	-0.56
C10	0.84	0.83	0.83	C21	0.70	0.70	0.70
C11	0.82	0.84	0.84				

[†] C1: NG-based electricity producers, C2: Coal-based electricity producers, C3: Hydrogen production, C4: Wind and solar energy providers, C5: CCS companies, C6: Minor energy consumers, C7: Energy intensive consumers, C8: Subsidies to renewables, C9: Investing in renewables, C10: Energy prices, C11: Energy security, C12: CO2 emissions, C13: Coal import, C14: Natural gas import, C15: Social concerns and panics, C16: Groningen field production, C17: Small NG producers, C18: NOx and SOx emissions, C19: GDP per capita, C20: Unemployment, C21: Renewables' accessibility.

For instance, no significant differences between the situation of coal-based powerplants, sustainable energy providers, energy consumers, and CCS companies are observed. Interestingly, it is revealed that phasing out the coal would happen one way or the other, without governmental excessive pressure. Once again, this proves that the Dutch energy system has been formed solidly toward the coal phase-out with the help of the regulation, besides the opportunity to become a natural gas exporter. Though all three scenarios show a sharp rise in energy price, scenario 2 shows a relatively lower jump in the prices and consequently, fewer social concerns are expected.

Nevertheless, there are fascinating differences between these scenarios. For example, the impacts of the policy of *coal to compensate for gas deficit* can be observed in electricity from natural gas-based powerplant rise in three cases, with the fourth scenario experiencing a slightly larger growth. As another result, the current policy (scenario 2) would jeopardize the environmental goals. However, scenario 4 shows less harm to the air quality.

Apparently, Groningen holds huge potential in the FCM. On the one hand, more production from this field shows economic opportunities and improvements ("GDP per capita", for instance) as well as less GHG emissions. On the other hand, it provokes citizens' concerns. Therefore, it indicates that policymaking in the vicinity of this scenario is a problematic task.

4.1.3 Scenario 5

This scenario is almost the same as scenario 1, except for the natural gas issues, which the government will be pushing hard to reduce its use in the long-term scenario. However, the system (with no manipulation from the government) is tentative to lose the value of subsidies. Moreover, coal will be present in the energy system as well if no precautions are taken. Above that, though social concerns will never drop in the fifth scenario, even with a heavy governmental intervention, less dissatisfied citizens are predicted. However, since the Dutch government decides to rule out the possibility of more natural gas extraction from Groningen, less natural gas export and unemployment are predicted.

4.2 Transition path

In this section, the behavior of the FCM after the first step until the final step is discussed. The findings from this section are particularly useful for making a policy with minimum burdens. In other words, the reaction of a concept from the initial value onward can be nonlinear. Thus, its value may exceed a tolerance limit or make the policy costly and illogical. Therefore, the transition periods are first scrutinized for scenarios 1 and 5 simultaneously. Then, the differences in scenarios 2 to 4 are compared.

4.2.1 Long Term Scenarios

In the first look, the time lag effect of the FCM on concepts of "natural gas import", "unemployment", "coal import", and "investing in renewables" can be observed. That means these four concepts move slowly with heavy static inertia. Among them, one can observe that as soon as the present crisis passes, The Netherlands can become a net exporter of natural gas.

On the other hand, all the other 17 concepts react fast. Once magnified, it can be seen that coal-based powerplants rise at first, but as time passes, this concept draws back to almost zero. The same is predicted to happen for natural gas-based powerplants, however, an offset can be seen between the two, which shows the path toward the coal phase-out. Air pollutant emissions also act in the same way. Meanwhile, production from the Groningen facilities, after a decent rise to answer the demand's needs, stays relatively stable. However, due to its probable positive economic impacts, it may be rising after step 3 (year 5) and remains high. In this scenario, it was assumed that the production rate from the Groningen field remains an option on the table.

But it can be seen that without further preventative intervention, production will rise after doing its job to make the Dutch energy system independent of Russian gas.

Furthermore, after a rise, perhaps, as a result of both energy price growth and more Groningen gas extraction, social concerns rise and stables for a short time. However, in the medium to long run, it drops due to economic improvement as well as seeing sustainable sources of energy becoming constantly widespread.

Overall, the conditions are relatively the same in scenario 5. However, due to a heavy push from the government to stop production from Groningen, despite solid decisions to move toward a sustainable energy system, The Netherlands can only become a net natural gas exporter at a later time than in scenario 1. In other words, the policy of exploiting small natural gas providers' expansion would be busy with supplying the internal energy demands. And as soon as the investment in renewables makes itself known after step 2 (around year 4), the excess gas can be exported.

Again, social concerns are expected to drop after a short period of increase, though this time the final value after 7 steps (around year 15) would be half in comparison to scenario 1; which means citizens would be happier in this scenario. Once GDP per capita and unemployment in both scenarios are compared, it is revealed that despite both economic indicators, along with energy security, having better conditions in scenario 1, social concerns are still lower in scenario 5. One reason for this might be the fact that for the Dutch people, the economy is not everything and they are concerned about other issues, like more natural gas in their energy basket to lower GHG emissions.

Yet, many other concepts react the same in both scenarios. For instance, since natural gas as a source of energy remains in the system, both CCS companies and heavy energy consumers grow.

4.2.2 Short Term Scenarios

In the short run, changes are difficult to analyze, mainly due to severe oscillations of the outcomes at each step. However, it can be claimed that undoubtedly, the interrelations between the Dutch energy system actors/concepts (or the FCM) forces down the coal-based electricity, slowly at the first step and then dramatically. Many other concepts like "hydrogen production", "wind and solar energy providers", and "renewable energy accessibility" almost behave the same way in all three short-term scenarios. However, the interesting differences are how these scenarios impact environmental concepts, economic issues, and societal considerations. Before detailing these impacts, the differences between particular concepts in various scenarios are tabulated in Figure 14 to Figure 22; Figure 23 acts as the common legend.

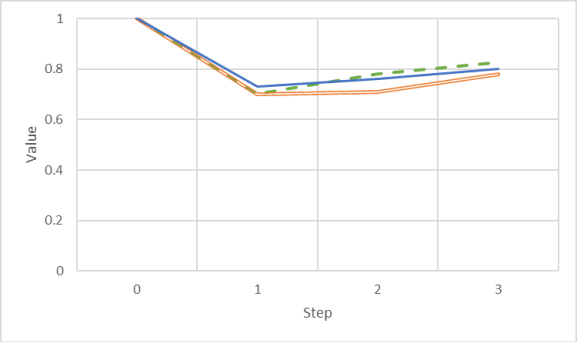

Figure 14. Small natural gas producers

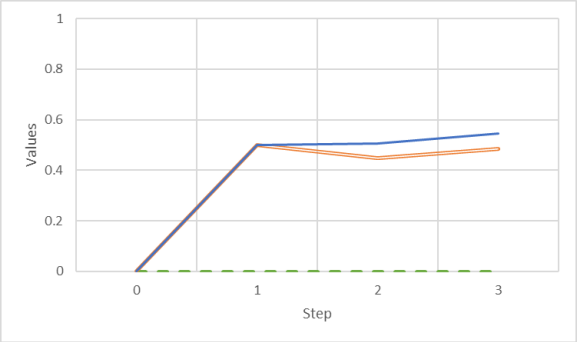

Figure 15. Extraction from Groningen

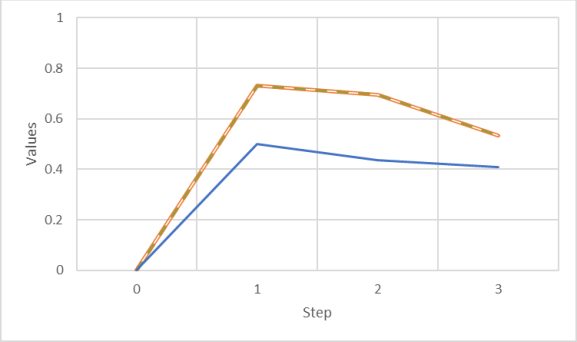

Figure 16. CO_2 emission

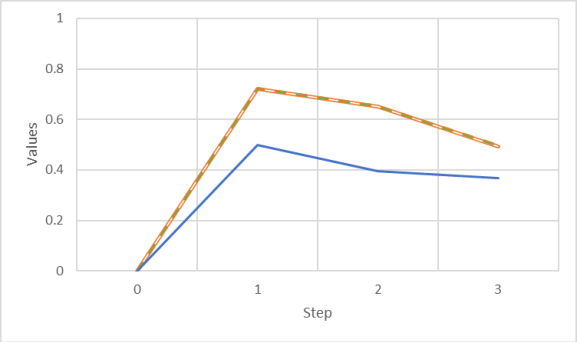

Figure 17. NOx and SOx emissions

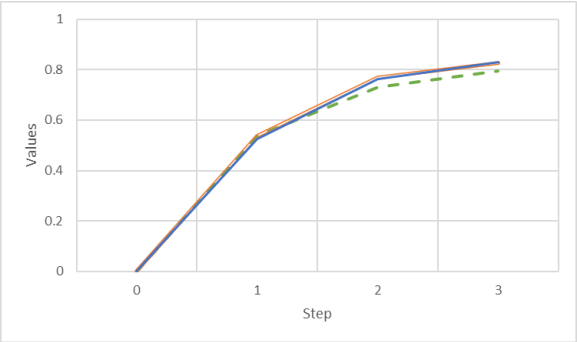

Figure 18. GDP per capita

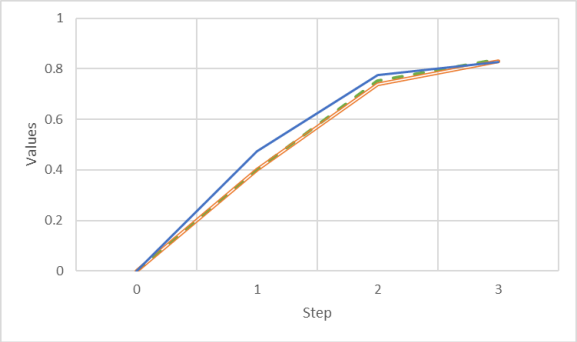

Figure 19. Energy prices

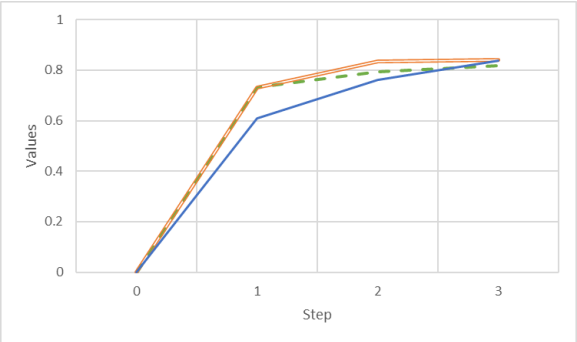

Figure 20. Energy security

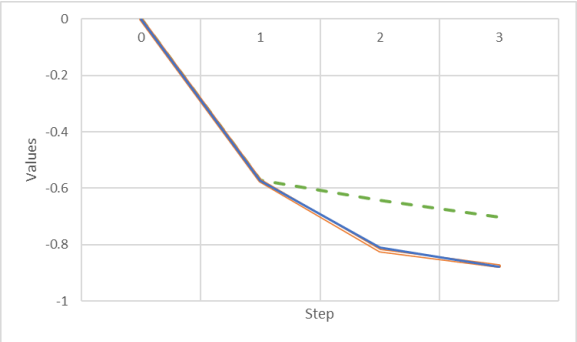

Figure 21. Natural gas import

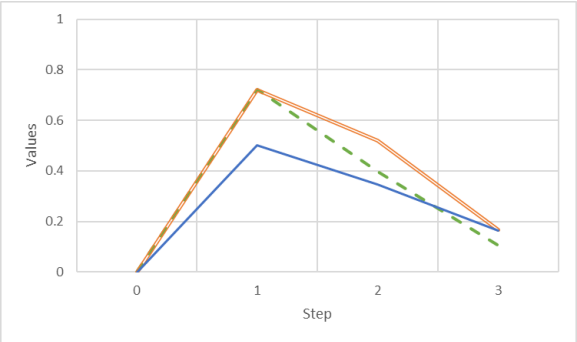

Figure 22. Social concerns and panics

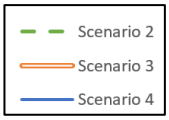

Figure 23. Legend for Figure 14 to Figure 22.

It can be seen that small natural gas producers react differently in the short run (Figure 14). In Scenario 2 which is the most probable scenario among the others according to interviewee 10, Figure 14 shows despite the future uncertainty about natural gas, the push from governments can overcome the reluctancy of small producers and persuade them to expand their business, while in the other scenarios presumably because of increase in production from Groningen field (Figure 15), small producers would remain less competitive. Moreover, due to coal-based electricity promotion by the governments, even production from Groningen would find itself less competitive in the short run (Figure 15, note the offset between the blue solid line and the orange doubled line).

From another standpoint, depending on how early coal is phased out, the environmental impacts would be alleviated. In other words, CO_2 emission and SOx/NOx emission act the same way, however, in scenario 4 in which it was assumed that coal-based electricity would constantly remain zero, one can observe less GHG emission (Figure 16 and Figure 17). It should be mentioned that the original idea of differentiating the types of air pollutants has worked perfectly (note the final values of SOx/NOx emission in scenario 4 which is lower than CO_2's counterpart).

Other than that, Figure 19 and Figure 20 reveal a negative proportionality between energy price and energy security. That means, for example, if the policies in scenario 4 are to be followed, unlike in scenario 3, less secure and expensive energy would be predicted during the transition time. However, scenario 2 remains in between these two extremes almost all the time. In fact, this would be achieved at the cost of GDP per capita. By looking at Figure 18, one can see that after step 1 (around 1.5 years), the rate of GDP per capita growth slows down in scenario 2. That is essentially due to the fact that less internal natural gas supply is foreseen in this specific scenario. However, if the production of natural gas from both Groningen field and small producers are not capped, more export (or negative imports) would be observed, which itself contributes to GDP per capita.

In terms of social concerns, Figure 22 shows different paths. Scenario 4 would cause a smaller social concerns peak, perhaps due to less coal-based electricity used; though it ends in a slightly higher value. Scenarios 2 and 3 act the same way in the first step, however, scenario 2 shows a rapid decrease afterward. This would achieve in the shadow of shutting down the Groningen facilities.

4.3 Theoretical Remarks

As previously stated, the Dutch energy system can be seen as a complex system comprised of different components interacting together to produce a common result. Having discussed the results of the FCM through different scenarios, one can observe how symmetrical actions in the face of the EU's regulation could lead to large-scale behavior like rising social concerns,

especially in the short run. This exemplifies the method Mitchell et al. (2001) approached a complex system.

Though implicitly, it was shown that due to the non-hierarchical structure of the Dutch energy system, information flows bidirectionally; proving the theory of Svítek (2015) which states in such a system information flow back and forth, and not in one direction like in command-and-control systems (Sheridan, 1988). For example, it was shown in both Figure 7 and Table 10 that a concept like "subsidies to renewables" which seemed to be a driver-only concept, turned out to be influenced as a result of social concerns.

The outcome of interviews revealed that the Dutch energy system follows the same principle as Li et al. (2021) explained, how different actors in a regional energy system act together toward a reliable energy supply. Particularly, interviewee 6 stated how his company together with others is trying to fulfill the possible energy deficit in the coming winter. From another perspective, rationality pushes for the energy to be supplied in any possible way. However, how citizens' social concerns react to scenarios 2, 3, and 4 (Figure 22) in which a more natural gas extraction from different resources was assumed to happen in the short-term, approved the way Walker et al. (2008) define a sociotechnical system.

Looking further back to Figure 7, one can trace many perpetuating relationships. For example, C7 affects C10 which itself influences C3, which then C8 is influenced by it and impacts C7. These cyclic interacting concepts clearly show that the agents in the Dutch energy system are impacted by the consequences of their reaction to a stimulus. In other words, the agents learn from their own behavior or adapt themselves to new conditions (Eidelson, 1997; Holland, 1992). In this manner, the Dutch energy system is a perfect example of a CAS with a high degree of compatibility.

5. Conclusion

Perhaps the dominant contributor to anthropogenic climate change has been the excessive use of fossil fuels in the past decades (Höök & Tang, 2013). On the other hand, ruling out fossil fuels may end up in an energy-scarce system (Höök & Tang, 2013). Consequently, the world had to switch to sustainable energy resources. However, in many cases, these shifts have taken a long time due to resource insufficiency and technological innovations (Solomon & Krishna, 2011) as well as the evolving nature of the complex adaptive energy systems (Holland, 1992). Accordingly, the European Commission, trying to shorten the transition time, enacted a controversial delegated regulation by which electricity from natural gas will be labeled a green source of energy as of 2023 (European Commission Delegated Regulation, 2022).

Regardless of how ordinary people reacted under the influence of the media as the base-level agents, almost no academic approach was found to investigate the consequences of this act on a complex adaptive energy system from a national perspective. For instance, how does categorizing natural gas-produced electricity as a green energy resource affect energy transition in The Netherlands?

Looking at the Dutch energy system from a CAS analysis point of view, one can see different actors and system components, "concepts" in FCM terminology, may be affected in different orders. In other words, who and what will be affected the most by this delegated regulation? Accordingly, is it necessary to protect a specific actor by setting complementary regulations to limit the possible damages? Moreover, will this regulation succeed in the phasing out of heavy fuels, or on the other hand, lower carbon costs will crowd out renewable investment and lead the energy system to a more carbon locked-in situation?

The Dutch energy system's reaction to the EU's regulation was proved to match the complex system theory, particularly, due to its evolving nature, it is a perfect example of a complex adaptive system theory. It was shown in **Error! Reference source not found.** that the perpetuating cycles in the Dutch energy system make its agents learn throughout the simulation from their own reactions. Accordingly, Kosko's activation rule with self-memory to infer results can be claimed that returned credible results. Social concerns as a common consequence of the concepts were observed to rise (and drop) to prove that in a complex system, the independent reaction of the agents would form a large-scale shift in socio-economical concepts (Levin, 2002).

Also, multiple bidirectional relationships between the concepts by which concept A influences concept B and vice versa demonstrated that the theory of Svítek (2015) works better than a command-and-control approach in the Dutch energy system. In other words, being decentralized in a non-hierarchical structure, in the Dutch energy system information flows forward and backward. That means, enforcing a regulation, from the government standpoint, will not be an easy top-down order. But, the dynamics of the system may govern how a new rule should be applied. In this manner, the theoretical contribution of this research would be how the government should manage not only new sets of rules and regulations but also any kind of direct manipulation of a certain concept. For instance, setting a target of a carbon-neutral energy supply by the end of 2050 to reduce GHG emissions is not sufficient. Instead, the energy system shall be seen as a complex adaptive system in which some agents might be influenced more than others.

However, the purpose of this study was not to expand the boundaries of these theories, but how these theories are applicable in predicting the collective behavior of the systems' agents. In this regard, it was proved that the responses of the under-investigation system can be elaborated almost flawlessly by employing the CAS theory.

On the other side, the Russia-Ukraine crisis which had not happened at the beginning of this study made chaos in the Dutch energy system. Uprising energy prices, besides the probable energy shortage in the coming winter (as mentioned by interviewees 6 and 10) have totally changed the game, at least in short term. The Dutch governments have to find a way to compensate for the energy shortages in the coming winter. They saw no other way to face the current crisis in the energy system, except to relax the energy and environmental goals they targeted before (Pascoe, 2022), though they could have been proud of themselves due to the almost perfect energy system they have formed.

It was discussed in chapter 4 that if everything had happened as had been happening before the Russia-Ukraine crisis, in a long run (supposedly 15 years), although GHG emissions would have increased, more sustainable resources would have been utilized. In other words, the delegated regulation in The Netherlands could have promoted the energy transition, with minimum burden on the society's concerns, while significantly would have favored both energy providers and consumers (scenario 1). Fortunately, in this scenario, no gas locked-in energy system could have been observed, though interviewees 3, 7, and 9 believed natural gas would have remained for a longer time than had been imagined, especially if the governments had changed their minds about production from Groningen facilities to fulfill the energy demand alongside persuading the smaller natural gas producers to expand their business according to interviewee 10.

It was also revealed that if hopefully, the Russia-Ukraine crisis finishes very soon, the governments will push the pedal to the metal to compensate for the current push back to their goals. Remarkably, it is predicted that they will most probably accomplish their mission with almost the same results as if there is no Russia-Ukraine crisis happened at all. However, there is less hope that the energy prices drop (scenario 5). This will inevitably result in more social dissatisfaction and concerns. Furthermore, as per interviewee 1, despite large companies taking advantage of subsidized energy prices, their final product price will rise which entails more disappointment for the ordinary people. However, large malcontent citizens are hardly expected, mostly because of all the economic growth they will experience. It was proved that the more pressure the government exerts on the energy system to switch to sustainable sources, the happier society they will face. That again means no threat of dwelling too much on the transition period, and consequently, a successful coal phase-out achievement. Still, there are risks in not reaching the targets of GHG emission reduction on time. In addition to the Dutch goals to electrification of energy consumption as much as possible (The Government of the Netherland, n.d.), it is recommended to first, improve or offload the local grid by promoting decentralized wind and solar electricity, and then spread the SDE++ (or other relevant subsidies) scheme to energy-production CCS projects. This indeed catalyzes the CO_2 emission reduction as a result of utilizing natural gas as a substitute source of energy for coal.

Nevertheless, both of the above scenarios can only be taken into account either before or after the current unstable situations, since they are long-term plans and can only be carried out in a safe and stable condition.

From another perspective, the short-term consequences of the regulation were investigated in three different scenarios depending on how the governments will react to the energy shortage in the short run. It was shown that even in a short period of time, and despite the recent promotion to the coal powerplants, the very robust and determined Dutch energy system will successfully phase out coal. However, even a small rise in using coal makes a great impact on GHG emissions (Figure 16 and Figure 17). Furthermore, it is predicted that the government will overcome the threat to energy security, though prices will grow. Fortunately, except for the social concerns, the regulation favors both minor energy consumers and intensive energy-consuming industries. However, this does not necessarily mean satiety of new policies.

Using the FCM Expert to perform the fuzzy calculations, made it possible to analyze the transition path toward the short-term results and understand how different policies impact different concepts/actors. It was evidenced that the key manipulating concept is the production from Groningen facilities. Given that The Netherlands has one of the largest natural gas reservoirs in the world (Dutch Oil and Gas portal, 2022), the possibility of producing natural gas from this field to satisfy the need of the Dutch energy market makes it very persuasive. Subsequently, in all the three short-term scenarios, the key factor is whether the governments keep their pledge and proceed to shut down the facilities at the expense of more GHG emissions or compromise their sayings to, first, pass the current situations safely, and second, become independent from the Russian gas in a longer run. However, during the interviews, it was observed that even talking about the Groningen production is a red line nobody dares to cross.

In this regard, it was revealed that the most conservative policy which supposedly has already been taken (scenario 2) behaves in between the other two. In this policy the tricky production from the Groningen field will have been put aside and to compensate for the consequences, smaller natural gas producers will be encouraged to increase their production. Depending on how fast they react, even in a short-term scenario, the Dutch energy system is predicted to become a net exporter of natural gas. However, the order of magnitude grows drastically if Groningen facilities come into play like in scenarios 2 and 3.

Nevertheless, conceivably the best finding was the reaction of society to the changes in the energy system in both short-term and long-term scenarios. In all the five scenarios a rising peak was observed for social concerns. However, between scenarios 1 and 5, in the latter, the peak value is less than the former. Still, the finest behavior was observed comparing scenarios 2, 3, and 4. Precisely, it is expected to see a much lower social concern rise in scenario 4, though, after approximately 5 years, the results are not much different from one another. Despite strong feelings about the earthquakes in the province of Groningen (Verdoes & Boin, 2021; Vlek, 2019), and the lack of support and compensation mechanism as stated by interviewee 4; this happens because people are concerned about the adverse consequences of substituting natural gas with coal as well as the energy prices and ultimately, dependency on the Russian gas (as mentioned by both interviewees 4, 5, and 6) and the extreme desire to move toward independence.

Seemingly, in the trade-off between using coal-based electricity to compensate for the energy deficit in the short term and removing the cap of production from Groningen, the FCM finds fewer social concerns regarding short negligence of the previous promises at the cost of less air pollution, and more secure energy, even though in the case of more natural gas production, the prices will not drop.

On the whole, contrary to some scholars' skeptical point of view (de Gooyert et al., 2014; Howarth et al., 2011; Stephenson et al., 2012; Szabo, 2022) this study suggests that the energy transition pathway toward utilizing sustainable energy resources, at least in The Netherlands, has been drawn correctly. This means, hopefully, the European Commission's delegated regulation, not only makes no difficulties for the transition but also facilitates it. Therefore, no substantial threat to investment in renewable resources is predicted. Consequently, heavy fuel phase-out is in reach in a long run, while no significant harm is exposed to the actors. In fact, many key stakeholders like the CCS companies or renewable energy producers see opportunities to expand their business. Meanwhile, due to the volatile price of natural gas, no sun can be seen on the horizon of energy prices. However, to manage the current energy crisis in Europe, the Dutch government can think of an optimum scenario.

This proposed scenario comprises a short-run increased production from the Groningen field to fulfill the energy deficit. Gradually, smaller natural gas facilities can take over the responsibility

of supplying the energy system's demand. Afterward, the Groningen facilities can be shut down forever. In the meantime, investment in renewables resource, particularly, hydrogen production which takes a long time to mature, will pay off and the excess natural gas can be exported.

On the positive side, this scenario makes fewer social concerns, according to Figure 22, and will also result in higher economic growth in addition to much less GHG emissions. However, on the negative side, from a pragmatistic standpoint, implementing such a policy is not as easy as it sounds. Yet, like the case of Enqvist et al. (2020) in India, a bottom-up governance approach may facilitate the task. That means, through the different levels of governance in the province of Groningen, people can be introduced to the probable negative consequences of natural gas, or better to say, positive outcomes of a short period of increased production in addition to considering competitive incentives for those at risk. With sets of rigid measures to monitor the conditions, this process can be smoothed.

In closing words, it is worth saying that the European Union's decision to conditionally label natural gas-based electricity will influence renewable energy investors/providers and CCS companies positively while raising the citizens' concerns. However, this regulation will not end in a gas-dependent energy system in The Netherlands. It also helps phase out the coal, and facilitates the transition to sustainable energy resources, with a minor negative impact on society's concerns. On the other hand, due to the well-formed energy system, this act may produce many opportunities for investment in renewables, mostly in hydrogen production, as well as CCS projects. Hence, one can conclude that contrary to what the media has been broadcasting, this particular part of the regulation will contribute much to the energy transition in The Netherlands. However, the Dutch energy system can be optimized to reach its goal in a shorter period. That means, there is still room for applying supportive policies to limit the damage to the citizens, though these suggested policies might sound hard to embrace by the people.

6. References

Abnett, K. (2022). *EU proposes rules to label some gas and nuclear investments as green*. https://www.reuters.com/business/sustainable-business/eu-proposes-rules-label-some-gas-nuclear-investments-green-2022-02-02/

Ameli, N., & Brandt, N. (2015a). *What Impedes Household Investment in Energy Efficiency and Renewable Energy?* https://doi.org/10.1787/5js1j15g2f8n-en

Ameli, N., & Brandt, N. (2015b). Determinants of households' investment in energy efficiency and renewables: Evidence from the OECD survey on household environmental behaviour and attitudes. *Environmental Research Letters*, *10*(4). https://doi.org/10.1088/1748-9326/10/4/044015

Andrew, R. M., & Peters, G. P. (2021). *The Global Carbon Project's fossil CO2 emissions dataset*. https://doi.org/10.5281/ZENODO.5569235

Aravindakshan, S., Krupnik, T. J., Shahrin, S., Tittonell, P., Siddique, K. H. M., Ditzler, L., & Groot, J. C. J. (2021). Socio-cognitive constraints and opportunities for sustainable intensification in South Asia: insights from fuzzy cognitive mapping in coastal Bangladesh. *Environment, Development and Sustainability*, *23*(11), 16588–16616. https://doi.org/10.1007/s10668-021-01342-y

Arent, D., Logan, J., Macknick, J., Boyd, W., Medlock, K., O'Sullivan, F., Edmonds, J., Clarke, L., Huntington, H., Heath, G., Statwick, P., & Bazilian, M. (2015). A review of water and greenhouse gas impacts of unconventional natural gas development in the United States. *MRS Energy & Sustainability*, *2*(1). https://doi.org/10.1557/mre.2015.5

Baron, R., Kaminker, C., Johnstone, N., Marchal, V., Steenblik, R., Youngman, R., Frankl, P., Remme, U., Wrake, M., Baroni, M., Cozzi, L., Hood, C., Varro, L., Baritaud, M., Finon, D., Taylor, M., Stoffer, B., Arvizu, D., Bazilian, M., … Füeg, J.-C. (2013). *Renewable Energy: a Route to Decarbonisation in Peril?*

Bartelet, H., & Mulder, M. (2020). Natural gas markets in the European Union: Testing resilience. *Economics of Energy and Environmental Policy*, *9*(1). https://doi.org/10.5547/2160-5890.8.2.hbar

Battistini, N., di Nino, V., Dossche, M., & Kolndrekaj, A. (2022, March). *Energy prices and private consumption: what are the channels?* ECB Economic Bulletin. https://www.ecb.europa.eu/pub/economic-bulletin/articles/2022/html/ecb.ebart202203_01~f7466627b4.en.html

Becker, G. S. (1983). *QUARTERLY JOURNAL A THEORY OF COMPETITION .AMONG PRESSURE GROUPS FOR POLITICAL INFLUENCE**. http://qje.oxfordjournals.org/

Berk, C., & Cem Berk, A. (2015). The Effect of Natural Gas Imports on GDP from a Financial Perspective: Evidence from Turkey. In *European Journal of Social Sciences* (Vol. 48, Issue 1). http://www.europeanjournalofsocialsciences.com/

Bessi, A., Guidolin, M., & Manfredi, P. (2021). The role of gas on future perspectives of renewable energy diffusion: Bridging technology or lock-in? *Renewable and Sustainable Energy Reviews*, *152*. https://doi.org/10.1016/j.rser.2021.111673

Bhander, G., Wai Lee, C., & Hakos, M. (2019). Perspective analysis of emerging natural gas-based technology options for electricity production. *International Journal of Emerging Electric Power Systems*, *20*(5). https://doi.org/10.1515/ijeeps-2019-0034

Biggs, N., Lloyd, E. K., & Wilson, R. J. (1986). *Graph Theory, 1736-1936*. Oxford University Press.

Boersma, T. (2016, August 4). *The end of Dutch natural gas production as we know it*. https://www.brookings.edu/blog/order-from-chaos/2016/08/04/the-end-of-dutch-natural-gas-production-as-we-know-it/

Boersma, T., & Jordaan, S. M. (2017). Whatever happened to the Golden Age of natural gas? *Energy Transitions*, *1*(2). https://doi.org/10.1007/s41825-017-0005-4

Bogdanov, D., Ram, M., Aghahosseini, A., Gulagi, A., Oyewo, A. S., Child, M., Caldera, U., Sadovskaia, K., Farfan, J., de Souza Noel Simas Barbosa, L., Fasihi, M., Khalili, S., Traber, T., & Breyer, C. (2021). Low-cost renewable electricity as the key driver of the global energy transition towards sustainability. *Energy*, *227*. https://doi.org/10.1016/j.energy.2021.120467

Brown, T., & Reichenberg, L. (2021). Decreasing market value of variable renewables can be avoided by policy action. *Energy Economics*, *100*. https://doi.org/10.1016/j.eneco.2021.105354

Bueno, S., & Salmeron, J. L. (2009). Benchmarking main activation functions in fuzzy cognitive maps. *Expert Systems with Applications*, *36*(3 PART 1), 5221–5229. https://doi.org/10.1016/j.eswa.2008.06.072

Bulavskaya, T., & Reynès, F. (2018). Job creation and economic impact of renewable energy in the Netherlands. *Renewable Energy*, *119*, 528–538. https://doi.org/10.1016/j.renene.2017.09.039

Burnham, A., Han, J., Clark, C. E., Wang, M., Dunn, J. B., & Palou-Rivera, I. (2012). Life-Cycle Greenhouse Gas Emissions of Shale Gas, Natural Gas, Coal, and Petroleum. *Environmental Science & Technology*, *46*(2), 619–627. https://doi.org/10.1021/es201942m

Byström, J., & Bostedt, G. (2019). *Master level thesis 1,15 ECTS The Master program in economics Umeå Universit*.

Carvalho, J. P. (2013). On the semantics and the use of fuzzy cognitive maps and dynamic cognitive maps in social sciences. *Fuzzy Sets and Systems*, *214*, 6–19. https://doi.org/10.1016/j.fss.2011.12.009

CBS. (2021, February 17). *92 procent woningen op aardgas begin 2019*. https://www.cbs.nl/nl-nl/nieuws/2021/07/92-procent-woningen-op-aardgas-begin-2019

CBS. (2022a). *Natural gas consumption 4 percent lower in 2021*. https://www.cbs.nl/en-gb/news/2022/09/natural-gas-consumption-4-percent-lower-in-2021

CBS. (2022b, March 7). *More electricity from renewable sources, less from fossil sources*. https://www.cbs.nl/en-gb/news/2022/10/more-electricity-from-renewable-sources-less-from-fossil-sources

Chan, S. (2002). Introduction. In S. Chan (Ed.), *Liberalism, Democracy and Development* (pp. 1–9). Cambridge University Press. https://doi.org/DOI: 10.1017/CBO9780511491818.001

Colombo, S., el Harrak, M., Sartori, N., Istituto affari internazionali, & OCP Policy Center. (2016). *The future of natural gas : markets and geopolitics*. Lenthe/European Energy Review.

Costello, K. W. (2017). Why natural gas has an uncertain future. *Electricity Journal*, *30*(7), 18–22. https://doi.org/10.1016/j.tej.2017.07.001

de Gooyert, V., Rouwette, A., van Kranenburg, H. L., Freeman, R. E., & van Breen Alliander, H. J. (2014). *Energy Transition Dynamics; Understanding Policy Resistance in the Dutch Energy System*.

de Jouvenel, H. (2000). A Brief Methodological Guide to Scenario Building. *Technological Forecasting and Social Change*, *65*(1), 37–48. https://doi.org/10.1016/S0040-1625(99)00123-7

Dutch News. (2022). Groningen gas should be 'real option' if Russia cuts supplies further. In *Dutch News*. https://www.dutchnews.nl/news/2022/06/groningen-gas-should-be-real-option-if-russia-cuts-supplies-further/

Dutch Oil and Gas portal. (2022). *Groningen gasfield*. https://www.nlog.nl/en/groningen-gasfield

European Commission Delegated Regulation, Pub. L. No. C(2022) 631 / 3, European Commission (2022).

EIA. (2021, November 4). *How much carbon dioxide is produced per kilowatthour of U.S. electricity generation?* Energy Information Administration.

Eidelson, R. J. (1997). Complex Adaptive Systems in the Behavioral and Social Sciences. In *Review of General Psychology: Vol. l* (Issue 1).

Energy Agency, I. (2020). *The Netherlands 2020 - Energy Policy Review*. www.iea.org/t&c/

Energy Report Transition to sustainable energy. (2016).

Enqvist, J. P., Tengö, M., & Bodin, Ö. (2020). Are bottom-up approaches good for promoting social–ecological fit in urban landscapes? *Ambio*, *49*(1), 49–61. https://doi.org/10.1007/s13280-019-01163-4

Fischer, C. (2010). Renewable Portfolio Standards: When Do They Lower Energy Prices? In *Source: The Energy Journal* (Vol. 31, Issue 1). http://www.jstor.orgURL:http://www.jstor.org/stable/41323272

Fleurbaey, M., & Blanchet, D. (2013). *Beyond GDP: Measuring welfare and assessing sustainability*. Oxford University Press.

Foreest, F. van., & Oxford Institute for Energy Studies. (2010). *The role of natural gas in the Dutch energy transition : towards low-carbon electricity supply*. Oxford Institute for Energy Studies.

Foxon, T. J. (2013). Transition pathways for a UK low carbon electricity future. *Energy Policy*, *52*, 10–24. https://doi.org/10.1016/j.enpol.2012.04.001

Fraedrich, E., Beiker, S., & Lenz, B. (2015). Transition pathways to fully automated driving and its implications for the sociotechnical system of automobility. In *European Journal of Futures Research* (Vol. 3, Issue 1). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/s40309-015-0067-8

Gardumi, F. (2017). *Coal: Social, environmental and economic concerns Introductory lecture-Energy commodities and technologies*. http://creativecommons.org/licenses/by/4.0/.

Groningen gas should be 'real option' if Russia cuts supplies further. (2022a, July 7). Dutch News. https://www.dutchnews.nl/news/2022/06/groningen-gas-should-be-real-option-if-russia-cuts-supplies-further/

Guidolin, M., & Alpcan, T. (2019). Transition to sustainable energy generation in Australia: Interplay between coal, gas and renewables. *Renewable Energy*, *139*, 359–367. https://doi.org/10.1016/j.renene.2019.02.045

Gürsan, C., & de Gooyert, V. (2021). The systemic impact of a transition fuel: Does natural gas help or hinder the energy transition? In *Renewable and Sustainable Energy Reviews* (Vol. 138). Elsevier Ltd. https://doi.org/10.1016/j.rser.2020.110552

Harmati, I., Hatwágner, M. F., & Kóczy, L. T. (2021). Global stability of fuzzy cognitive maps. *Neural Computing and Applications*. https://doi.org/10.1007/s00521-021-06742-9

Harris, J. M., & Roach, B. (2016). *ENVIRONMENTAL AND NATURAL RESOURCE ECONOMICS: A CONTEMPORARY APPROACH*.

Hayes, A. (2021, July 4). *Medium Term*. https://www.investopedia.com/terms/m/mediumterm.asp

Hekkert, M. P., Hendriks, F. H. J. F., Faaij, A. P. C., & Neelis, M. L. (2005). Natural gas as an alternative to crude oil in automotive fuel chains well-to-wheel analysis and transition strategy development. *Energy Policy*, *33*(5), 579–594. https://doi.org/10.1016/j.enpol.2003.08.018

Helmers, E., Leitão, J., Tietge, U., & Butler, T. (2019). CO2-equivalent emissions from European passenger vehicles in the years 1995–2015 based on real-world use: Assessing the climate benefit of the European "diesel boom." *Atmospheric Environment*, *198*, 122–132. https://doi.org/10.1016/j.atmosenv.2018.10.039

Hill & Associates, I. (n.d.). *ECONOMIC BENEFITS OF A COAL-FUELED POWER PLANT COMPARED TO NATURAL GAS PREPARED FOR PEABODY ENERGY Economic Benefits of a Coal-Fueled Power Plant Compared to Natural Gas*.

Holland, J. H. (1992). *Complex Adaptive Systems* (Vol. 121, Issue 1).

Holland, J. H. (2006). STUDYING COMPLEX ADAPTIVE SYSTEMS. In *Jrl Syst Sci & Complexity* (Vol. 19).

Höök, M., & Tang, X. (2013). Depletion of fossil fuels and anthropogenic climate change-A review. *Energy Policy*, *52*, 797–809. https://doi.org/10.1016/j.enpol.2012.10.046

Howarth, R. W., Santoro, R., & Ingraffea, A. (2011). Methane and the greenhouse-gas footprint of natural gas from shale formations. In *Climatic Change* (Vol. 106, Issue 4, pp. 679–690). https://doi.org/10.1007/s10584-011-0061-5

Ishwaran, M., King, W., Haigh, M., Lee, T., & Nie, S. (2017). Environmental and Social Value of Natural Gas. In *Advances in Oil and Gas Exploration and Production* (pp. 101–111). Springer. https://doi.org/10.1007/978-3-319-59734-8_4

Jakob, M., Flachsland, C., Christoph Steckel, J., & Urpelainen, J. (2020). Actors, objectives, context: A framework of the political economy of energy and climate policy applied to India, Indonesia, and Vietnam. *Energy Research and Social Science*, *70*. https://doi.org/10.1016/j.erss.2020.101775

Kebede, B. (2014). Rational Choice Theory. In A. C. Michalos (Ed.), *Encyclopedia of Quality of Life and Well-Being Research* (pp. 5401–5403). Springer Netherlands. https://doi.org/10.1007/978-94-007-0753-5_2422

Knittel, C., Metaxoglou, K., & Trindade, A. (2016). Are we fracked? The impact of falling gas prices and the implications for coal-to-gas switching and carbon emissions. *Oxford Review of Economic Policy*, *32*(2), 241–259. https://doi.org/10.1093/oxrep/grw012

Kokkinos, K., Karayannis, V., & Moustakas, K. (2020). Circular bio-economy via energy transition supported by Fuzzy Cognitive Map modeling towards sustainable low-carbon environment. *Science of the Total Environment*, *721*. https://doi.org/10.1016/j.scitotenv.2020.137754

Kosko, B. (1986). Fuzzy cognitive maps. *International Journal of Man-Machine Studies*, *24*(1), 65–75.

Lansing, J. S. (2003). Complex adaptive systems. *Annual Review of Anthropology*, *32*, 183–204. https://doi.org/10.1146/annurev.anthro.32.061002.093440

Leshem, S., & Trafford, V. (2007). Overlooking the conceptual framework. In *Innovations in Education and Teaching International* (Vol. 44, Issue 1, pp. 93–105). https://doi.org/10.1080/14703290601081407

Levin, S. A. (2002). COMPLEX ADAPTIVE SYSTEMS: EXPLORING THE KNOWN, THE UNKNOWN AND THE UNKNOWABLE. In *BULLETIN (New Series) OF THE AMERICAN MATHEMATICAL SOCIETY* (Vol. 40, Issue 1).

Li, J., Song, K., He, X., & Luo, H. (2021). Reliability Evaluation of a Regional Integrated Energy System Based on Complex Network Theory. *Proceedings - 2021 IEEE Sustainable Power and Energy Conference: Energy Transition for Carbon Neutrality, ISPEC 2021*, 840–845. https://doi.org/10.1109/iSPEC53008.2021.9736060

Li, R., & Leung, G. C. K. (2021). The relationship between energy prices, economic growth and renewable energy consumption: Evidence from Europe. *Energy Reports*, *7*, 1712–1719. https://doi.org/10.1016/j.egyr.2021.03.030

Li, R., & Su, M. (2017). The role of natural gas and renewable energy in curbing carbon emission: Case study of the United States. *Sustainability (Switzerland)*, *9*(4). https://doi.org/10.3390/su9040600

Liu, Z., Ciais, P., Deng, Z., Lei, R., Davis, S. J., Feng, S., Zheng, B., Cui, D., Dou, X., Zhu, B., Guo, R., Ke, P., Sun, T., Lu, C., He, P., Wang, Y., Yue, X., Wang, Y., Lei, Y., … Schellnhuber, H. J. (2020). Author Correction: Near-real-time monitoring of global CO2 emissions reveals the effects of the COVID-19 pandemic. *Nature Communications*, *11*(1), 6292. https://doi.org/10.1038/s41467-020-20254-5

Mitchell, M., & Newman, M. (2001). *Complex systems theory and evolution*.

Nair, A., Reckien, D., & van Maarseveen, M. F. A. M. (2019). A generalised fuzzy cognitive mapping approach for modelling complex systems. *Applied Soft Computing Journal*, *84*. https://doi.org/10.1016/j.asoc.2019.105754

NAM. (2022a). *English information*. https://www.nam.nl/english-information.html

NAM. (2022b). *NAM-Missie en visie*. https://www.nam.nl/over-nam/missie-en-visie.html

Nápoles, G., Espinosa, M. L., Grau, I., & Vanhoof, K. (2018). FCM Expert: Software Tool for Scenario Analysis and Pattern Classification Based on Fuzzy Cognitive Maps. *International Journal on Artificial Intelligence Tools*, *27*(7). https://doi.org/10.1142/S0218213018600102

Naqvi, S., Wang, J., & Ali, R. (2022). Towards a green economy in Europe: does renewable energy production has asymmetric effects on unemployment? *Environmental Science and Pollution Research*, *29*(13), 18832–18839. https://doi.org/10.1007/s11356-021-17093-2

NOS. (2019, December 23). *Hemweg power station officially closed, four coal-fired power stations left*.

ONE-Dyas. (2021). *ONE-Dyas-Press release Draft decision for gas extraction from field N05-A now available for inspection*. www.gemsnoordzee.com

Organisation for Economic Co-operation and Development. (1998). *A SATELLITE VIEW OF TAXES AND SUBSIDIES*.

Özesmi, U., & Özesmi, S. L. (2004). Ecological models based on people's knowledge: A multi-step fuzzy cognitive mapping approach. *Ecological Modelling*, *176*(1–2), 43–64. https://doi.org/10.1016/j.ecolmodel.2003.10.027

Park, K. S., & Kim, S. H. (1995). Fuzzy cognitive maps considering time relationships. *International Journal of Human-Computer Studies*, *42*(2), 157–168. https://doi.org/10.1006/ijhc.1995.1007

Pascoe, R. (2022, June 20). *Dutch to boost coal-fired electricity production to save gas*. https://www.dutchnews.nl/news/2022/06/dutch-to-boost-coal-fired-electricity-production-to-save-gas/

Peelen, J. J., Bevers, J., & de Booij, T. (2020, November 26). *The proposed Dutch carbon tax in short*. https://www.dentons.com/en/insights/alerts/2020/november/26/the-dutch-carbon-emission-tax#:~:text=The%20carbon%20price%20to%20be%20paid&text=A%20price%20of%20%E2%82%AC30,carbon%20rate%20of%20that%20year.

Piekut, M. (2021). The consumption of renewable energy sources (Res) by the european union households between 2004 and 2019. *Energies*, *14*(17). https://doi.org/10.3390/en14175560

Prasad, Bhanu. (2008). *Soft computing applications in business*. Springer.

Quackenbush, S. (2004). The Rationality of Rational Choice Theory. *International Interactions*, *30*(2), 87–107. https://doi.org/10.1080/03050620490462595

Riahi, K., van Vuuren, D. P., Kriegler, E., Edmonds, J., O'Neill, B. C., Fujimori, S., Bauer, N., Calvin, K., Dellink, R., Fricko, O., Lutz, W., Popp, A., Cuaresma, J. C., KC, S., Leimbach, M., Jiang, L., Kram, T., Rao, S., Emmerling, J., … Tavoni, M. (2017). The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. *Global Environmental Change*, *42*, 153–168. https://doi.org/10.1016/j.gloenvcha.2016.05.009

Rosen, M. A., & Koohi-Fayegh, S. (2016). The prospects for hydrogen as an energy carrier: an overview of hydrogen energy and hydrogen energy systems. In *Energy, Ecology and Environment* (Vol. 1, Issue 1, pp. 10–29). Joint Center on Global Change and Earth System Science of the University of Maryland and Beijing Normal University. https://doi.org/10.1007/s40974-016-0005-z

RVO. (n.d.). *Sustainable energy transition subsidy scheme (SDE++)*. Retrieved June 21, 2022, from https://business.gov.nl/subsidy/sustainable-energy-production/

RWE. (2022a). *Biomass and the energy transition*. https://benelux.rwe.com/en/innovation-and-future/biomass

RWE. (2022b). *Projects*. https://benelux.rwe.com/en/projects/?country=Netherlands&destination=Projects%20in%20development&ppaStatus=*&target=*

Safari, A., Das, N., Langhelle, O., Roy, J., & Assadi, M. (2019). Natural gas: A transition fuel for sustainable energy system transformation? *Energy Science and Engineering*, *7*(4), 1075–1094. https://doi.org/10.1002/ese3.380

Sakamoto, S., Nagai, Y., Sugiyama, M., Fujimori, S., Kato, E., Komiyama, R., Matsuo, Y., Oshiro, K., & Silva Herran, D. (2021). Demand-side decarbonization and electrification: EMF 35 JMIP study. *Sustainability Science*, *16*(2), 395–410. https://doi.org/10.1007/s11625-021-00935-w

Scheepers, M., Palacios, S. G., Jegu, E., Nogueira, L. P., Rutten, L., van Stralen, J., Smekens, K., West, K., & van der Zwaan, B. (2022). Towards a climate-neutral energy system in the

Netherlands. *Renewable and Sustainable Energy Reviews*, *158*. https://doi.org/10.1016/j.rser.2022.112097

SDG 7. (n.d.). The United Nations. Retrieved March 29, 2022, from https://www.un.org/sustainabledevelopment/energy/

Sgaravatti, G., Tagliapietra, S., & Zachmann, G. (2022, June 13). *National policies to shield consumers from rising energy prices*. BRUEGEL DATASETS. https://www.bruegel.org/publications/datasets/national-policies-to-shield-consumers-from-rising-energy-prices/

Sheridan, T. B. (1988). Trustworthiness of Command and Control Systems. *IFAC Proceedings Volumes*, *21*(5), 427–431. https://doi.org/10.1016/S1474-6670(17)53945-2

Solomon, B. D., & Krishna, K. (2011). The coming sustainable energy transition: History, strategies, and outlook. *Energy Policy*, *39*(11), 7422–7431. https://doi.org/10.1016/j.enpol.2011.09.009

Stephenson, E., Doukas, A., & Shaw, K. (2012). "Greenwashing gas: Might a 'transition fuel' label legitimize carbon-intensive natural gas development?" *Energy Policy*, *46*, 452–459. https://doi.org/10.1016/j.enpol.2012.04.010

Stern, N. (2006). *Stern Review: The economics of climate change*.

Stigka, E. K., Paravantis, J. A., & Mihalakakou, G. K. (2014). Social acceptance of renewable energy sources: A review of contingent valuation applications. In *Renewable and Sustainable Energy Reviews* (Vol. 32, pp. 100–106). Elsevier Ltd. https://doi.org/10.1016/j.rser.2013.12.026

Svítek, M. (2015). Towards complex system theory. *Neural Network World*, *25*(1), 5–33. https://doi.org/10.14311/NNW.2015.25.001

Sweeney, S. (2018). The Energy Revolution Will Not Be Subsidized. *New Labor Forum*, *27*(3), 77–82. https://doi.org/10.1177/1095796018789907

Szabo, J. (2022). Energy transition or transformation? Power and politics in the European natural gas industry's trasformismo. *Energy Research and Social Science*, *84*. https://doi.org/10.1016/j.erss.2021.102391

Szustak, G., Dabrowski, P., Gradoń, W., & Szewczyk, Ł. (2022). The relationship between energy production and gdp: Evidence from selected european economies. *Energies*, *15*(1). https://doi.org/10.3390/en15010050

TEG. (2020). *Updated methodology & Updated Technical Screening Criteria*.

The European Green Deal, European Commission (2019).

The Government of the Netherland. (n.d.). *Dutch goals within the EU*. Retrieved April 4, 2022, from https://www.government.nl/topics/climate-change/eu-policy

The Government of the Netherlands. (n.d.). *The future of fossil fuels*. Retrieved April 4, 2022, from https://www.government.nl/topics/renewable-energy/the-future-of-fossil-fuels

Paris Agreement, United Nations (2015).

Unruh, G. C. (2000). *Understanding carbon lock-in*.

van Berkel, D. (2019). *THE URGENDA CLIMATE CASE AGAINST THE DUTCH GOVERNMENT*. https://www.urgenda.nl/en/themas/climate-case/

van der Kam, M. J., Meelen, A. A. H., van Sark, W. G. J. H. M., & Alkemade, F. (2018). Diffusion of solar photovoltaic systems and electric vehicles among Dutch consumers: Implications for the energy transition. *Energy Research and Social Science*, *46*, 68–85. https://doi.org/10.1016/j.erss.2018.06.003

van der Linde, C. (2015). *Transition? What Transition? And Why Energy per Carbon Matters*.

Venable, J. R. (2006). *The Role of Theory and Theorising in Design Science Research*.

Verdoes, A., & Boin, A. (2021). Earthquakes in Groningen: Organized Suppression of a Creeping Crisis. In *Understanding the Creeping Crisis* (pp. 149–164). Springer International Publishing. https://doi.org/10.1007/978-3-030-70692-0_9

Vlek, C. (2019). Rise and reduction of induced earthquakes in the Groningen gas field, 1991–2018: statistical trends, social impacts, and policy change. *Environmental Earth Sciences*, *78*(3). https://doi.org/10.1007/s12665-019-8051-4

Walker, G. (2015). Come back sociotechnical systems theory, all is forgiven …. *Civil Engineering and Environmental Systems*, *32*, 170–179. https://doi.org/10.1080/10286608.2015.1024112

Walker, G. H., Stanton, N. A., Salmon, P. M., & Jenkins, D. P. (2008). A review of sociotechnical systems theory: A classic concept for new command and control paradigms. *Theoretical Issues in Ergonomics Science*, *9*(6), 479–499. https://doi.org/10.1080/14639220701635470

Whitney, K., Bradley, J. M., Baugh, D. E., Chesterman Jr, C. W., & Jr, C. (2015). Systems theory as a foundation for governance of complex systems. In *Int. J. System of Systems Engineering* (Vol. 6, Issue 2).

Wilson, I. A. G., & Staffell, I. (2018). Rapid fuel switching from coal to natural gas through effective carbon pricing. *Nature Energy*, *3*(5), 365–372. https://doi.org/10.1038/s41560-018-0109-0

Worldometers. (2016). *Coal Production in the Netherlands*. https://www.worldometers.info/coal/netherlands-coal/#:~:text=in%20the%20world.-,Coal%20Imports,(16%2C442%2C056%20tons%20in%202016).

Zhang, X., Myhrvold, N. P., Hausfather, Z., & Caldeira, K. (2016). Climate benefits of natural gas as a bridge fuel and potential delay of near-zero energy systems. *Applied Energy*, *167*, 317–322. https://doi.org/10.1016/j.apenergy.2015.10.016

7. Appendix 1 (Interview Transcripts)

Interview No.	**1**
Date:	**20-May-2022**
Duration:	**32' 32"**
Interviewee affiliation:	**Green hydrogen expert**

Interviewer:
To begin with, let me have a very short introduction. My name is Arash Kamali. You know I'm a student of University of Twente, the MEEM program, environmental and energy management.

Interviewee:
Yeah.

Interviewer:
As my thesis, I'm working on this recent delegation act of the European Commission which conditionally approved or labeled natural gas-based electricity green. Well, we know that it has been a long time talking about natural gas as a transitional fuel, but this act, I believe may you know shift something or actually tilt the balance in some ways. So, I would like to understand it ['s effects] better. I would like to have a better understanding about this. It's impacts on the energy transition in general and some specific question which is going to come in a couple of minutes. So, to begin with, I would like to have your general overview about this act. I mean, what do you think is the consequence of this act in a specific?

Interviewee:
Yeah, yeah, yeah. So maybe. And I shortly introduce myself. So, I'm leading the green hydrogen program within TNO of main, made it on the green hydrogen. And if you see in Europe, I mean currently there's no green hydrogen production Intel top. So, after actually the Netherlands is after Germany, the biggest grey hydrogen producer. So, I mean let's produce around rough numbers like 1.7 million tons of grey hydrogen with that's caused a big, big emission and this height is produced mainly by natural grass. And obviously they need to be changed quickly. And we need regulation and we need the whole set of regulations. And especially for hydrogen an important regulation, is the fit for 55. Do you know? Published also report on that.

Interviewer:
No.

Interviewee:
And that's basically saying that 50% of the hydrogen being used needs to be green. I mean that's the proposal of the Commission.

Interviewer:
Yes.

Interviewee:
Yeah, and that's an absolute number. So, it's like in percentages. And so, as a big consequence for Germany, Netherlands, because we are so big producer of this grey hydrogen. So, if you go

to 50% it's cost that we need to have 8 or maybe 12 GW of electrolyzer production in order to build the current demands.

Interviewer:
Yes.

Interviewee:
So, that's one group of people. Say that's just a big in bills for the whole green hydrogen development and other group is saying, yeah, that's too much. We need to go to blue route. So, the carbon capture and storage.

Interviewer:
Yes.

Interviewee:
But for both you can make a story, but that's why you also the Dutch Parliament set from to the European Union. We don't want an absolute, no, we don't want the person to know more but more an absolute number on this hydrogen. There I know a lot of. On the […] I'm. I'm not really the expert because I'm a bit of a so. So, if you can maybe put your questions a bit more in a broader perspective than can I, I don't know. I'm not reading all the text so that's so you need to give a bit of more like broader than yeah.

Interviewer:
OK. Yeah. So as far as I mean up to now, I understand that, OK, for producing green hydrogen, we need huge amount of electricity and this electricity should actually produce should be produced somewhere. You know if we are lucky from big solar panels and so on. And if we are not, it should be actually made of natural gas. OK we have this act which actually labels this kind of electricity green.

Interviewee:
True, yeah.

Interviewer:
I mean natural gas based conditionally, of course green and OK, so in this way, how do you see the hydrogen specifically? Being promoted or even hinders? I mean, production of hydrogen through this? I mean by considering this act being enforced by the end of this year.

Interviewee:
Yeah. Yeah. I mean one big thing. Yeah. You know, I think in the that's in that they're delegated act especially for hydrogen is that there need to be exploration between green hydrogen production and additional renewable electricity. Geographic connection. So, this to renewable, so she needs to be nearby an ideal production. And so, at time coloration. So, when there is wind electricity produced, it need to be connected to the hydrogen production in in over 50 minutes. I mean that's and if you I don't know what will be in the final like text but I mean that's makes sense because.

Interviewer:
Production plants.

Interviewer:
Yes. Hydrogen on the shelf behind you is not the goal, it's more a mean student. It's a means to

decarbonize. It's a means to. All these kinds of things. So, if you ask me, it's I think it's a good direction that there will be a law that green hydrogen need to be at. Yeah. Directly. Like these three things so. Yeah, geographic connection. Extra renewables need to be in place and that time correction. So that's I think that's, the really good argument because it's really. You're helping that this green line is really additional to just renewable exists and it just stimulates that we use electricity. The arguments for it not having this direct link is that the business case will become less interesting because you can run your electrolyzer if you put it offshore only for 4000 hours. And you buy such a pricing machine. It's cost millions for a megawatt. You want to run, run it continuously and from a business aspect I understand that because you want to produce all the time but then you basically producing hydrogen based on the mix of your electricity. Yeah, the first obviously the country, but that's not so. So, I'm saying there's a transition period. So, I mean we know we have to mix but say with heat pumps or with others we just use it because it's we need to make the whole change renewable. So, we need to heat pumps, it's for houses. I mean it's good to have heat pump and that it's not running on electricity here, but I've got solar panel. So, it's organized on helpful. So, I mean so we see the same situation in in different application let's say, but I think there is a big difference because he prompts for houses that's not professional. These hide action will be deployed by professional organizations and they can really tweak make it happen, but the downside is that what we [need is] there will be probably the more subsidies or more. In order to get this first project happen, so that's a bit of the balance where we in. And what I know on your and now thinking on your first question, I thought for producing electricity by gas? I thought there was, like a gap on the CO2 emissions per kilowatt hours. And there is also a mandate, but that was a draft text on capturing the CO2 at.

Interviewer:
Exactly, exactly. That was, you know, actually one of my other questions that well, well, we can guess that GHG emissions would increase as a result of this let's say, act, you know, promoting natural gas based electricity but how do you see? How do you see the problem in this way that for example, by enforcing this act, you know most of the coal burning power plants could be phased out? I mean, because natural gas would be, you know, much cheaper to say or let's say, we did some kind of subsidies, they can have the access to this natural gas and then little by little would, you know, fade it out? And yes, it might in a way contribute to at least GHG emission. Do you see this happening? I mean, are you optimistic to something like this or not? Or you would say something quite different?

Interviewee:
Yeah. I think there will be a number of instruments to face that goal. I mean, if you look at the deadlines, I mean, we have our own targets. So, we've got our emissions targets. So, we say no, now the coal fired power plants need to be phased out to certain date. And I think it's a national decision. And there is also. Now only to coal powerplants they can run on. I think it was 30% of their capacity because of that to admission. So that's national policy to limit the use of coal and obviously Germany and other. All the policies, so that's more the national policies to face as call.

And if you, I mean yet in the energy market it's an open market. So, I mean we have got issue to price which is now at €90.00 button which probably will go higher if we reduce this you to GHG emission. First, then we have got the gas, we've got renewables at the end, all these electricity will compete with each other. So that's the how market will be and then the call will

compete with gas. So that's, that's the market system. But I think from Europe would definitely need to also have strong regulations to indeed phase out this coal and phase out this gas in a future phase out, like basically all fossil fuel energy sources, I think. But the biggest one of the biggest questions is how can we ensure that we have? That's the important one because we, I mean the in the end we will have huge amount of renewable electricity, offshore winds or onshore solar and we have a huge negative electricity price. So, we need that dispatchable power and that's going to be interconnection with all the countries that can be batteries that can be electric boilers that can be green hydrogen which go on and off when there is availability. But that's really important to have that. But also, when there is no solar and winters, we need to have something to generate this electricity that can be a future with hydrogen storage and use it. Also, hydrogen generators. But there will be a period that we still need to use this gas fired power plants too.

Interviewer:
Exactly.

Interviewee:
Yeah, it's all about timing. So, that's the they think challenge, yeah.

Interviewer:
So may I say that you think that in this way? Maybe if the market is free as it is, or leave free as it is, well, investment might outflow from renewable to, you know, other fossil fuels for example, because they may be much cheaper, they may be much easier accessible and so on.

Interviewee:
There's a there's a there's a really good question. I think to shorten extent, they're like companies really focusing on renewables. So put the company like […] developing wind parks and they will see that they are exposed to the price market. So, they come and develop hydrogen. So, they not, I don't think they're going to go in natural gas. So, there's certain companies really choose that direction. They're also a lot of company's worth assets. So, there's asset in BMS fired and they probably want to use these assets as long as possible. So, they can treat them to lower their emissions, to have CCS [assets]. And yeah, obviously they come and compete with. That their money is competing with renewable projects. So yeah, that's day will play the game within the the field which the operation is defining at the moment.

Interviewer:
Yeah, I can understand that.

Interviewee:
Yeah, to say it's if it's. Yeah, I mean obviously it's complicated, but there. But then there is a need because I mean if there is no electricity, I mean there isn't certain security of supply and that's where this is all about let's say.

Interviewer:

Yes. And talking about this, I mean, specific area, can you say or name, any specific policy which comes to your mind?

Interviewer:
Maybe, for example, from government side that helps you know, this transition from possible

fields specific to gas actually happens as soon as possible, and it, you know, supporting policies. To get rid of this gas you mean?

Interviewer:
Yes, because you know, some say, this specific act may promote use of natural gas, you know, may, let the natural gas be more conventional, but we need a policy from government to cap this gas consumption maybe, I don't know. Or, we need some supportive policies actually to not to dwell on this transition time period, yeah, very much.

Interviewee:
Yeah. I mean, they're the obviously number of policies, for example one. Yeah, I mean basically if you look at industry, I mean gas, use in, in industries much cheaper than gas use in at housing, the greenhouses sector in the Netherlands, I mean their gas is also much cheaper because I mean its less stacks.

Interviewer:
That may I may interrupt just a second. You know, because you are working on the hydrogen and specifically on green hydrogen. Let's have a comparison between, you know, how government can facilitate using a great. I mean, sorry, green hydrogen. Instead of using grey hydrogen or in the worst-case natural gas as a source of energy.

Interviewee:
Yeah. How can the government facilitate that? Yeah.

Interviewer:
Yes, exactly.

Interviewee:
Yeah, I mean I think the best way to facilitate that just to put a mandate if you ask me mandates on the using so. For example, in fuels and also in aviation, there's now they put them in the fuels in your car 2.5% or something like that needs to be green and it can be all biofuels, or it can be hydrogen. Aviation, they will do the same. So, then you really stimulate the market. So not with subsidies, not with, but just if you supply you make sure that this person amounts needs to be green and then you actually stimulate. And I think that's most cost effective and get also clarity to the market. There is an off take for this green product. I think that's the I think that's a really an efficient way doing that. And obviously I mean the best way you know it's like you to pricing. So, get rid of all the free targets free and in and that's last weekend and the European Commission is a great one that of European Parliament that yeah, the also the scope of the ATS is growing from to build environment mobility. So that's I think a good one.

Interviewer:
Yes.

Interviewee:
Yeah, and for hydrogen, I mean, obviously there is now many policies coming in place there. All countries have targets going to bigger watts scale so yeah.

Interviewer:
And let me ask another question, if you don't mind. Regarding the hydrogen market, I mean hydrogen as a source of energy, do you see it can promote any economic indicator actually for example? Maybe unemployment rate or something like this. For example, if we have a specific

market for it, so we might have you know, some guys employed in that market or work in that market. So, I don't know, maybe in some ways.

Interviewee:
Yeah. we can, we can. Let's say, say some examples about something. The characters, I mean kind of make indicators, which might be, you know, shifted or tilted. You mean that people lose jobs in fossils and going to renewables?

Interviewer:
If for example or, actually you know not exactly losing the jobs in fossil markets, but producing something new or creating something new.

Interviewee:
How getting something new? Yeah. First, I would put the other way around. There will be probably a big shift in industry in Europe because I mean the gas prices won't be as low as we have them. So, there will be a shift from fertilizer companies. They will probably now have on the table. Will I stay in the Netherlands or will I stay in Europe or what should I move to areas somewhere else? And hopefully they say not somewhere the first green gas, but somewhere else where it's green renewables and they can make the production more renewables. But question why are they sitting in the Netherlands for example, they were coming here because we have cheap natural gas, natural gas is they're not anymore. I mean they could stay there if we have good lot of renewables, a lot of hydrogen. But I mean there are plans but not there yet and they'll be they're coming five years and can they wait so long. So that's a big question saying with that are still there from and they need to green but a lot of pressure. Small, near the city. Not the renewal and energy. Enough employment. So, they're all different regions, right. And insurgency stays here or not. So that one side that can move more towards where that is this today where is short and supply change, where is the really demands now what's the demand for fertilizers in Europe? I don't know, go hard, but I can imagine that they're more demand. For example, Dairy farming and anything so there. So that's one thing. But obviously there will be new business. I mean we working at you know with technology development, creating new technologies and we can export these technologies. If you ask me now, it's still like really small. But I mean it can become as it should because like an NL, had it really, really, really offended technology manufacturing with the whole high-tech industry. So that's obviously a vision which is now on the table. But the question is, is the, I mean we're probably not only one having that.

Interviewer:
Yeah, it's, I know.

Interviewee:
I mean, every country wants to be the top in the world and top in the world, I mean. I think at SDG you know we are quite good. I think we are two, five in electrolytes or research. So, I mean looking at the numbers, we are there, but I mean looking at the industry, I mean Germany is much farther with companies like […] and a decent group and all these big were so they. So, we can't do it alone and deadlines. But I think in Northwest Europe we can have a technology leadership position and not wait for China. Taking that over and producing all this technology with also which they are really good at, but also now we see some drawbacks, I think material. So, show social circle circumstance where people work in all these kinds of things. So, we can do that better in Europe if we have stronger regulations, yeah.

Interviewer:
OK. And you mentioned this problem that those kinds of companies. Do you think hydrogen would be common in heavy energy consumers section, for example, steel companies? I don't know. Maybe some refineries or you know? Because, you know, they did. They might be reluctant to using hydrogen specifically.

Interviewee:
I mean the they have a need for decarbonize. So, I mean, if they need you, I mean if they can use electricity directly. I mean depending what's available and what's best for the process. I think there's a big willingness using this hydrogen because it's for a lot of companies quite easy to integrate it in the process.

Interviewer:
But in comparison with natural gas, how do you see this?

Interviewee:
I yeah. I mean, in the end, it's all about pricing. I mean, natural gas, I mean, if you know the business case, you know much more attractive. I mean, yeah, much more traffic. I mean also the hydrogen will be higher price because if you use it, blue hydrogen is also based on natural gas. So that's not very big difference, but for electricity. Yeah, I mean it's more attractive to go to hydrogen in the end so. But yeah, it's not there yet. So that's the issue at the moment. But if you ask me from if you're going to really invest billions in in Europe to import liquefied natural gas from somewhere else or are we going to use green hydrogen in Europe ourselves or you going to import this green hydrogen somewhere else? So, I think that's a good way to, yeah. To not have the connect 15 years bound to this liquefied network as you can import all over the world.

Interviewer:
Exactly. I think we are going to the closing section. So, I kind of asked my questions you know. But you know, I had a lot. But I tried to keep it short. Do you think hydrogen would be as much conventional and popular in households in, you know, near future or no, you're aiming for large industries?

Interviewee:
Yeah. I mean at the moment the, standpoint is using of hydrogen in households the coming decades. It doesn't make any sense. I mean, because there's no hydrogen at the moment because there are many alternatives, heat perms, heat networks. You need 20 degrees. I mean, why are we going to use hydrogen? Where does you can have much, much more extra value in industry for example. So, the only reason why we were using gas at the moment because it is so much available, I mean that's not the case at the moment because we have no hydrogen available. So yeah, I mean we are quite a, yeah, we're not doing any effort on that. I mean it's good to experiment that obviously they will be some areas where we have hydrogen in analysis. But at least in the Netherlands, not that big, no.

Interviewer:
OK. Thank you. Thank you for your time. I don't want to take your time more than this. If you want to say anything, I'm here to listen. Otherwise, I just have to finish this interview. Thank you for your time again.

Interviewee:
Yeah. So nice ring it. And I mean a good short questions. I think we need it. So go for it, yeah.

Interviewer:
Yeah. Thank you.

Interviewee:
Alright. Cheers and good luck.

Interviewer:
Thank you. Have a good day. Bye.

Interview No. **2**
Date: **24-May-2022**
Duration: **21' 02"**
Interviewee affiliation: **Business development agent at an energy producing company**

Interviewer:
OK, so let's get to business as soon as possible. I don't know if you know there's a delegation act in the European Commission that conditionally label natural gas or let's say electricity from natural gas, green. So, I just wanted to investigate on this specific act and whether it's going to promote or hinders the energy transition and so on. So, for the first question, I would like to have your opinion about these, the consequences of these acts in general, how do you see it in general?

Interviewee:
I have to say when I came out, I didn't really understand why suddenly I think it's a political thing, I think. That's probably more to do with, you know, the whole political situation in the Russia conflict then than anything else. But like I say, I mean I'm looking at the delegated act from about hydrogen that came out on Friday night last week. Do you know about this one?

Interviewer:
Unfortunately I'm not that up to date.

Interviewee:
OK, so that's the one. I'm really that I need to know about. That's a basically about how you can produce hydrogen. What qualifies green hydrogen to be renewable? So, and that's connected to being connected to an offshore wind park. Temporal additionality, all these different criteria. And I have to that's what I was a bit afraid that I won't be able to answer so many of your questions because I heard very vaguely about this green approached to gas.

Interviewer:
Yes.

Interviewee:
But I don't read about it. It's not part of my work at the moment, so. I find it difficult to say in general what that is going to mean. I would imagine that the. The gas will be some be used a lot more will be a lot more in demand, right? As you can qualify it as green. And that might have implications on the on how you can do the ETS. For example, the emissions trading scheme, whether that gets affected by it. But I really speculating, I'm sorry.

Interviewer:
No, no, it's OK. It's OK. I understand. I would like to know; you know because when we called the big source for producing electricity green. So, it might be it might become more let's say accessible for many electricity producers in the Netherlands specifically to have access to natural gas actually. And, how do you see the affordability or reliability of energy in total? You know, because in the Netherlands the government actually emphasized on producing more electricity, whether from renewable or in this specific case, from natural gas. Do you think it is going to promote the affordability, reliability or it will go the other way around?

Interviewee:
I don't think that'll have much impact on the on the pricing or on the affordability as I think the amount of gas coming gas reservoir either way has to be taken out of the ground as we process put into electricity plant. There might be some downstream effects like us talking about you might be able to have slightly higher willingness to pay for the gas or you can put the gas price up. But I think the basic fundamentals are that the gas is very expensive at the moment. It's not great to be able to use gas to burn gas at this point, when you can do it with coal, for example, or are the cheaper commodities. So I'm not sure how much effect this delegated act will have on the fundamentals of the of the actual market. I think like I said, maybe the downstream side a bit more in terms of, yeah, selling your electricity as green. I think there might be some traders who are willing to do that, but I don't know.

Interviewer:
Yeah. OK. So, you kind of actually pointed out one of the other questions of mine, which is how do you see, you know this helps phasing out heavy fuels, for example, coal in specific you know, because natural gas, we know that it is if we can call it a little bit greener than cold and let's say less grey or less black than coal. So, do you think this act will help them? Help coal burning facilities to take advantage of this act?

Interviewee:
Yeah, exactly. I'm not sure again if it's a little bit same reasoning as I had before. How much impact is this act have on the fundamentals of when you burn coal or when you burn gas? I'm not too sure if it has that much of an impact on it, because if you're burning coal for electricity. Yeah, like you said, it's not. It's black. It's not good. You're not going to get you credits. You're going to pay for those credits on the market if you burning gas? You, you're already being slightly more secure. I think the effect will be little, but it would definitely be towards burning more gas than coal.

Interviewer:
OK. So, in this case, your skeptical about investment outflow from renewable, or renewable might be vulnerable?

Interviewee:
What did not crowd out like proper renewable investment like in wind and solar? If you label gas green that it sorts of dive, you then draw the invest away from proper renewables because you know people are already in gas, large companies like […] as opposed can just burn that instead. […] is investing in not all of the renewables that are, so this act does not affect will not alter their strategy in any way. Because, you know, we want to get away from gas and reliance and security supply issues.

Interviewer:
So if I may say, you think that's one way or the other, it will not end up with natural gas dependency as I can understand.

Interviewee:
No, I mean, I think we want to get away from natural gas dependency, right? Yeah.

Interviewer:
OK. Thank you very much. So let me go to the specific questions. Yeah, I know that you're not

talking on behalf of your company, but in your mind, I would like to know, if you have a plan to take advantage of this act in specific?

Interviewee:
I would say no, not that I've heard of. I can answer that very quickly, yeah.

Interviewer:
OK. And do you think […] specifically will be affected by this act.

Interviewee:
I think our, I know the right person to answer that, but I think the portfolio then we have a large gas portfolio. So, we make a lot of electricity with our CCGT. If that's suddenly becomes a green way, producing gas producing electricity. Maybe that has some positive effects on our business. I on the you know that we can sell it at a premium. I'm not sure, I'm not sure.

Interviewer:
OK, so do you know anything about any kind of subsidies which might be applied to your business?

Interviewee:
Interesting. Yeah. I mean, that's the other reason you can say what was get more subsidies on board. I don't think we're doing that. It would, I really don't think we're going to be as far as I'm aware of. […] wouldn't do those kinds of things.

Interviewer:
OK. Thank you. So, I can imagine that […] has already decided to move away from natural gas and you know it's not going to be that.

Interviewee:
Yeah. We're looking at decarbonizing our natural gas turbines. Yeah, yeah. With hydrogen, for example, yeah.

Interviewer:
Yes, I've already seen some plants, you know, actually doing a mixture and then you know little by little completely substitute and natural gas with hydrogen.

Interviewee:
Yeah.

Interviewer:
Let's assume that you know. Unlike what you said about that, this act might, uh have any effect on the, you know, let's say renewable market, if you were a politician or let's say the government part, what kind of policies would you have? I mean, could you think of a way to reduce the bad sides or say alleviate the bad effects of this act? I don't know, like, maybe the carbon pricing, you know, put the limit. I mean, put a cap.

Interviewee:
Yeah. Like I was talking about the ETS. What have become a lot easier to than, you know, flood the market with green certificates, so then indeed lowering the cap or would make sense to alleviate that, but I'm not. I'm not a policymaker. And you took the words out of my mouth.

Interviewer:
Yes, I can understand. Yeah. And do you think of or can you think of any other stakeholders might be affected according to this act rather than renewable energy suppliers?

Interviewee:
Yeah. Well, like I said, I find it quite weird that you can label gas green. Although I'm quite progressed before the Russian situation, but I think gas is fine like compared to coal, but labeling it green does affect stakeholders like you know, like these renewable power, small power companies that are starting up, maybe starting up their own renewable power projects. And then have to compete with gas, which might be, a lot easier for large company to start up and running so I guess. I think the households right in Holland, like they're all burning gas for their, for their heating. Is it suddenly? Does that mean that we're green? You know, we can sell our house, our late energy label gets better because we have CO2, less CO2 emissions because it's a green gas.

Interviewer:
Maybe.

Interviewee:
Yeah, I think everyone gets affected in the value chain.

OK. I can imagine. Yeah, of course. So, I would say, you know the other question. Let's go to the other question and I think I'm already done with it, I guess. Do you see any economic indicators which might be affected, I mean, in total, in your opinion, maybe unemployment rate or something like GDP per capita or something?

Interviewee:
Yeah, I would. Again, the impact I think would be quite small on GDP and stuff like that from such as an act. Maybe not, maybe. Yeah, I'm just trying to think of the Groningen, if that's suddenly green and you could start mining that and then you can you can probably increase the economic benefits there and burning them. Yeah, I just don't know what the impact of that act is in terms of economics.

Interviewer:
OK, so you mean, the government is still lagging behind of these, you know, acts. Maybe they need more time to know what it is and let's say decide on what should they do on result of it.

Interviewee:
Yeah. When was this act published?

Interviewer:
Actually they decided upon on 2nd of February this year. But it's going to be enforced at the end of this year. I mean the 1st of January 2023.

Interviewee:
There's this sort of made and published before the Ukrainian situation.

Interviewer:
Exactly.

Interviewee:
I can see that probably changes a lot if they'd known about this.

Interviewer:
Yeah, maybe.

Interviewee:
They wouldn't have made published it the way they did.

Interviewer:
Yes, but, but you know, I can say that it was on the agenda for two years. The two and something years, you know, and actually I should say that they have a very tough and robust criteria for their, you know, limitations, I mean.

Interviewee:
Right.

Interviewer:
Yeah, but at the end of the day, you know, they kind of decided on that and published it.

Interviewee:
It was the what's the whole purpose behind it? Was it just to make it easier to fulfill our targets for renewables or what is it?

Interviewer:
You know. They actually in the Act itself, which is of a couple of pages and it is not actually it has not only addressed the natural gas it has addressed nuclear power and so on. But they were very concerned about the situation we have right now, you know about the GHG emission. They say they, let's say they said that we are very behind the schedule. So, we're not doing well. So, let's push it a little bit by facilitating transition from heavier fuel like coal, then you know. But you know, I wonder whether this, approach would have any negative or downside. So which might be one thing, for example, is that, you know, by making natural gas less harmful in the general perception, you would make it more competitive to renewables. Specifically, Netherlands, because, yeah, I know that Groningen field is going to be closed or shut down it was all the Ukrainian Russian war, tilt the balance, or let's say made a chaos in the market. But yes, because in the Netherland, the Dutch Government has a large amount of natural gas they might take advantage of this act to move from coal burning [power plants] as fast as possible which was all before this invasion.

Interviewee:
Exactly like we shut down most of our coal fired power stations. I think we have two left which are going to be closed as well in the nearby future. But yeah, I think I did. I can see the gas would be a good way of transitioning from heavy fossil fuels to renewables.

Interviewer:
Let me just check a little bit on my question. I think you have mentioned all of them. Yes, yes, I think I think I'm done. Yeah. And yes, yes, thank you. Thank you very much for, you know, taking part and have a good day.

Interviewee:
Great. And let me know how you get on with your results and making the thesis.

Interviewer:
Yes, yes, of course. Of course. You know it's going to be some kind of formality. You know, I should actually finish the thesis, get it evaluated and then I should ask the university if I'm permitted to publish it online or not.

Interviewee:
Perfect. Thanks very much. Good luck with everything.

Interviewer:
Thank you. Thank you very much.

Interview No. **3**
Date: **31-May-2022**
Duration: **29' 37"**
Interviewee affiliation: **Engineering manager at an energy producing company**

Interviewer:
Well, I don't know if you have heard of this delegated act I'm working on. You know, conditionally approved or labeled natural gas screen, not natural. That's actually the electricity from natural gas green. And yes, I wanted to know what is your opinion? I mean in general to have a helicopter view, how do you see this act affect the energy market in general?

Interviewee:
OK, so. A clearly coal at my background is as a coal engineer, so I can start that call at 900 kilograms per kilograms of CO2 per MW hour. Is one of the most dirty and at 20 or 30 kilograms per MW hour, wind is obviously going to be the cleanest and so and the 450 or 500 gases in the middle.

Interviewer:
Of course.

Interviewee:
So it represents. It's not perfect, but it represents a transition fuel.

Interviewer:
Exactly.

Interviewee:
And. It's a necessary conceit in the purest form of the word. Unnecessary contrivance in order to move step by step by step from the nine hundreds here to the 10s twenties down here.

Interviewer:
Yes, exactly. OK. So, I can see that you, you know like many others believe that this act may just be useful as not to dwell too much time under transition. I mean, we should consider that we are going to transition from coal to some cleaner, absolutely clean or let's say green energy, but natural gas can help us to go there.

Interviewee:
Right, right. I don't think it'll be absolutely clear because there's a because there's a carbon cost associated with the infrastructure for wind or solar or for nuclear. All of, yeah, all of the concrete that you've got a cast and all the steel you've got to make. So, over the lifetime of the assets, it's going to be 10s of kilograms per MW hour, not hundreds for the for gas or 100, nearly 1000.

Interviewer:
Yeah. OK. Thank you very much. I would like to know; you know that this act is not enforced yet. It's going to be put into force. I mean from first of 2023 so I would like to know whether you think energy would be more affordable, specifically electricity, than without as a result of this. Because some say intermittency of renewables or maybe some restrictions like this. When natural gas comes into play, it's going to make it more reliable. And sometimes they say more affordable. How do you see this?

Interviewee:
OK. I'm not particularly well informed in this, but my generalist position is that this allows the status quo to continue. OK, so, this legislation for our very practical point of view, doesn't change anything directly that it. It might mean that we have to change our permitting system. As in our license to operate and our emissions and environmental permits, and so we might have to rework those and I don't know, I'm not sufficiently well engaged with that to know but from a practical you can see I've got my overalls on from a from a practical point of view it will it'll be business as usual. The bigger threat for us is you're based in the Netherlands, aren't you? So, so. So, the bigger threat for us is moving from so-called G gas to H gas. Are you aware of this transition?

Interviewer:
Not exactly. I'm sorry.

Interviewee:
OK, in two sentences because it's about all I know. G gas is gas from Groningen. I've been up in Friesland and that's a that's. So that's extracted from underneath the North Sea and the Vattenfall see.

Interviewer:
Wadden island, yeah.

Interviewee:
Yep, but it's led to earthquakes and tremors, which have disturbed people's houses. So, there's a there's an intention to stop G gas production and to move to H gas, which I think stands for high caloric gas production. OK, imported gas. And as a consequence, we are going to have to make modifications to our plant for that transition to take place. Not hundreds of millions of euros, but we are going to have to make as small changes to our plant.

Interviewer:
Yeah, exactly. So, you mean, in medium term, we're going to see, kind of gas dependency in the energy market?

Interviewee:
Right, it allows gas. My understanding is that it allows gas to remain as the status quo, so there's no pressure on gas to become rarer or more common, it remains where it is. It's only. Reducing coal capacity will make gas more popular cheaper renewable penetration would make gas less popular. But also, more peaking more intermittent. So, this act that you're talking about doesn't move it either way, it only establishes this as a transition fuel. And we would see the biggest change will come is as the gas become less as renewables become more and more deeper and deeper penetration than our gas assets have to be. More modulating.

Interviewer:
Yeah. So, you mean you mean actually gas should, fill the gap of renewables?

Interviewee:
Right.

Interviewer:
OK, so in this way, I want to know if you believe that investments outflow from renewables to

natural gas or no you are of those people who believe that renewables will do their job regardless of natural gas.

Interviewee:
Right. OK. Again, this is completely unevidenced position. This is only a hunch. I imagine that natural gas will probably be with us for an extra. For another 10 to 20 years. So, there will be increasing pressure to extend the life of the existing natural gas assets. Given uncertainty in the energy markets there will be little appetites from big producers like […] to invest in new gas assets. They will have to be a very, very compelling case. But investing in new gas assets and there's going to have to be a really strong capacity mechanism rather than delivering for MW hours. We have to be paid for availability, not for volume. Does that make sense?

Interviewer:
I think what you want to mention or point out is that, the minor consumers are not playing a role in this game. You know, as far as I could understand.

Interviewee:
No, no, I'm not saying that. I'm saying for big utilities like […] if we are to invest more money in gas fired plants, we would have to have a really strong government backs subsidy mechanism. That that will pay for availability. So, installing power at installing new gas that may run maybe only 100 days a year. So, we don't. We're not going to make very much money on those hundred days a year, but we're being paid to be available 300 and 300 days a year.

Interviewer:
OK. So, you're actually talking about supportive policies from the government. If they want to keep the status quo or the present condition.

Interviewee:
Yep. Right. So either there's got to be a capacity mechanism for us to be able to invest and know that there's a return for new plant. All we've got to invest or we've got to make up a lifetime extension of existing assets so that assets that have already got are making these numbers up to 20 years of their plan 2025-year life. We've got to undertake a really, really engineering science review to work out the remaining life of those assets and the risk associated with those assets so that we can stretch them for peaking and back up not for 25 years, but for 35 years.

Interviewer:
So yeah, as far as I understand, there will be some kind of strategic decision which actually imposed on the plants or let's say big utility providers. If the governments want to have this or let's say if we want to have this natural gas with us for a couple of years later.

Interviewee:
Yeah. Either the government is going to make a commitment to a capacity payment. All the utilities are going to have to look at [the] engineering science to be able to say this, this asset that's already 20 years old and should be retired at 25. How can we extend that to 35 years and still remain reliable and safe? Yeah. And there's the really important things we can't compromise on. We cannot compromise on process safety. So, we've got to have an engineering review from our notified body to say that that that those blades will last another however many 1000 hours. And that will start, reliability is strong enough that when we press the button, we know that we're going to come on. So, we're not going to forfeit. Or capacity payments for not delivering to our capacity payments.

Interviewer:
OK, thank you very much. Let me ask you the other question. Yeah, you actually did mention the risk and reward thing within your company and also, the about the policies, and OK, do you think that you know, when it comes to the natural gas-based electricity, minor stakeholders like household will be affected at all. What I want to know is that, for example, suppose that this act comes into force and gives some utility providers to take advantage of it by maintaining or let's say, operating their plans, their existing plans for couple of years more and produce electricity. Would that electricity, or let's say, that produced electricity affect any households regarding from the energy price up to reliability and affordability or you think that households would actually be, I mean remain intact or unaffected.

Interviewee:
OK, so if I take off my industry clothes and I think as a householder. Yeah. Then only the upper middle class and the wealthy have the luxury to decide to source a green power. For many households, especially in the last 3-6 months since the energy price increase affordability is probably a higher concern than the environmental credential and while there's two different scenarios. One is moving from gas at 500 grams per kWh, up to moving backwards on the scale to coal. Yeah, and that would be seen as a retrograde step and therefore not acceptable. If you are following the news. The other option is that you continue to use gas, but the rest of society creeps away down towards here and you're stranded as using gas. So, the first example that would be that might be more visible to more households and considered unacceptable, but remain in the status quo as the rest of society moves, it moves down to lower carbon. That's a creeping change that most people wouldn't see and would be much more emitting palatable. Much more sustainable. A digestible and that wouldn't be a problem for many households, I think.

Interviewer:
Thank you very much. So, in this way, do you think by I mean remaining on the natural gas for maybe one or two decades more, any economic indicators would change, I don't know. Perhaps unemployment rate or GDP or something? Because, you know, we have always had conflict or I don't want to say battle, but it's kind of a battle between renewables and how to shift as soon as possible to renewables with lower carbon footprint and this, you know, natural gas-based electricity if we want to move from this to the other we may compromise some, or maybe gain some economic benefits.

Interviewee:
OK. In terms of macroeconomic KPI's, I don't, I can't think of any that one of the consequences is. I understand that the energy demand is increasing, increasing, increasing. I think it's doubled since 1990, something like that, from memory. But you you'd have to correct me and it's only going to get something works higher and higher and higher, with deeper penetration of electric cars, electric transport. Increasing electrification of other forms of transport, domestic heat or whatever services might have used direct fossil fired would be using electric sources instead so maintaining a gas, a fleet of gas fired assets allows that deeper electrification of other services as those so that allows a deeper, faster electrification of those end user services. And, while the renewable penetration is not very deep the consumers feel like they're electrifying and they're preparing their end and then it's the responsibility of industry then to catch up with decarbonizing their supply, rather than decarbonizing at an electrifying demand so it facilitates the electrification of demand and then we'll catch up with decarbonizing it later.

Interviewer:
Thank you very much for being a part of this research. I have nothing to ask right now. If you want to add anything, I mean in general or in a specific any recommendation. Otherwise, I can, you know, let you go to the other meeting you have.

Interviewee:
Thank you. I'd love to see the outcome of your study. I'd love to see what other people from industry have said in response to the same questions, to see where I stand. So, once you've done your thesis, send me a link and I'd love to read it and see where we are and see where we're going.

Interviewer:
Yeah, thank you. Definitely. But you know, it might need some time for these formalities. I mean to be submitted and, you know accepted by supervisor and after all that I will let you know the results. Yes definitely.

Interviewee:
Brilliant. OK, all the best. I've I wish you good luck.

Interviewer:
Thank you. Thank you very much. Have a good day.

Interview No. **4**
Date: **01-June-2022**
Duration: **19' 08"**
***Interviewee* affiliation:** **Energy expert at an energy producing company**

Interviewer:
OK, because I don't want to waste much of your time. Let me start. I don't know if you have heard of this act. I was talking about a couple of minutes ago, but yeah, they, you know, European Commission decided to call energy. I mean, electricity from natural gas green. Of course, conditionally. I mean, the rule is set to limit the CO2 emission of the power plants to a certain limit. But yeah, it is called green and maybe many companies can actually take advantage of any subsidies applicable.

Interviewee:
With I think you should have a maximum threshold footprint. I think the threshold footprints requirements are far very strict they are.

Interviewer:
Actually it is 262 gram per, you know, kWh, yes.

Interviewee:
This low.

Interviewer:
Yeah, it is not that strict, of course, but yes, you know, it's going to come in a minute because I think they had this intention to phase out heavier fuel consumption, for example coal power plants and so on. But in general, if you have heard of this act, what do you, I mean, how do you say it or what is your perception about this act in general? I mean will it hinder or promote the transition?

Interviewee:
For me, I don't [know] all the details, but for me it's really about financial and taxation. So, I think really has to do with the investments. So, it's also done with new investment and now not with existing equipment. That's what I understand.

Interviewer:
Actually, both can be involved in this act as far as I know.

Interviewee:
OK, I didn't know the details. Yeah, I think it's in the political compromise. So, I think it's. I'm well, I'm not. I'm. Yeah, I think it is in the good it's in the right direction and maybe not directly to the moon, but I think you're quite a big step. So yeah, I think it's yeah.

Interviewer:
OK, very nice. And you know because they came for electricity production from natural gas. Do you see energy, I mean, because of these issues right now we are facing, I mean from supplying natural gas in the Netherlands, of course, the war in Ukraine and Russia, do you think energy would be more reliable and affordable as a result of this act? I mean, the electricity for the household or for the, consumers would be affordable.

Interviewee:
I don't think that this act makes a big difference so, if you look at like the Netherlands, we have a lot of gas-based power plants. And I think during the transition, we really need them for supplying balancing power. I think for reliability of the power supply you need to discuss power plants and so that's import auto called power plant can also do it with cars has a lower threshold to footprint. So, we need them. And then the question is and, I'll think if you have more winter solar, more renewable power you still need them. But with less operating hours a year. But they should the lot of them should still do. The more majority should be still be there for availability, reliability and maybe in the future you can convert it to hide it in or something, I don't know.

Interviewer:
OK.

Interviewee:
Now if you look to this act, I don't think if you look like to Netherlands, I don't think it is really having impact on the number of gas plants management. I don't think they will build extra. It might build some extra gas plants in Europe for balancing, so I think that principle OK. So that's situation then. If you now look, yeah, I think this long term. So now we have the war in Ukraine. But I don't hope it will take it will last forever.

Interviewer:
Yeah. And I hope so.

Interviewee:
And so during the transition, there will be gas available, but we will consume less gas, but we should be more sensible with the gas, so don't spoil it. So used in an efficient way.

Interviewer:
Yeah, definitely. So, you mentioned that it doesn't have a very huge impact on the Netherlands or it might not have that much impact.

Interviewee:
This act. Not.

Interviewer:
OK, so, how do you see this for example; You know, as far as I know, there are just a handful of coal power plants and still working. Do you see that this act may promote, you know, co-firing of natural gas in those plants or for example, phasing out coal?

Interviewee:
No, no, no, no, no, no, no. That's a fairly large investment. There's a lower efficiency now. You won't do that. No, not at all.

Interviewer:
OK, thank you. And well, suppose that. Let me ask it in this way. Do you see enough motivation and intention for, you know, phasing, I mean transitioning from fossil fuel to the renewables in general, do you think this act which actually facilitates using of natural gas, you know may result in a gas dependency, more gas dependency or no?

Interviewee:
Now for me, this act is not so heavy. So, for me this it's only one of the there are hundreds of acts in Europe and this just one of them and maybe from the public opinion it it's like a little bit negative public opinion. But I think the main course is really on renewables, but they need balancing and storage power. So, I think that's more important than this act and this act make facilitate some gas fired problems. Maybe some gas fired power plants in Europe who would not have come without act. This act, but will come with this act. OK, that I think that will help for transition and the balancing so. But I don't think that this acts not the game changer.

Interviewer:
OK. Thank you very much. So, let's, I mean, you kind of answered all my questions in just one sentence, but let me put it in another word to have you still with me. Suppose that, some gas plants. I mean, take advantage of this act as a result of, for example, the subsidies. I mean, as far as I know, SDE++ has some advantage for the natural gas burning electricity provider as long as they're green.

Interviewee:
Yeah, but they in the Netherlands, they won't create subsidies for natural gas plant now.

Interviewer:
You know that, because they actually improve the emission. I mean CO2 emission or let's say reduce CO2 emission, there wouldn't be any subsidies in the Netherlands for the industries.

Interviewee:
There are lot there's SDE++ to reduce the direct CO2 emission from industry. Yeah. But I'll think this is a European act. And that's really on the European, but the Dutch won't establish an SDE++ subsidy for network host plants that won't come there.

Interviewer:
OK. So, in that way you mean that the Dutch Government would not make any decision to align themselves with these European Commission act.

Interviewee:
Now I think this is European, because I think they are I think that's it's allowed from this act to treat within taxation scheme and something like a gas with this thing like a renewable power or something. That is not obligatory, so you don't have to get it. So that's my understanding. So, I think it's more, you are allowed to do it with the and you have to do with national implementation. But I don't think it's obligatory. So that's a very big thing. So, the Dutch Government, I think, well, they never stimulated network gas plants with SDE++. So, in the political sense analyze that won't happen.

Interviewer:
OK, so in that way you mean that the company is working on the carbon capturing and storage facilities can take advantage of this act? I mean it does, it's not going to work in this way for them, I mean.

Interviewee:
No, I don't see. Yeah, maybe for copper kept the storage from natural gas, but then there should be special arrangement for them. So. Well that I think, OK, but one step back, so I'll show the ditch part. Government is looking for flexible power. They also know we need

flexible power and they want to reduce the carbon. So I think that is being studied. What flexible power should we have in the Netherlands, low carb and flexible power? So that's in parallel study ongoing now discussion on going and now and it could be carbon capture, storage could be hidden, it could be something different. There might be. I agree with you. There might be if the outcome of that analysis is, we could best have captured network gas plant. They might establish a SDE++ scheme for that. That might be possible. That might be possible, yeah.

Interviewer:
OK. Thank you, and let me ask you, so in that case, if we consider that, for example, the price of natural, I mean electricity from natural gas as a result of this act changes in a way because you know subsequent subsidies, you know prices, you know differ so, if something like this happens, do you see any impact on the household or minor energy consumers or even heavier energy consumers?

Interviewee:
OK, let's one step back. So, if you look like that, so it's really about balancing power. So, you want to create zero-government balancing power for the so that's, that's actually and this act could enable that for. See you too. But I think it's new investment. I don't know if carbon capture. I think it's for new plants. So, I don't know if carbon capture is part of this.

Interviewer:
I'm sorry to interrupt you. It is explicitly written in the taxonomy that, you know, this act is established to promote this carbon capturing. OK, then it could be that we have carbon capture with our flexible power plants.

Interviewee:
Yeah, otherwise, it won't have any impact on the power price. No, because, otherwise the power plant has to pay the CO2 price.

Interviewer:
Yes, exactly.

Interviewee:
And normally they did 60 scheme subsidized the difference between the your cost price and the reference market price. So, the reference mark applies. So, this is the base of the SDE++. So, I don't think it won't affect the price. It only, it will probably lower the price because of the enables, yeah, it enables power plants to install carbon capture storage. That might in the security they will, they will install it. And with high threshold to prices, then these power plants are more as more have more advantages for the CO2 price. So, I think it will slightly lower the price in the end. Yeah, but on the other hand, the SDE++ is paid by the customers buying an extra additional on their power price. So, I think in the end they really don't have a large impact on the power price. It will have minor impact.

Interviewer:
OK, indeed. I'm really interested in the, you know, final destination of different scenarios in this area, because on the on the one hand, yeah, that the Netherlands is a net importer of the natural gas and you know, as a result of this war supplying natural gas is very difficult at the moment. And on the other hand, the Netherlands, has a very huge natural gas reservoir, especially in Groningen. Do you think as a result of all these stuffs, all the policies to make

green energy might be affected at all? For example, you know the government might decide to extract more from this area in the coming years.

Interviewee:
Yeah, yeah. For rational way to look at this. And if emotional way to look at this. And I think one on rational way, it will be good to do it. But from an emotional way it all the stuff we had to Netherlands and we were not able to earthquake. So, you don't want to make it to bring people in danger. Well, the compensation mechanisms were fairly complex and how we were not very good on that. So actually, from the emotional way they promised growing it to stop or to reduce the cost supply. And but I think for my personal view, I think it would be smart to keep it open and to keep your energy independency. And you have you have to have a solution for people in growing. But I think that that's possible. So that's the situation. So, I don't know it's a balance between emotions and ration. And at the moment, the emotions are,

Interviewer:
Very high.

Interviewee:
Very high. So, the ration is not always there. But yeah, I think so. That's the balance.

Interviewer:
Yeah, I can understand. So as my final question, let's say, considering the situation we are now in the Netherlands, do you think is there any risk for investment to outflow from renewables to more fossil fuels or no?

Interviewee:
No.

00:16:32.700 --> 00:16:37.160
Interviewer:
OK. Thank you. Thank you for this. You know, strong no.

Interviewee:
And then in the Netherlands North, we have so many gas plants. So, we don't do it. So maybe we only have to install carbon capture storage. I think in Poland and countries like that it can happen, but you will really see what you see actually is that we now see we're very dependent on gas from Russia.

Interviewer:
Yes.

Interviewee:
And I'll think on that respect. You should be very, sensible that the gas at so have very efficient cost consumption. So, in that respect, I don't think they will install carbon capture storage because that's quite inefficient. It decreases the efficiency of a power plant. So, in that case, it's not only here too, but I think this so based on the cost dependency. I think it's first really to also the countries with the low penetration rate of new renewables, it's first to do more renewables there, you just reduce the power production and the gas consumption. And maybe at the end then you have some balancing problems and then you have to do something. But I think for the short term, I don't think so because actually yeah, it's such a risk at the

moment. So, I think that risk and the cost market it's, yeah it makes more difficult than efficiency of renewables.

Interviewer:
OK. Thank you. Thank you. Very good answer. I think., I've asked all the questions I had and yeah, I tried to keep it short as much as much as possible. So, in the end, if you want to add anything or you know, any comments are more than welcome right now.

Interviewee:
OK, no, no problem. No thank you for you. So, you [are] part of policy management department [in the University of Twente].

Interviewer:
No, I study in the behavioral management and social sciences. This program is a part of that faculty actually.

Interviewee:
Yeah. OK, that's good. OK, yeah.

Interviewer:
Thank you very much at the end.

Interview No. **4**
Date: **01-June-2022**
Duration: **19' 08"**
Interviewee affiliation: **Energy expert at an energy producing company**

Interviewer:
OK, because I don't want to waste much of your time. Let me start. I don't know if you have heard of this act. I was talking about a couple of minutes ago, but yeah, they, you know, European Commission decided to call energy. I mean, electricity from natural gas green. Of course, conditionally. I mean, the rule is set to limit the CO2 emission of the power plants to a certain limit. But yeah, it is called green and maybe many companies can actually take advantage of any subsidies applicable.

Interviewee:
With I think you should have a maximum threshold footprint. I think the threshold footprints requirements are far very strict they are.

Interviewer:
Actually it is 262 gram per, you know, kWh, yes.

Interviewee:
This low.

Interviewer:
Yeah, it is not that strict, of course, but yes, you know, it's going to come in a minute because I think they had this intention to phase out heavier fuel consumption, for example coal power plants and so on. But in general, if you have heard of this act, what do you, I mean, how do you say it or what is your perception about this act in general? I mean will it hinder or promote the transition?

Interviewee:
For me, I don't [know] all the details, but for me it's really about financial and taxation. So, I think really has to do with the investments. So, it's also done with new investment and now not with existing equipment. That's what I understand.

Interviewer:
Actually, both can be involved in this act as far as I know.

Interviewee:
OK, I didn't know the details. Yeah, I think it's in the political compromise. So, I think it's. I'm well, I'm not. I'm. Yeah, I think it is in the good it's in the right direction and maybe not directly to the moon, but I think you're quite a big step. So yeah, I think it's yeah.

Interviewer:
OK, very nice. And you know because they came for electricity production from natural gas. Do you see energy, I mean, because of these issues right now we are facing, I mean from supplying natural gas in the Netherlands, of course, the war in Ukraine and Russia, do you think energy would be more reliable and affordable as a result of this act? I mean, the electricity for the household or for the, consumers would be affordable.

Interviewee:
I don't think that this act makes a big difference so, if you look at like the Netherlands, we have a lot of gas-based power plants. And I think during the transition, we really need them for supplying balancing power. I think for reliability of the power supply you need to discuss power plants and so that's import auto called power plant can also do it with cars has a lower threshold to footprint. So, we need them. And then the question is and, I'll think if you have more winter solar, more renewable power you still need them. But with less operating hours a year. But they should the lot of them should still do. The more majority should be still be there for availability, reliability and maybe in the future you can convert it to hide it in or something, I don't know.

Interviewer:
OK.

Interviewee:
Now if you look to this act, I don't think if you look like to Netherlands, I don't think it is really having impact on the number of gas plants management. I don't think they will build extra. It might build some extra gas plants in Europe for balancing, so I think that principle OK. So that's situation then. If you now look, yeah, I think this long term. So now we have the war in Ukraine. But I don't hope it will take it will last forever.

Interviewer:
Yeah. And I hope so.

Interviewee:
And so during the transition, there will be gas available, but we will consume less gas, but we should be more sensible with the gas, so don't spoil it. So used in an efficient way.

Interviewer:
Yeah, definitely. So, you mentioned that it doesn't have a very huge impact on the Netherlands or it might not have that much impact.

Interviewee:
This act. Not.

Interviewer:
OK, so, how do you see this for example; You know, as far as I know, there are just a handful of coal power plants and still working. Do you see that this act may promote, you know, co-firing of natural gas in those plants or for example, phasing out coal?

Interviewee:
No, no, no, no, no, no, no. That's a fairly large investment. There's a lower efficiency now. You won't do that. No, not at all.

Interviewer:
OK, thank you. And well, suppose that. Let me ask it in this way. Do you see enough motivation and intention for, you know, phasing, I mean transitioning from fossil fuel to the renewables in general, do you think this act which actually facilitates using of natural gas, you know may result in a gas dependency, more gas dependency or no?

Interviewee:
Now for me, this act is not so heavy. So, for me this it's only one of the there are hundreds of

acts in Europe and this just one of them and maybe from the public opinion it it's like a little bit negative public opinion. But I think the main course is really on renewables, but they need balancing and storage power. So, I think that's more important than this act and this act make facilitate some gas fired problems. Maybe some gas fired power plants in Europe who would not have come without act. This act, but will come with this act. OK, that I think that will help for transition and the balancing so. But I don't think that this acts not the game changer.

Interviewer:
OK. Thank you very much. So, let's, I mean, you kind of answered all my questions in just one sentence, but let me put it in another word to have you still with me. Suppose that, some gas plants. I mean, take advantage of this act as a result of, for example, the subsidies. I mean, as far as I know, SDE++ has some advantage for the natural gas burning electricity provider as long as they're green.

Interviewee:
Yeah, but they in the Netherlands, they won't create subsidies for natural gas plant now.

Interviewer:
You know that, because they actually improve the emission. I mean CO2 emission or let's say reduce CO2 emission, there wouldn't be any subsidies in the Netherlands for the industries.

Interviewee:
There are lot there's SDE++ to reduce the direct CO2 emission from industry. Yeah. But I'll think this is a European act. And that's really on the European, but the Dutch won't establish an SDE++ subsidy for network host plants that won't come there.

Interviewer:
OK. So, in that way you mean that the Dutch Government would not make any decision to align themselves with these European Commission act.

Interviewee:
Now I think this is European, because I think they are I think that's it's allowed from this act to treat within taxation scheme and something like a gas with this thing like a renewable power or something. That is not obligatory, so you don't have to get it. So that's my understanding. So, I think it's more, you are allowed to do it with the and you have to do with national implementation. But I don't think it's obligatory. So that's a very big thing. So, the Dutch Government, I think, well, they never stimulated network gas plants with SDE++. So, in the political sense analyze that won't happen.

Interviewer:
OK, so in that way you mean that the company is working on the carbon capturing and storage facilities can take advantage of this act? I mean it does, it's not going to work in this way for them, I mean.

Interviewee:
No, I don't see. Yeah, maybe for copper kept the storage from natural gas, but then there should be special arrangement for them. So. Well that I think, OK, but one step back, so I'll show the ditch part. Government is looking for flexible power. They also know we need flexible power and they want to reduce the carbon. So I think that is being studied. What flexible power should we have in the Netherlands, low carb and flexible power? So that's in parallel study ongoing

now discussion on going and now and it could be carbon capture, storage could be hidden, it could be something different. There might be. I agree with you. There might be if the outcome of that analysis is, we could best have captured network gas plant. They might establish a SDE++ scheme for that. That might be possible. That might be possible, yeah.

Interviewer:
OK. Thank you, and let me ask you, so in that case, if we consider that, for example, the price of natural, I mean electricity from natural gas as a result of this act changes in a way because you know subsequent subsidies, you know prices, you know differ so, if something like this happens, do you see any impact on the household or minor energy consumers or even heavier energy consumers?

Interviewee:
OK, let's one step back. So, if you look like that, so it's really about balancing power. So, you want to create zero-government balancing power for the so that's, that's actually and this act could enable that for. See you too. But I think it's new investment. I don't know if carbon capture. I think it's for new plants. So, I don't know if carbon capture is part of this.

Interviewer:
I'm sorry to interrupt you. It is explicitly written in the taxonomy that, you know, this act is established to promote this carbon capturing. OK, then it could be that we have carbon capture with our flexible power plants.

Interviewee:
Yeah, otherwise, it won't have any impact on the power price. No, because, otherwise the power plant has to pay the CO2 price.

Interviewer:
Yes, exactly.

Interviewee:
And normally they did 60 scheme subsidized the difference between the your cost price and the reference market price. So, the reference mark applies. So, this is the base of the SDE++. So, I don't think it won't affect the price. It only, it will probably lower the price because of the enables, yeah, it enables power plants to install carbon capture storage. That might in the security they will, they will install it. And with high threshold to prices, then these power plants are more as more have more advantages for the CO2 price. So, I think it will slightly lower the price in the end. Yeah, but on the other hand, the SDE++ is paid by the customers buying an extra additional on their power price. So, I think in the end they really don't have a large impact on the power price. It will have minor impact.

Interviewer:
OK, indeed. I'm really interested in the, you know, final destination of different scenarios in this area, because on the on the one hand, yeah, that the Netherlands is a net importer of the natural gas and you know, as a result of this war supplying natural gas is very difficult at the moment. And on the other hand, the Netherlands, has a very huge natural gas reservoir, especially in Groningen. Do you think as a result of all these stuffs, all the policies to make green energy might be affected at all? For example, you know the government might decide to extract more from this area in the coming years.

Interviewee:
Yeah, yeah. For rational way to look at this. And if emotional way to look at this. And I think one on rational way, it will be good to do it. But from an emotional way it all the stuff we had to Netherlands and we were not able to earthquake. So, you don't want to make it to bring people in danger. Well, the compensation mechanisms were fairly complex and how we were not very good on that. So actually, from the emotional way they promised growing it to stop or to reduce the cost supply. And but I think for my personal view, I think it would be smart to keep it open and to keep your energy independency. And you have you have to have a solution for people in growing. But I think that that's possible. So that's the situation. So, I don't know it's a balance between emotions and ration. And at the moment, the emotions are,

Interviewer:
Very high.

Interviewee:
Very high. So, the ration is not always there. But yeah, I think so. That's the balance.

Interviewer:
Yeah, I can understand. So as my final question, let's say, considering the situation we are now in the Netherlands, do you think is there any risk for investment to outflow from renewables to more fossil fuels or no?

Interviewee:
No.

00:16:32.700 --> 00:16:37.160
Interviewer:
OK. Thank you. Thank you for this. You know, strong no.

Interviewee:
And then in the Netherlands North, we have so many gas plants. So, we don't do it. So maybe we only have to install carbon capture storage. I think in Poland and countries like that it can happen, but you will really see what you see actually is that we now see we're very dependent on gas from Russia.

Interviewer:
Yes.

Interviewee:
And I'll think on that respect. You should be very, sensible that the gas at so have very efficient cost consumption. So, in that respect, I don't think they will install carbon capture storage because that's quite inefficient. It decreases the efficiency of a power plant. So, in that case, it's not only here too, but I think this so based on the cost dependency. I think it's first really to also the countries with the low penetration rate of new renewables, it's first to do more renewables there, you just reduce the power production and the gas consumption. And maybe at the end then you have some balancing problems and then you have to do something. But I think for the short term, I don't think so because actually yeah, it's such a risk at the moment. So, I think that risk and the cost market it's, yeah it makes more difficult than efficiency of renewables.

Interviewer:
OK. Thank you. Thank you. Very good answer. I think., I've asked all the questions I had and

yeah, I tried to keep it short as much as much as possible. So, in the end, if you want to add anything or you know, any comments are more than welcome right now.

Interviewee:
OK, no, no problem. No thank you for you. So, you [are] part of policy management department [in the University of Twente].

Interviewer:
No, I study in the behavioral management and social sciences. This program is a part of that faculty actually.

Interviewee:
Yeah. OK, that's good. OK, yeah.

Interviewer:
Thank you very much at the end.

Interview No. **5**
Date: **01-June-2022**
Duration: **26' 34"**
Interviewee affiliation: **Public affairs advisor at a natural gas supplier company**

Interviewer:
I think I should start by introducing myself. My name is Arash. I'm studying a program, environmental and energy management in the University of Twente. I picked energy track and for my thesis, I'm working on the recent delegated act of the European Commission in which electricity from natural gas is called conditionally, of course, called green. I wanted to understand the impact of this act on the, I mean on different actors in the energy market, in the Dutch energy market, actually. And yes, I'm very happy to have you here as a, let's say, natural gas supplier. But you can again you can give your personal opinion and of course your name would not be revealed at all. If everything is OK, I can start by asking a general question of if you have heard of this act, what is your general idea about it? Is it going to promote the energy transition or is it going to hinder it?

Interviewee:
Yes, well, we have heard, of course, that the taxonomy regulations and. Well, we are not direct participant in this but I believe yes, it has of course impact on the energy transition and it's a bit difficult this act to my opinion, because that's not only [thing]. There's a difference between The Netherlands, for instance, and the rest of Europe. Fortunately, if you look at the eastern countries, you would say this is a positive thing because it will promote energy transition for an as Holland or the Netherlands is already well equipped in the energy transition and it has a lot of natural gas already in place. That this will for the Netherlands not really have that much impact anymore, I would say so. And in a way, I say, I would say it has a positive effect on the energy in transition, if you look at them a broader context, for instance on a European level, but just looking at the Netherlands, it's it might not have that much impact because as I said, there is already a lot of high density of gas connections to the building environment and from the nuclear part that to new nuclear power stations will be built anyhow so it's a complicated questions in a way as I know what I mean in, in, in a broader sense, I would say it, of course it will encourage the energy transition. But on the other hand, it depends on from which part you look at it.

Interviewer:
OK, so let me be a little bit more specific. You know, there was a lot of debate or let's say actions taken for electrifying the households especially and industries. And I believe this act in a way can affect both minor users of electricity and also major users. Do you see or do you think this act may in a way promote the affordability and security of the electricity in general to all the one who would demand energy or energy consumers?

Interviewee:
I don't know. I don't think so actually, because I'm not sure, because if you look at the act and specific on nuclear, it means there will be more nuclear on the market and I believe there is a lot of electricity will be undermarked due to the crisis we have now and all the program should have started so, the there's going to be a lot of energy on the market, nuclear. Through wind. But anyhow, that should happen anyhow, will it have to happen, otherwise we need molecules

as well. But the molecules are used in the building environment, but also in industry. Also, in the power generation. So therefore, we need all the molecules and electricity. Yes, there has to be more electricity around.

Interviewer:
Yes, I know. So, as far as I know, there are just a handful of power plant burning coal in the Netherlands. Actually, they're still operating. And do you think they may in a way want to get, I mean take advantage of this act to for example, switch from coal to natural gas in anyway. Because you actually are in the middle of the energy, supplying chain. So, you may know whether there's a willingness to, you know, switch from coal or heavy fuels to low carbon fuels. For example, like natural gas.

Interviewee:
Yes. But and I'm on the hand, I would say. Maybe there will be no switch from coal to natural gas, but the switch from getting coal to hydrogen.

Interviewer:
Yes, the more sustainable among green ones, yeah.

Interviewee:
So, but that does not. There will be a direct step, but I'm not really into the energy supply. I'm not in the energy, so I'm just only in the gas business. So, I'm [not] really sure what the plans are over there, but, looking at nowadays, it's a bit more complicated due to the crisis in Ukraine, so the whole act is a big the yeah, I'd how do you say it's a bit obsolete actually.

Interviewer:
Yes, exactly, exactly. You know, actually, I started studying this specific act before the war actually emerged, so yes, it actually makes everything a chaos right now, but let's put it aside, do you think the consumers will ask for more natural gas as a result of this act? I mean especially the large and heavy consumers. It can be for example, gas turbine power plants or they can be, you know, some kind of industries that can take advantage of for example, SDE++.

Interviewee:
Looking from the Dutch perspective, I would say no. Probably there are some countries. Probably but, but it all makes it so complicated due to the war. So, because the reliance on the Russian gas is, it has that much impact, I'm not sure whether this will happen. Because there will be a shortage of gas.

Interviewer:
Definitely yes.

Interviewee:
And natural gas, LNG, probably. I'm not sure. Not sure whether it will replace coal. In other countries is probably of course, that has been the whole meaning of this act actually, isn't it? It's hard to replace coal by using nuclear and natural gas. So that's the reason why it's green and nuclear has been promoted largely by the French authorities. They want to spend nuclear and gas has been into it as well.

Interviewer:
Yes, uh yeah. I just read a news today. I mean, this morning, that's actually Russia has stopped selling gas or let's say […] stopped buying natural gas from Russia due to some, you know, I

don't know, business issues, I'm not sure, but I wanted to know well, suppose that Netherlands or the Dutch authorities doesn't want to have the Russian gas anymore. Do you think it is going to lead to more extraction from Groningen field in a way?

Interviewee:
Well, that's a that's a complicated question. That's a question we get quite a lot nowadays the Russian, the Russian flow, we have a contract with gas from. We had to we of course we buy the gas and there are some things in the contract and they wanted to have a an account 50 accounts with a Russian account bank account if you can't fulfill so that's the reason why we didn't go along with that.

Interviewer:
Yes.

Interviewee:
That's from there for stopped the deliveries to the Netherlands so. Now we won't get any gas from them anymore. That's a pity in a sense because we need all the gas at the moment to fill our storages. Just but I don't think it's not up to me. It's up to us what's going to happen with Groningen. It has a much bigger influences and other people have to decide, and especially if you look at what's happening in running anyhow so I believe the focus will be still to stop the production of chromium, but anyhow there might be a challenge. If you look at the at the way how to proceed when there is a shortage of gas. But you know, throwing them is on step 10. It's not the first out. So first we have to isolate our houses. We have to reduce, our use of energy and etc.

Interviewer:
Yeah, I can imagine. And so, in this way, if you think the business of natural gas in Netherlands is going to be affected by this act or by other things around this act. I mean, the players of the game we are facing right now, for example, Russia, Ukraine, even, some NGO's and you know, trying to get rid of the gas. If that's the case, I mean, if we want more natural gas from, the supply chain, do you think the market is mature enough or is strong enough to handle this amount of excess gas needed for the demand side.

Interviewee:
No, I don't think whether there is the Russian weird that much dependent on the Russian deliveries, think of gas it will have a huge impact on Europe. If you look at the gas deliveries and the gas will have to come or will have to derive from other countries like probably the United States to Europe or from Qatar or whatever. And so probably there will be more gas on the market but then you have another thing like who's going to buy. Is it going to to Europe or is it going to China? That's the big question.

Interviewer:
Yes, exactly. Yes, it would be another competition, of course and yes.

Interviewee:
Yes.

Interviewer:
Let's assume that natural gas consumption rises in a way. And do you think any economic

indicator increased. I don't know, maybe unemployment rate increased or GDP increased or something like that?

Interviewee:
So if I understand the question correct, you mean if it's natural gas will grow, will it have an effect on the,

Interviewer:
Economy. Yes.

Interviewee:
Yes, I would say so, yeah, it has. It has happened in the Netherlands for instance, we have been producing since 1960s and you can see what has happened to the production of the natural gas in, in the Netherlands and as well if you look at the even bigger, if you if you go to India, China whatever, all those countries, if you if they have more if they have the energy available, I would say the welfare would go up. And there will be more industry and more possibilities to have the economy working better.

Interviewer:
And, for the final question, I don't want to say there's a battle between renewables and fossil fuel, but it is the way it goes actually right now. As an actor in the fossil fuel energy supply chain how do you see the future of renewables in the Netherlands? In specific, I mean, do you think it's going to, I mean the renewables, will win this battle at the end of the day. For example, in 2050, as it is said before.

Interviewee:
Yes, I would say so. If I would say the renewables will replace the fossil fuels in the end and the molecules will still be around. So that's another thing. It's the fossil fuel we have always said fossil fuels are we will produce the fossil fuels on the natural gas until there is another better solution. And natural gas has always been competitive to the coal and therefore I'll be always had those. It's part of the solution because it's it has less CO2 emissions than the call and nowadays, we have new technologies. The wind for instance, or other solutions, energy carriers. So, I would say renewables will if you would, call it a battle will win the end, but I wouldn't pronounce it better battle. It's just we need to. We need to have supplied everyone and at the moment there's no better solution. And if you look at what happened few years ago there was a in the building area, you can you know what I mean? And the households, it must be wanted to get rid of the gas. There was a huge campaign. It was called from [Dutch word]. I don't know if you understand that, but it's that's pronation. Get rid of the gas. And if you see what happened in, in two- or three-years' time, our production or our comes consumption of natural gas has risen. It's all due to the fact that the alternative energy carriers were not able to get bigger or to expand and the Dutch gas was used for the electricity, for instance, in Germany, so the consumption was higher in the Netherlands than expected and well before. The campaign of get rid of natural gas so I would say there's a huge dependency on natural gas still and you can see it nowadays what happens in the Ukraine.

Interviewer:
Yes, yes, definitely yes. I just missed one question. Sorry, do you see any policy gap to alleviate or to make the consequences of using natural gas right now at the moment in the transition

phase I mean less harmful. Do you know any policy to suggest or propose to help this transition, goes faster?

Interviewee:
I'm not, not really actually, but I can't. But I can say is that sometimes I have the feeling that you already said to me of the battle between renewables and fossil fuels? I was, I would say probably there is a battle, but I wish there would not. I don't know why. Why is there a battle? Of course, there's a battle because once you have an opportunity that's important. But on the other hand, I believe there is a focus on the climate at the moment and it and that's going to win anyhow, so I wish the different energy carriers, they have to cooperate together. That's only thing and that's and how that comes, how it will affect in the policy way and I don't know actually to just to be open and to listen to what's the right solution.

Interviewer:
OK. Thank you for your time. I don't want to take much of your time anymore, so if you have something to add or if you want to say something, I will listen. Otherwise thank you very much.

Interviewee:
OK, mate. Well thank you very much and I wish you good luck with your thesis. Please can you provide me a copy or do you want to provide me a copy if you have finished or let me know what has happened with it?

Interviewer:
Yes, of course. Definitely you know after some formalities.

Interviewee:
And when you succeed, nice to know.

Interviewer:
Definitely. OK, sure. Sure. Thank you. Thank you very much. Have a good evening.

Interviewee:
OK, OK. wish you all the luck. OK. Bye.

Interview No. **6**
Date: **03-June-2022**
Duration: **24' 10"**
***Interviewee* affiliation:** **Regulatory & Government affairs at an energy infrastructure company**

Interviewer:

I think we can now start. Yeah, let me start by a very quick introduction to myself actually, I'm studying a master's program in University of Twente program energy and environmental management. Yes, as a part of my thesis, I need to have your professional let's say opinions about this delegation act, how it's going to affect energy transition and how do you want to take advantage or you want you know, you should take some actions regarding alleviating the consequences it might have and so on. My supervisor and I decided to build a fuzzy cognitive map and we have some actors you are one of the biggest one and I need you to give me your idea in whole I can have specific questions. Otherwise, I would prefer to stop talking more and let you talk as much as you can. Do your due to time shortage and yeah, give me your idea and whole and then if anything is missing, from my side, I would ask and, in the end, we can wrap it up. Yes.

Interviewee:

Okay. Yeah, first of all, my name is […], I work at […] which is the which is an energy infrastructure company, we own several TSO. So, transmission system operators, they also own natural gas storage, natural gas, interconnectors, natural gas storage, all kinds of natural gas assets, but are not allowed to be active in production, and trade or supply. So that's natural gas, but we're also active in transporting heat, CO2 transport and storage. And of course, very active in the field of hydrogen, transport, import and storage all are relevant for this topic. So, so, we are talking about the above what we call taxonomy and there are two, two delegated acts on the on the under this when we go to your taxonomy, and to my understanding, from your interview questions you are focusing on the second one, the second one is nuclear and natural gas, yes. So, we of course, as possibly we look at it as a whole, because both delegated acts impact us. They give us obligations as a non-financial institution. But what for us will mean that we need to in our annual report, we need to give transparency about what is what are our comply and taxonomy compliance activities and what are the activities that are non-compliance with that. So, I think so, because we are an infrastructure company, a lot of the things that are that we are doing right now are compliant. So, in the hydrogen infrastructure, natural gas infrastructure, all these infrastructure elements, and we are we are compliant, compliant in that in that field, I guess. But for us, it gives an extra it gives strength, it gives transparency obligations, and I think in the end, that's a good thing. It's a good thing that it starts with transparency on who's doing what, where you'll still have dodgy companies here and there, which will try to like, circumvent these deals. But I think for a lot of larger, larger players, you will have to be compliant. NGOs, what are you reporting there. So, from the start, I think this is a good point. When this was being discussed in Parliament, we have but we also looked at it as a bit of a storm in a glass of water. You know, it did big discussions on how gas is sustainable and nobody ever said that, you know, it is about financial institutions financing certain activities, and being allowed to label that as green investments. Now think last week, there was a, for the first time I think a German company had the police letter, they will read it, because they sell products that they call green, but weren't based on taxonomy. So very, very [interesting] topic that you are researching is now

already seeing its effect. For us, it gives transparency obligations, as said, we think, had all discussion in the media was about, now suddenly natural gas is green. Nobody says that. It is okay. Can you finance it as a financial institution? And then saying, hey, this is great. So, then you need to answer the next step. So, I think nobody, at least not the journalist went into the details directly. What exactly does it? Yes? Because exactly when I'm not in full into the into the rules, so but if you I think for natural gas that says if you for example, invest in a new natural gas power generation unit, it has to comply with certain CO2 emission standards. Exactly. According to me. They are quite strict. I have not, I don't know the final numbers, but I what I saw, at least what I during the process, I think they were quite, they mean something then you need to take measures to exactly have avoid

Interviewer:

Violation.

Interviewee:

Exactly. And it that is okay, if you do that. You also need to be ready for renewables, let's say for renewables can be hydrogen can bring at Green Gas, biomethane, whatever. That one, I think is a bit soft. To be honest, because we've seen that discussion here in the Netherlands coal fired power plants that were being built. Or the permits were being given in, let's say, 2008 2010 they also had the obligation to be carbon capture ready. And that didn't really mean anything. You know, it was like a hollow phrase, where were added the coal or the power company said yeah, that means that we have to reserve a little space like a soccer field, half a soccer field where you can be able to capture installation. That's it. So, NGOs still see this as a threat.

[interruption due to connection lost]

Interviewer:

You were talking about the thresholds

Interviewee:

Thresholds I think are the most important in the in the delegated Act specifically on natural gas. So, what does it really mean? What do you can you just still build a natural gas fired power plant and do nothing or do you need to take specific abatement options making sure that you're remain under these limits so that from so that's, I think that is how we look on it. If you more on an even bigger scale it is it could also lead to financing, How do I say that so, it means it could make transition transitionary or investments in renewables cheaper because they are cheaper to finance because a there's less risk premium or non-compliancy premium in your in the capital you extract from financial institutions. So, so, manager yet at a depth in your in your project or in your project finance or in your however, whatever balance sheets and that can reflect a higher or lower premium dependent on your level of compliancy. So, that is so you can expect non-compliant investments, they can still be financed. However, these financial institutions are okay, and I will be more non-compliant in my total portfolio, I can really sell this to investors as a financial institution as a year is here as an investment so that that will lead I think, to a higher Yeah, higher rates that they will that they will charge. And as a bonus for more that taxonomy compliance issues. So, in general, on the one hand, you could say, yeah, it makes it makes the transition cheaper. But I think everybody recognizes that you need to have a, you cannot make the switch at once. And you need to have transitionary measures in place,

you see that in Germany, taking a hard left or hard right. Will, at one moment in time bite you in the tail. They're saying goodbye to coal and nuclear power, at the same time, not having Russian gas. What are we going to do right now? So, I think that has an impact on the general level.

Interviewer:

Very good. Very good. Thank you for all your comments. So, there are two questions. I'd like to ask first, you don't see any threat for an investment in renewables in the near future as a result of this act, for example? Because, yeah, maybe natural gas can also be a competitive energy source, but it is now kind of a green material. So, you know, investors may want to, you know, invest in something, which brings them more profit.

Interviewee:

Yeah, I understand that. So, so you're I think you're trying to your thesis is, is that, because it's still interesting for investors to also invest in natural gas projects? Will you also Well, you do and will you also invest in renewables? Or will you shift your money exports? transitionary measures? And I think, yes, the taxonomy and delegated acts play a part in it, but it's, it's a minor part, because it's no it is it will impact it will impact the cost of capital. But still, you will take if you have, I would work for a power company or an energy company, I would, I would, yes, this is a part that I take into my business case. So, I know what my cost of capital will be. But there is at the energy market is much more as much more other factors. So, I think the direction is clear where everybody wants to go, we all know how tricky these investments in fossils are. There is scrutiny from NGOs from parliament. So, this helps the transparency. I think that is for the that's why I mentioned that in the beginning. So, it helps avoiding having a lot of dodgy companies and you don't know what they really invest in. So, in that sense, I think it will, it will strengthen it and I don't think it will, it will hamper the energy transition. I think it will even strengthen it because of the transparency requirements.

Interviewer:

Very good. Thank you. The other thing I want I mean; I was going to ask is that you kind of mentioned the policy and the government and the role of government or let's say transparency measurement. But do you see any gap in the policies to let's say promote the intention of let's say European Commission regarding this phasing out for example coal and heavy fuels? Is everything fine.

Interviewee:

Boo, I think in the blue let's say let's see, the other thing is how many new things are we going to build and finance is the government promoting that right now. Then for that I would like to look more at Germany or Belgium for example, where you are focusing on gas fired power generation because I can also talk for hours on hydrogen and what for example, the taxonomy means for electrolysis, so, hydrogen production, but let me focus on natural gas fired power production. And then I think the same holds because a government as to is in the end responsible for security of supply. So, if they see, okay, let's phase out coal, let's phase out nuclear, you need some kind of dispatchable power generation or you have to do this month response at the end you side but that's more complicated. So, if you see that, for example, Belgium has a tender scheme or a tender open for natural gas fired power generation Germany is looking into okay, we need to make sure that we have some kind of reserves for this or congestion management is

we need also dispatchable power fired by natural gas. I think they think that is more important than the taxonomy rules. Okay. So, yes, I think the answer is yes, we see this happening. So, there is a taxonomy but I think for a government who's responsible for this, they Yeah, they see this, but they say okay, but we also need to make sure there is there still is some form of dispatchable power generation let's take the Dutch example. So, we are hitting a heart crisis right now. So, no gas this winter. Yeah. So brace yourself know that it can be serious shortages. Yes. So, they say okay, we will we will lift the cap on coal fired power generation, this is not about investment. So, the investment is already done, but you still see yes, there is policy to okay security of supply is more important. Yeah. So, I think there is a like a policy ladder or something or a policy hierarchy that I think at a member state level or anyone who is responsible for the energy system looks at it from a different perspective. And so, then back to the for example, the tenders for power generation with natural gas in Germany and orange in Belgium. So, the government simply says we need this somebody has to build it, give us your number, how expensive or how many, how much money do you need from us and in that a company will take into account Okay, I will be partially non-compliant. So, I will calculate this in my number and say okay, I need a higher whack because of the taxonomy. So, government. So, that is how I look at it. So, the issue is bigger and security of supply is a bigger, definitely more important, okay. Thank you for granted. I think governments take it for granted.

Interviewer:

Okay, very nice. We are actually coming to the end of this meeting, but for the last question, in short, if you can, you know, answer it in a short way. Do you think any economic indicators much change as a result of these taxonomy for example, building new let's say gas power plants, gas fired power plants may you know, reduce the let's say unemployment rate or something like that are very, very rare?

Interviewee:

So, to understand your question, you say Okay, are there I think you are looking for what would be economic indicators to let's say amend these delegated acts.

Interviewer:

Exactly, exactly. Yes,

Interviewee:

Yeah. So again, I think I don't think nobody will do this, if nobody will really trigger on, for example, unemployment rates. I think it is all about security of supply. And somewhere, I think in your thesis you should default attention to. Okay, saying goodbye to Russian gas, and what does that mean? So, I think as security of supply having, and it's not only natural, natural gas, but it's also coal. So, what will be sometimes for that you need investments. So, if you don't need an investment, it will still be on your transparency list. So, I have this, but if you're investing in something new, so I think the most economic it's not really an economic indicator, but security of supply on an energy level will be good impacts, let's say a revision of A of this delegated act. On the other hand, I don't think that will happen. Okay. Because it is about compliance, it is about a higher risk premium will make it a little bit more expensive. And thus. So, it's also the Okay, now let's say the other way around, I think they could also if we solve this natural gas crisis due to say goodbye to Russian gas. So, if we have solved that, I think they can even sharp and the delegated acts, say, let's, let's make it a bit more tough. So, the indicator

is, okay, do we need to go faster or still being and that's an energy system, economic economist, you need to look at the you also, you always need flexible, a flexible power system, let's put it like so you need sources to deal with seasonal storage, you will need to make sure you can match supply and demand during the day. Yes, you can do that. Also, with partially with renewables, but you need also other solutions. So, the faster these solutions come online, the better. So, the quicker we move to hydrogen and having electrolyzers which can really, really balance and even out the systems combined with hydrogen storage, that could say, okay, let's sharpen it up at the end. So, hope it helps.

Interviewer:

Yes, indeed. Thank you. Thank you for your very passionate, and energetic interview. I'm going to finish it now. I don't have your email address, if it is, if you can send it to me. So, if you can send me an email so I will have your address for I don't know, maybe some more disturbance and irritations for you.

Interviewee:

Always happy to help.

Interviewer:

Thank you very much.

Interviewee:

Okay, good luck. Thank you very much.

Interview No. **7**
Date: **03-June-2022**
Duration: **26' 46"**
Interviewee affiliation: **Renewable energy expert at a renewable energy company**

Interviewer:
Let me begin with introducing myself. My name is Arash. As you can see, I'm a student of University of Twente in a program called Environmental and Energy Management and as a part of my thesis I am focusing on the recent delegated act of the European Commission conditionally considering natural gas-based electricity, green of course as you have just mentioned, it is not directly affected your business and you know renewables, but I believe that as a part of the energy market in the Netherlands, it somehow may affect renewables in general. So, the as a as I mean as a professional who is working on the renewable energy specifically in solar and wind, I would like to have your opinion about this some very short question. Of course, the question that I've sent to you is kind of a general one, but regarding your preferences, we can make it short or we can actually move from side to side, I don't mind it. I guess you are OK and you're happy with answering and giving it or expressing your ideas. To begin with let me start by, I don't know if you have. I mean if you could find time to read or actually scan the act, but the act, as I told you in a nutshell, it has many branches, but the specific one I want to focus on is that considering natural gas-based electricity, I mean electricity produced from natural gas, with certain amount of CO2 emission is going to be green. So, I wonder how this might affect affordability or energy security in whole because you are actually working on an energy providing, let's say business. So, do you think it's going to tilt the balance in the security. I mean we have right now because of the Russian gas.

Interviewee:
Yeah. So. Maybe if I if I can, I can ask 22 questions up front or maybe check 11 assumptions so in my understanding is that this the reason or some of the users of this of this package. Uh, and how it will affect the industry one is on financing I pursue and on. And whether or not you can call something green financing on. Yeah, and be able to put your money in, in the gas fired power station rather than wind or solar. So. So that's one of the purposes I would see but also on say national level accounting or like in Europe that figures would generation from IGCSE meeting these requirements that then also be counted as green and which will be able to meet your target levels through this sort of technology as well? Or is it primarily the first,

Interviewer:
Actually, it's kind of a mix, you know. It specifically sets a limit on the CO2 emission and yes it's going to let's say at the same time aims for phasing out coal plants. I mean, which are actually already being used. But at the same time, the financing of building new plants, let's say is the goals of this act which can be affected in a way. So yes, as far as I know, it has both intentions at the same time.

Interviewee:
Yeah. So then in, in terms of security of supply, I would say yeah. That you would like to resolve. So, you're like basically you're. Your base load your main volumetric source of supply. I would say that, that should be focused on renewable sources, they're cheapest. They're local. You don't rely on anybody to send you either gas or coals or oils or whatsoever. And therefore,

in that light, this takes away a little bit of your security if you also allow your investments to flow towards gas fired power stations in that sense. Then again, you need somebody or some technology to deal with intermittency of renewables.

Interviewer:
Definitely.

Interviewee:
And get her a couple of ways you can. You can solve this. But there will be some fossil in the in the mix. And then I rather have a gas fired power station rather than ever coal fired power station step right. The question is for me whether new investments in gas are justified for that for that cost or what it whether you want to make sure that through. Yeah, so forms of capacity mechanisms for that sort of thing, make sure that that you can postpone closures of gas fired power stations that. And maybe are 20 years old or 25 or whatsoever, and maybe a bit less efficient. And then other, then a new gas fired power station. But. Yeah, for me personally. I wouldn't say that the investment in new fossil capacity should be justified from a security of supply perspective and rather focus on what is there and if you go for new bills, yeah, really focus on speaking capacity and. So that's something that I will that this package, but maybe this is resolved in solving some other way have a limitation on when you can run these plans and just run them for balancing your power grid rather than providing base load so.

Interviewer:
Yes, I can understand. So as a company works in the renewable, don't you see any threat for example, the investment might outflow from renewables to more of gas based?

Interviewee:
Fossil based, yeah. To a certain degree, yes, if you. If you say that. Also, your foundation of your power sourcing can be gas based and can be considered as green, then yes, there is a risk. I do feel that we are now at the point where you should be able to be cost competitive also for providing the say your base load power from renewable sources. Even taking into account the cost of balancing or like midway, mitigating this intermittency. You know this will change in the future as well, most likely, but especially if you [go for] natural gas power generation. I think renewables should be cost competitive over the long run. So, they should be but.

Interviewer:
Sorry to interrupt you. They should be. But, are they right now? I mean are they cost competitive?

Interviewee:
Well, for new build I think so for new build and in, but maybe that that also depends a little bit on which region you were in. So, if you have good solar sources. If you have good wind sources, yes, if you are away from the coast, and maybe not in the most sunniest of areas. There may be more, more challenging and that's true, but we are I feel we are at this tipping point at least and for some reasons we are beyond that tipping point. So, in that sense, or from these fundamentals, I, I would say that, I mean, there's a bit of risk of competition and from the fundamentals that there should not be that much money be drawn away from renewable investments. I'll, but we all know that or I feel that there are quite some lobbying powers from conventional industry that have traditionally been able to attract funds from one well towards their direction. I would, I would say so that that's where I would see where I would see a risk. And also, in terms of

target settings, simply target setting if you allow fossil-based electricity also to be flagged at as renewable, distract away your attention. So, so that's where I see a risk. And in terms of financing specifically. Thus far over the last couple of years finding investors has not been very challenging for renewable energy projects, so the money is available.

Interviewer:
Good news.

Interviewee:
And if it depends a little bit where you are and how risky things are, but in general these sorts of projects are financeable and you would be able to attract the funding that you need. Maybe in a in a more insecure world. Yeah, yeah, you could think of all sorts of scenarios, economic downturn or like international geopolitical stress in some way. It might not be that obvious anymore in a couple of years' time, but thus far, like finance means generally not. It goes right for these sort of projects.

Interviewer:
Yes, thank you. Thank you for your detailed answer. I want to know, well, let's, let's assume making I mean generating electricity or energy from renewables who do you think is the most one who is affected, I mean energy intensive consumers like, for example steel companies or in the minor level. I mean the lower level, for example, household level, who is the most affected one if renewable energy arises or developes?

Interviewee:
So there's the ultimately there's one. Well, we have one power exchange or like ultimately one power price and both commercial companies would buy more or less at that rate through their supplier and so households would be so there are there could be equal benefits in this in this sense.

00:14:55.830 --> 00:14:56.300
Interviewer:
So as far as I can understand that there's no difference in price of I mean the cost of purchasing electricity in the market, whether you are a business, I mean commercial business company or you are household.

Interviewee:
So the price, the price of your generated kWh is similar. At the end and it's just that your transportation cost and your taxes and these sorts of things they are different. They don't. They don't depend on what the kWh constitution of whether that's generated by nuclear or fossil or renewables. But there's a little bit of distribution of income in this sort of thing, so. I don't know if you followed the discussion on like a big data center setting up shop.

Interviewer:
Yes, yeah.

Interviewee:
In in the netlist writer. So, we all pay some money in into the common pot for renewable energy to be funded, but I as a household consumer, I pay much more than a commercial user and now a commercial user sets up shop because I have cheap, sustainable electricity there. So, there's

the distribution of money towards the industry where industry benefits relatively more of having access to renewable electricity.

Interviewer:
Yeah. OK. Thank you, just another question. Because of I actually didn't want to mention this part, but you know it is a very huge debate. So, I have to, you know, consider that the war in Ukraine and Russia actually and the Russian gas, let's say. Suppose that, in the Netherlands the government doesn't want to buy or are not allowed or whatever. They don't want to supply. I mean, they don't want to receive gas from Russia anymore. Specifically in this winter, we're going to have some problems definitely. Do you think renewables are mature and developed enough to fill the gap of this deficit between at the moment?

Interviewee:
No, we are so, so far off. It's just so far off. It's and you cannot deploy this capacity fast enough. So, if you would have been able to plan on these five years in advance. It's not the technology readiness. I mean this. That you, you can now build 10 MW, 12 MW wind turbines offshore. Yeah. If the Dutch Government would have said OK, we want to be energy independent from Russia five years ago, you would have been in this position and you could have said OK, well, well guys, shut down the valve. We're fine. We'll figure it out on ourselves.

Interviewer:
OK, so let's see that from another perspective. So, this is an opportunity for the future, I think, that's for example, if you know the threats of being independent from natural gas, being a net importer of natural gas makes an opportunity for the government to invest more. Let's say, ease the investment in the renewables in the near future.

Interviewee:
Hopefully. Yeah. So that's yeah. I mean there are if you could think about the positive lining on this on this crisis well. Well, let that be it. I would, I would say. Then again, it's there's quite a big difference between. Making these statements as a politician versus actually putting it into practice so. In practice, what I see in my daily business is that these sorts of hurdles that we have that we need to clear on bringing these projects to life are not actively being lowered at this point in time, so. I mean, ambitions are raised and in particular for offshore wind. But once you're [working on] renewable energy in the Netherlands in particular it's very difficult and, it's slowing down rather than speeding up.

Interviewer:
So do you think that is because of the lack of policies or because of the complexity of bureaucratic issues?

Interviewee:
Yeah, both actually and it all stems from government at national level, who don't want to take the responsibility. And push down decision making to lower-level governments. And don't want to burn their fingers themselves because it's political suicide. Yeah, they don't want to tell the story but on the story is you cannot have energy transition without somebody being offended. It's simply the case these wind turbines. They are visible solar panels. They do take up space that that would otherwise be agricultural farmland, for instance. Somebody will be annoyed. But you cannot have everything in in one go, but that's a different story.

Interviewer:
Yeah, I can imagine. And for the final question, because we are getting to the closing stages of this interview. Suppose that this opportunity which actually comes from this crisis in the gas market, you know, benefits the renewable investments. Do you think any economic indicator changes as a result of this renewable development? For example, I don't know, maybe unemployment rate or something like that?

Interviewee:
Yeah, I saw your question in the questionnaire. I've been thinking about this so. And we are already at terrific low unemployment rate, so that's actually a big problem before the energy transition, I would say because we need engineers and we need, well, not only people like ourselves, but also the people who can actually, you know, insulate houses and install solar panels. So I would not see it in terms of employment, although I do see structural employment possibilities for technically school personnel and especially, practical, technical guys, well, and hopefully girls in in the future as well. But like in terms of income I wouldn't. I would say that loops back a little bit to you to your earlier point. Well, in, in a positive way would think about this is that renewable energy so distributed source should be available for everybody should be accessible for everybody. So that also means that the benefits of having this sort of technology rather than going from a centralized world would be decentralized so everybody could have benefits of solar panels or buying a little bit into a wind farm or whatsoever. I think this sort of distributed system uh allows for like more equal. Like sharing of the benefits rather than just profit accumulating to the utilities and that being said, I mean the big push in in renewables will be for offshore wind will be for large installations. So that's still the corporate in this world of the well, the rooms that I'm sitting in right now basically. Yeah, but at least one these are sort of the well, things that I would like. That I would hope to see on this transition.

Interviewer:
Yeah, I hope so as well. Thank you, for your time. Uh. Well, I've actually finished with questions.

Interviewee:
You're paying for forgetting, I hope. Hope it was somewhat useful.

Interviewer:
Yes, definitely. Yeah. It was very insightful. Yes. And thank you. If you want to add anything, I'm all ears. Otherwise, thank you for your time and have a good day.

Interviewee:
Yeah, that's for now. But I'm very curious to the to the results of your research, so please share them when you're at the point.

Interviewer:
Yeah, there's kind of a formality. You know, I should submit it and once reviewed, I will be able to give the results to all the participants.

Interviewee:
Yeah. Well, curious to see, well, best of luck for finalized this project and speak again in the future.

Interviewer:
Thank you very much. Have a good day. Bye.

Interview No. **8**
Date: **10-June-2022**
Duration: **23' 30"**
Interviewee affiliation: **Energy efficiency consultants at a heavy energy consuming company**

Interviewer:
OK, let me begin with a very short introduction of who I am and the project will be, my name is Arash. I'm studying a program called Environmental and Energy Management in the University of Twente as my final thesis, a part of it, I'm working on the recent European Delegation Act, which conditionally approved or labeled natural gas-based electricity green. In general, I want to understand how this act might affect, you know, some other actors in the energy market, for example, energy consumers, producers and so forth. And you as an energy consumer is one of the targets actually, I think might be affected as a result of this act. So, in my thesis report, I will only call you and your statement as the interviewee in an energy consumer, and that will be all. And yeah, these are according to the guidelines of the University of Twente. So, if you want to say anything, I'm all ears otherwise, I will jump into the questionnaire and some specific ones.

Interviewee:
That's alright. Maybe I'll give a short introduction about the transition and let's say the industry I'm working in the […] because that makes, let's say the questions a little bit more easier and also what will happen in the future because let's say natural gas will play a big role in that.

Interviewer:
Definitely.

Interviewee:
So I'll start a little bit of presentation and introducing while I'm talking. I'm working in a […] and in a […] nowadays we make from coal […] or let's say big […] in our […] furnace then we move the […] to a […] factory and we reduce […] and then we make […]. So, this is a very big part of the CO2 in the Netherlands. We produce 12 million tons of CO2 and that we have to get rid of and we have to change a lot. And what we have to change is what I told you, the […] furnaces that is coal based and that we want to make hydrogen based. Though in 2030 we want to build a hydrogen reducing plant and they are with electrolyzer but in 2030 there will not be so much. Let's say renewable energy there will be some, but not everything, so we will have to use natural gas as in transition. So that is what will happen and then we shut down one coal fired furnace and also other plants. This is an electric oven. This is what will happen if you get a lot of renewable energy onshore and this is let's say the wall socket to get all that into the […]. And the situation after. So, in 2050, maybe earlier 2045, we only use hydrogen with renewable energy. So we're now talking, you wanted to know the interaction between the act of, let's say, the EU now the short term and short term is what we call phase one. Like one is, what you see here in a scenario we in 2035 we use natural gas to fire up that new hydrogen based plant because we don't have enough hydrogen. Having said that, that's a little bit of context I want to talk about because as a consumer, I'm going to tell you what will happen in our scenarios, so start sharing. My role in this is I'm energy efficiency consultants, looking at a short term decarbonization, looking at projects with our works. We have 10 works which have to make the transition from natural gas or work rising gases and will make the change to

electrification or hydrogen based. And that's where I have, now a lot of work to do come up. This does give a little bit more context on your question. What does natural gas and greening it will happen with us.

Interviewer:
Yeah, yeah, that was awesome, actually. I just wanted to, you know, keep silent. And, you know, you just go on because in a way, you were just answering all the questions I had, so, if you want to continue, I'm all yours. And I, you know, appreciate it.

Interviewee:
No, no, you have protocol to follow. So, let's start with that. This was a little bit introduction to little bit more focused what natural gas means as a transition because we're not the only one going for hydrogen. So, I see a big, very big transition, natural gas, the mold not only in the Netherlands but, well, let's say into Europe.

Interviewer:
Yes, of course. So, in this way, I can say and correct me if I'm wrong, that you have hard let's say deadlines for using renewables and phasing out natural gas. So, if we want to talk about medium term and long term. You think that, you're at least as an energy consumer. This act will not end up in a natural gas dependent industry?

Interviewee:
No, we don't have a buy in.

Interviewer:
OK. OK. So very nice to hear that. Let's ask it in another way that the only substitution for this natural, I mean, let's say coal or heavy hydrocarbon-based energy resources, you see only hydrogen and you're not after for example electricity and so on.

Interviewee:
Some parts of the factory will be electrified and the natural gas of the, let's say ovens which have not so high temperature. The advantage of natural gases that you can mix it with hydrogen so you can slowly go to, let's say from zero to 100%. So that's why it is a transition.

Interviewer:
Yeah. OK. So, Let’s assume that, we face a situation in energy market that, for example, renewables by renewables, I mean wind and solar energy, which actually end up with electricity in a way become cheaper or not cheaper, more accessible. How does this affect you? I mean, how does renewable accessibility affect a company who right now actually supplies, majority of its demand from coal and natural gas.

Interviewee:
It affects us a lot because now we're an electricity producer because with coal we produce work rising gases, we burn it and we produce, let's say, our own electricity. If you get rid of the coal, you're now, we'll have to import electricity. And renewable has one disadvantage. It's not a stable production and what we need for our production, we need a stable electricity. So, you will see not only changing renewables have an effect on the electricity grid, but also make it to store it in to store. I mean you will see that there will be converging to hydrogen. But we will play another role in that, but natural gas will have to help to get stable. Also, electricity grid.

Interviewer:
Yes. Definitely. So, the other question I have is that let's say invasion of Ukraine aside, and let's, for example, assume a day that everything goes back to, for example, a couple of months ago and the market is the same as it has been. Do you think more, let's say natural gas will help your energy supply chain be more secure? I mean, would you see yourself more secure in having access to energy?

Interviewee:
If I compare it to coal, I can buy anywhere to be honest. Gas you have to get through pipelines. There's a very strong grid in the Netherlands, so you can import it from anywhere. And although gas can be imported via the LNG route, I don't think the supply will be let's say a problem only the pricing because that's more the mechanism, the of the availability and yeah, because 50% of the supplies now is coming from Russia. We are supposing in this hypothetical situation that it's not Russia who is shutting off, but between 2020 is not a problem.

Interviewer:
OK. OK. Very nice. Thank you. I was going to ask something about, but let me ask it in this way. Do you have certain plans to utilize more renewable, especially hydrogen, to your plant? Do you think, for example, if we have more access to now called green electricity, if we have more access to this kind of electricity which we know that's originally comes from natural gas, do you think your investment in renewables might, for example, shift in a way to, for example, acquire more electricity, which is now labeled green and has many benefits, you know, regarding the subsidies, might be applicable to that, do you think any outflow from renewables?

Interviewee:
Now maybe. A little bit on the electricity. The electricity is labeled with a certain pension percentage of CO2 because we use natural grid electricity. And you will see in the upcoming years it will green because the availability of renewables is increasing, but it still has a percentage up to 2030 of, let's say, CO2. What I think would happen is with this gas to electrification, what does the customer want, because the customer says I need green [product]. So, and you can label national natural gas green, but that's not happening. So, there is another let's say driver to change to 2040 to get green and that is not the natural gas act but the customer.

Interviewer:
OK, very nice. And do you see any lack of policy in for example, let me ask it in a more general view, do you see any lack of policy regarding this transition from carbon based to less carbon based and then to, you know, carbon free energy resource right now? Especially in the context of heavy consumers like […].

Interviewee:
Now that's a little and that's little bit is creating the level playing field for company. And you have now some, let's say gas in place, but the politics are not consistent. So, my biggest worry is that they come up with some level playing field, but the next government, which comes in two years will change. It's not that I miss something because the climate law is giving a, let's say, the reduction of 40%, but we need a very stable investment policy and also subsidies to get there and I think they will be there. Because these are plants, you have to make for 10 years, you don't change. Let's say what you saw. You build a factory not in two years. So, there will be a discrepancy between what the politics are doing and what we have to do. I think is there a

lag. This distance so that it changed too much sometimes and that's not so good for investment plan.

Interviewer:
OK, so you need more stable, let's say decision making and policy.

Interviewee:
Yeah, long term. And let's say you have stable policies.

Interviewer:
OK, very nice. And, yes, we know that, as a huge company you actually can contribute a lot to, for example, economic indicators like unemployment rate or let's say GDP and so on, bearing in mind that this act might affect you, how do you think your company may contribute to these two indicators I just mentioned.

Interviewee:
Let's say we have a big problem. The unemployment rate that we, we don't have enough labor of people.

Interviewer:
Oh yeah, you're actually, you're actually struggling with the other way around.

Interviewee:
Yeah, because we have, let's say 9000 people and most of the people are older than 50 years. So, we have to change. We have to educate new operators, new people in the upcoming 10 years. Yeah, we have a serious problem because you can build something, but you hardly get people to operate your plant. That's a little bit maybe not answer you want here, but.

Interviewer:
No, no, it's OK.

Interviewee:
So I foresee in that the biggest problem. You need everyone to make that transition to be honest.

Interviewer:
Yes, definitely, of course. I think, I asked all of my questions and there were some very tiny ones that you already, perfectly answered. Yes, that's all from my side. I see no more issues left. Once again, I'm very thankful and delighted for your time and if you want to add anything, I'm yours and the time is yours to say anything you want.

Interviewee:
Thank you. It was a pleasant conversation and I hope you will succeed in getting your master degree. And when is it planned that you?

Interviewer:
Well, I have to finish it by the end of the August. I hopefully will be graduated. Thank you. Thank you very much for your time and have a great weekend. Thank you.

Interviewee:
Have a nice weekend and bye.

Interview No. **9**
Date: **14-June-2022**
Duration: **19' 32"**
Interviewee affiliation: **Manager at a carbon capturing company**

Interviewer:
I think yes, it's just started. First of all, I would like to thank you for your time and actually I think I don't need to introduce myself.

Interviewee:
No.

Interviewer:
And not to waste your time and to keep it short, I want to know your opinion in general. What do you think about this delegation act that's conditionally of course called electricity from natural gas, green, in general, how do you see it? You know, do you see it's going to promote the energy transition or it's going to hamper or hinder it in a way, the floor is yours.

Interviewee:
I think this can really help energy transition because you're staying on well-known well proven technologies and keep on using. Using that and I think that's the key. Of course, it has to be in combination with carbon capture, at least you need to take out the CO2 for the largest part. And that for me for our personal business is of course very good. It also helps to accept a carbon capture as a technology, I think.

Interviewer:
Yes, definitely yes. We have seen, you know, recently in the Netherlands, of course there's been a lot of effort to electrifying energy consumption, you know, to make use of electricity instead of, for example, direct natural gas in the household levels. And you know, maybe in some industries. So, suppose that this act, you know, comes into force by the end of this year. And you know, we have some I mean, let's not bias your mind, I mean. But let me ask it in this way. Do you think that energy for, you know, even household levels or in macro level would be more affordable and reliable and secure according to this act? Because of this, you know, investment in electrifying almost everything in the Netherlands.

Interviewee:
I think the main application for this would be in large, well, at least for if you talk about your home, your, your private world, I don't think you will find a carbon capture after every CV boiler in Holland so that would be a bit ambitious so, I think that the main application in that respect would be electric power from gas fired power stations where you can do carbon capture and I think that's very good. However, and of course, there's a lot of discussion on the dependency on natural gas on Russia at the moment, and that is of course difficult. So, I think that, for at least for those applications and for households, it's good to electrify. Basically, yeah.

Interviewer:
OK, you actually mentioned the other question of mine, which is how do you see dependency to natural gas as a result of this act, for example, you know, because it is in a way tries to replace heavy fuels, for example, coal and oil with natural gas. Do you think we're going to face a gas locked in society or gas locked in industry in the coming years?

Interviewee:
I think this is a, although it's obvious it's a very tough question because it's very much depending on where we will get our natural gas from. You see on one side, we want to become independent from Russia, which is the biggest natural gas producer in the world, at least for European market. And on the other hand, you have other countries that want to supply a liquid natural gas to Europe. However, there is a price tag to it and they will not try to make it as cheap as possible. There's also business model behind it, I think. Yeah. So, in that respect, this act I think will make us more relying on the natural gas for a longer time than we think now. But the conversion from heavy or how you say that heavy fuels or coal or that kind of stuff into gas, I think that transition could be, could be easier, could that could help, but it will make you more dependent on natural gas and I think that's. I think the biggest by far the biggest benefit is maybe not looking at the power generation and the big gas fired power plants, but look at the industry because they industry is huge all over Europe. They have a lot of equipment that are running on natural gas or it could be CHP plants, it could be engines, it could be turbines, it could be boilers, there could be ovens and those things if you want to get away from natural gas, I mean that means a huge investment in the entire production facility in Europe, which I think is almost undoable, it's at least in the time frame that stands for, and this act gives the producers or the industry the opportunity to keep on doing what they're doing best, right, making cookies or making paper or whatever. And still become green by adding a carbon capture plant.

Interviewer:
Yeah. So, in this way, in let's say in long term you don't see any threat for renewables. You know for example investment to outflow from renewables to you know traditional natural gas or fossil-based energy supplies.

Interviewee:
No, I just think the downside is that dependency on natural gas from especially some specific countries or other sources, because in Holland we don't have that much anymore. At least that's what they say.

Interviewer:
OK. Thank you for your answers. Up to now, I would like to know if you have plans, I mean, any cases in your company to for example, take advantage of this acts, do you think it is going to, you know, help you with your business to improve or you know it doesn't have any effect on you?

Interviewee:
It does very much have an effect on me because it helps me sell my product.

Interviewer:
Yes.

Interviewee:
It makes selling my product easier and also convince customers to this technology, but also to invest in the natural gas plant instead of something else. So, I will use it mainly in commercial discussions with customers.

Interviewer:
OK. And in comparison, among your customers, I mean I know that you have different types of customers because you know depending on their fuel, they use for their you know energy

providing or energy supplying which one do you see more attracted to this Act? The coal-based electricity producers or I mean heavy fuel or for example, natural gas based one?

Interviewee:
Well, for me and in the business, we're doing, I think the industry again is the is the biggest.

Interviewer:
OK, then want you actually are focusing on are the one who uses natural gas directly as a source of energy. OK, very nice. And, but this I don't know how much you are familiar with this type of grey hydrogen, which is pretty conventional nowadays. Do you think increasing or producing any grey hydrogen especially would have any effect on your company? You know, in a way or the other.

Interviewee:
Well this this can also be a commercial opportunity for me. I mean, if you have to take out the CO2 from the from the natural or the yeah, the natural gas to produce hydrogen and that's great. So, there I see an opportunity, although I must admit it's opportunity that I haven't explored so far yet. I know it's there, but I didn't have the time to dive into it. Yeah. Like I'm just also see that. My background is also in the […] industry. I've been working for a very long time and I see there that people who were focusing on hydrogen all over the place by manufacturer talks about my turbine can run on hydrogen and I'm the best. But now that it's everybody can do it, or at least it's working on proving that you see that people think, well, maybe there's hydrogen is not ideal because it's so expensive and it's very limitedly available. So, from that respect. I'm not sure if that will be such a big part of the future. Especially if you consider how much hydrogen you can put into a large turbine, that's huge amounts, yeah.

Interviewer:
Maybe an irrelevant question. Do you see any kind of subsidies which can actually, help you with your business actually to improve, you know, because you are going to reduce this, I mean GHG emission in total, if we can call in this way, do you think there are any subsidies available and if so what are they and if not how or what kind of policies can you imagine of or think of that can you know help you with your business?

Interviewee:
Well, the more subsidies the better, of course. It all comes down to the dollar. But there is some, but there is not much. I would like to there to be more there there's for instance one customer we're talking to who is in investing in a new CHP plant actually not far from Leeuwarden and he wants to attach a carbon capture to it. And it's a new combination he can apply for some subsidies, but not for any capture system. It's available only when you do something new, and I think that could be maybe expanded a little bit.

Interviewer:
OK. Very nice. And OK, in this way, I think I've asked a lot of questions and, you know, I'm running out of the questions of course, because you're answering very directly, I mean and precisely. So yes, I don't have to actually try to extract more. Yeah. Let's assume that this actually promotes generation of electricity from natural gas in a way. Do you think it is going to, you know, increase or even decrease any economic indicator, for example GDP?

Interviewee:
I think this is a very, very tough question that is, I don't think I can give a sensible answer to it.

I don't. I don't understand. Simply don't have the knowledge. I can I mean electricity. We need. But I don't see it as something that will generate more jobs. It just might help maybe even not the congested electricity network that we have in in Holland. But that's more network related than generation related, I think.

Interviewer:
Yes, I just asked this question once again before, but if you don't mind, I would like to know specifically, do you think any lack of policies regarding the, you know, taking advantage of this act?

Interviewee:
Well, there is. There's still a lot of discussion about this act itself. Maybe that's the first thing to solve. If you read about it, there are many people for it, but also many people against it for several reasons. But I don't think at the moment it needs a lot more policies.

Interviewer:
OK. Yeah. Do you think a competition between the business you have, for example carbon capturing and you know renewable technologies, at the moment?

Interviewee:
Well, I think this market is so huge, so big, there is room for so many companies. I'm really not. I know I cannot be the only one I know. I cannot be the biggest, but there's still such a large part of the market that we can capture. I think that there's plenty for all of us. I think that even if it can take a small part of the market then then you can still earn a nice living.

Interviewer:
OK. Yes. Because, you know, the reason I asked this question is because I'm going to build a fuzzy cognitive map, so I have different concepts that might have effect on the other, you know concepts. So, I just wanted to know if there is a relation between, for example, renewable accessibility to people or to the industries, let's say and for example CCS companies, is there any relation between them in a way, you know, positive or negative?

Interviewee:
Well, I think especially our technology, enables people to keep on doing what they're well doing well. It's the same answer as I give before maybe, but I think this is this is the key you can keep on focusing on your own core business. And even with us as a company that I think the best way forward would be to offer carbon capture as a service, so the customers don't even have to worry about it. So, we'll take care of it. You keep on doing what you're doing best.

Interviewer:
Yeah. OK. Thank you very much. I have asked all of the questions I had and, in the end, you know, if there is anything left or you want to comment on or you want to ask or everything I'm totally yours. Otherwise, thank you for your time. And yeah, I can finish.

Interviewee:
OK, I'm sorry that my camera didn't work.

Interviewer:
No, no, it's OK. It's totally OK. Thank you very much for your time and have a nice evening.

Interviewee:
That same to you.

Interview No. **10**
Date: **22-June-2022**
Duration: **28' 47"**
Interviewee affiliation: **Energy advisor at the Ministry of Economic Affairs and Climate**

Interviewer:
OK. Before we go to the details, let me I mean introduce myself a little bit. Well, my name is Arash. As you can see, I'm studiyng a program called Environmental and Energy Management at the University of Twente and for my thesis report, I'm working on the delegated act of the European Commission, which conditionally labeled natural gas-based electricity green. I would like to say that, uh by now I have almost finished, you know, building the fuzzy cognitive map, which I'm going to work with and I don't want to, you know, and I won't be wasting your time with general questions like, for example, how do you see this? I mean, will it promote affordability and reliability of the energy in the Netherlands and so on? And I would like to ask about the, you know, let's say future scenarios regarding this present situation we have in the Netherlands. And yes, that's how I'm going to use your opinions here, but before you know, diving to the questionnaires, it is, I think, nice to have your idea about this act. How do you think about it? I mean, do you think it's going to promote energy transition or, you know, it hinders it in a way.

Interviewee:
OK. First let me introduce myself as well […]. I work at the Ministry of Economic Affairs and Climate. In a part of the ministry that's involved with the top sector policies and industrial and sustainability policies. And half of my time, due to one thing and half of my time, you're right. So from the top sector perspective, I'm secretary to the top sector energy, which is a public private partnership on all kind of innovations regarding climate change. And today, the other half of my time, I'm involved with several topics on sustainability of the industry in the Netherlands. Including fiscal issues, but also electrification, circular carbon, the infrastructure issues and the like so that's basically what I'm doing. So, your questions specifically on this topic involving of course. The gas crisis we have in the Netherlands as a result of the war in the Ukraine. Well, it's not my special interest, but I know a bit about it. So that's how I introduced myself at this moment. I've tried to find someone who could tell you a bit more specific on the topic, but unfortunately, I haven't been able to track the right person down in time and I thought, well, another week might be too late for you.

Interviewer:
Yes, definitely. You know, I have to finish it by the end of this month. I mean, the draft version actually should be submitted, you know in the first week of July. OK, thank you for your introduction. And yes, I still want to know how do you think about the act itself?

Interviewee:
Well, well, actually, you're in general the Ministry of Economic Affairs and Netherlands in general are in favor of the, energy and climate policies of the European Union. Of course, we support strongly the EU in the measures taken. And regarding the war Ukraine showed that the consequences will have to be met, of course, and I think what the Act is, a way to deal with the consequences. If you look at the Netherlands specifically, we want to increase innovation and

actually a bit more than that. Also, the rollout of other possibilities of using gas. Which means, of course, that there is a huge extra push on, for instance, hydrogen production in the Netherlands. Next to that, I think public knowledge that we also encourage import of liquid natural gas from the United States or other countries worldwide show basically that what we're doing in the Netherlands at this moment. Not knowing the act very precisely. Well, in general we are supportive, but there could be of course some articles that are due to further discussion.

Interviewer:
Yeah. So, at the moment, I can understand that, there are no specific regulations in alignment with that act actually enacted or being enacted in the Netherlands. Is that correct?

Interviewee:
Well for first of all, that European acts have to be implemented in the Netherlands when they are in place. Second, we have a policy on how to deal with the gas crisis. That's not yet stated in in law in the Netherland, yet. Well, of course we have within the existing laws possibilities for crisis situations, but at the moment we were thinking about what should be the priority when we have a lack of gas in the Netherlands. That that's one thing and this involves also some of the bigger industries in the Netherlands, and I think what the priority is refers to households to prevent them being in the cold, and then of course the next the industry and economic issues. Of course, all kind of institutions like hospitals, etcetera come first as well. So, we're thinking and we also discussing with the industry that the possibilities of when the crisis is really there and there is really a big lack of gas in the Netherlands, how should we divide this scarcity? And then, well, some of the bigger companies might have less access to natural gas in the Netherlands.
So of course this comes through the price. So, we are not really doing it if it isn't absolutely necessary, but you might have learned also that government at the moment is busy trying to refill the gas storage in the Netherlands.

Interviewer:
Yes, yes.

Interviewer:
Yeah. And it should be as full as possible. But when we reach targets like at least 60% or so, then we hope to evolve, the situation that we have to take the measures on the on the crisis level as I stated. What I'm telling you is basically common knowledge in public knowledge. Although I'm not sure if all the newspapers are quoting correctly, but it is actually. What it is the and I think that you could all show look at the parliamentary discussion on the topic. Then you can find the official information about it, although I'm not sure whether or not you can find it in English.

Interviewer:
Well, actually Google Translate made it easy nowadays. Yes, I can look for it. Thank you. Let me ask it in this way. Well, suppose that we have, three temporal decision-making process or let's say activities which is short term, medium term and long term. In short term I could understand from what you said that yeah you have to prioritize the demand side for example between household emergency services and then industries to just, you know, divide or distribute the amount of gas or let's say energy we have right now or we're going to need in the coming winter, but what about medium term and long term? Because you know the crisis right now, I mean the war in Ukraine, will be finished, you know, it's going to finish. It's not going

to last for, you know, decades. Let's hope for that at least. But after that and after everything goes back to, for example, what has been a couple of months ago or last year, do you see any plan? Any policymaking? Which can promote this energy transition just keeping this present or current situation aside.

Interviewee:
Yeah. Well, first of all, our Minister has already made public debt. This crisis, which is for the short term, indeed a real crisis. On the medium term should be met by enhancing the innovation and also the roll out of other means than gas showed. He sees it as an extra stimulation to quicken the energy transition towards, for instance, hydrogen, which is the most obvious first. The thing that comes in mind, but also other forms of renewable energy are also. So, you see that in the industry a lot of processes might be electrified. So also, if we already had a plan of course for more offshore wind in the Netherlands to do also for our industry of course. So, these plans are only enhanced by the fact that we have described […] we hope and we believe that in the medium term and the long term we will be more independent on Russian gas and then of course, there's also Norwegian gas. There's also gas from other regions, etcetera. So, whether or not we will be fully independent from gas exists or just from the Russian gas to be seen. But the idea is that within a few years we will be independent from Russian gas that that's the what we aim for and what we think we can achieve. And in the meantime, we have to take these extra measures and one was. Well, I think yesterday or the day before issued and that there's we will have to call plans running more than we had in mind. That way we had the policy that from this year on the only 35% capacity for the coal plants and we're back 100% capacity, which is of course an extra carbon emission in the Netherlands. In terms of the energy trading system, it is not a problem because there's this European and of course it has to do with prices.

Interviewer:
Absolutely. Yeah, definitely.

Interviewee:
That would evolve. But as you can well understand, the NGOs are not very happy with this decision. And of course, the government has to make the decision whether or not, well, do we want the electricity or not and what are the options instead of data came up with this plan. So that's a short-term we hope and we aim for. Well, independence from Russian gas at least independence from gas as a as a whole if possible. And well, it triggers of course more fundamental issues. Today's Russia tomorrow it might be China or some Middle Eastern country or whatever so geopolitical. The developments are actually helping us to reconsider where we are dependent on and if you look for instance also at the feedstock of our industry, specifically in energy, you have the scars metals where they come from. Then our Dutch policy and I believe also the European policy, is more and more on looking into where are we really dependent? How can we lessen the dependence for geopolitical reasons? As I stated showed it is a trigger for more than just gas.

Interviewer:
Yes, thank you. Thank you for your detailed answer. I have a, let's say tricky question here, where does Groningen stand in this, you know, getting independent from the Russian gas because in the Netherlands, yeah, we already have lots of natural gas reservoirs, but we decided on not to use them anymore. Do you think any possibility, at least in for example, let's say short

term or medium term that policy makers or the governments, you know, change their mind and you know, start extracting more from Groningen field?

Interviewee:
Well, first of all, you can never say never. Policy [makers] will change their mind is always possible. So, but that's the general generic answer. But the what this government already has made public is that using gas from the holding of fields will be absolutely, absolutely, absolutely the last resort. So, the answer is no, we're not going to do that. We're not in the situation that we think we need it right now. So, we're not going to do that. Then again there is discussion about extra gas from the North Sea and other fields in the Netherlands.

Interviewer:
Yes, yes.

Interviewee:
So that's not as much gas as there is in the Groningen field of course. But there we are really exploring the possibilities to get extra gas from there and even if you look at more economical way, we have some smaller gas fields on the Dutch North Sea and it takes extra money to have the last reserves out of this, for instance by electrification and things like that. But given the gas prices as it is this moment economically, it's feasible to invest in this extra extraction from the fields. So, so well, we're thinking about that, but not the Groningen field. That's really the thing we don't want to. But then again, that's what we think about now at this moment. And I think that only if the winter is extremely cold and we have no gas left or then perhaps politician might be inclined to wrinkle shatter.

Interviewer:
OK, thank you. And, you know, let's say, , in long term, as you just mentioned, the Dutch Government have planned to phase out or rule out natural gas, but in the meantime, I mean up to that point, we need to lower the carbon emission, let's say CO2 emissions to the atmosphere. Do you think there would be, some kind of subsidies or incentives, let's say, for carbon capturing and storage companies in place in, I don't know, maybe in the medium term and long term.

Interviewee:
Yeah. Yes, we already have. We have the SDE scheme, which is a subsidy scheme, but it is due to the agreements we might, the client, the Dutch climate agreement states firmly that it's only for industrial carbon emissions, not for energy carbon emissions. So, for instance, the coal plants which are more activated right now as I stated. Well, first of all, if you want to implement carbon capture and storage for four days school plans while you're four or five years further on before you have implemented it. And by that time, we hope we have alternatives, so it makes enough not very much used to go into this. This shows the policy way, but at this moment we are the subsidy schemes are for the carbon emissions of the industry and then you can think about, for instance, the plants that make grey hydrogen if you do it with carbon, with CCS then. Of course, you have blue hydrogen and the Netherlands together with Germany is the largest hydrogen producer, grey hydrogen, so to say in Europe, and also one of the largest users of hydrogen. You know, and by far the largest user compared per capita. Which is actually also, well, difficult concerning the European plans, that 50% of all hydrogen use in the industry, by 2030 must be green hydrogen and it is a huge amount for the Netherlands and for some countries not using hydrogen as it is. Well, there's a goal, but for us it really a huge issue. We want I think

about 6 gigawatts of electrolyzing capacity in 2030 and then we also need to import some green hydrogen or green ammonia or what form whatsoever. And at this moment we have installed 2.5 to 3.5 megawatts. So, the gap is enormous and the loss and the next eight years to invest in in this capacity, but then again, never waste a good crisis. As I say, this gas crisis is an extra impulse to go forward on this. Of course, with all the extra offshore wind, it will also be feasible that, and we know about a lot of companies really having already made their final investment decision on the building height of hydrogen electrolyzers so we are optimistic, but then again, the challenge is forever huge on this point is there's a bit of an answer on your question.

Interviewer:
Yeah. Thank you. Yes, because we are getting to the, you know, end of this interview and I don't want to waste much of your time more than this. Thank you very much. For the first, time, your time actually devoting to this interview. And then your precise answers. Now if you want to add anything or you think you know it's good to have, any comments are more than welcome. Right now, the floor is yours. Otherwise. I should finish or end the interview and, wish you a very good day.

Interviewee:
OK. Thank you very much. I would be very interested in receiving your paper or an outline of it when ready and at this moment I don't have anything to add. Have you any questions? You know my e-mail address. So, you know how to contact me. So, feel free to at any questions you have.

Interviewer:
Thank you.

Interviewee:
Although I cannot promise that I can answer all your questions of course, but, well, we'll see. But in the meantime, I wish you all the best in finishing your paper and your study. So, as it is.

Interviewer:
Thank you. Thank you very much and have a good day. Bye.

Interviewee:
OK. You're welcome. Bye.

8. Appendix 2 (FCM results)

Table 17. Figures of scenario 1

Step	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.00	0.50	0.50	0.50	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.00	0.50
2	0.36	0.12	0.71	0.77	0.88	0.80	0.88	0.71	0.80	0.75	0.82	0.56	0.42	-0.40	0.48	0.51	0.60	0.53	0.75	-0.24	0.66
3	0.29	0.05	0.84	0.90	0.94	0.90	0.95	0.75	0.99	0.82	0.87	0.49	0.49	-0.71	0.19	0.51	0.71	0.44	0.83	-0.49	0.70
4	0.26	0.06	0.87	0.91	0.94	0.91	0.97	0.73	0.99	0.83	0.87	0.47	0.49	-0.85	0.10	0.58	0.77	0.39	0.84	-0.66	0.72
5	0.26	0.06	0.88	0.91	0.94	0.92	0.97	0.71	0.99	0.83	0.87	0.47	0.49	-0.91	0.09	0.62	0.79	0.38	0.85	-0.76	0.73
6	0.26	0.06	0.88	0.91	0.94	0.91	0.97	0.71	0.99	0.83	0.87	0.47	0.50	-0.92	0.10	0.63	0.79	0.38	0.85	-0.81	0.73
7	0.26	0.06	0.88	0.91	0.94	0.91	0.97	0.71	0.99	0.82	0.87	0.47	0.51	-0.93	0.10	0.63	0.80	0.38	0.85	-0.82	0.73

Table 18. Figures of scenario 2

Step	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21
0	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
1	0.39	0.73	0.53	0.50	0.50	0.49	0.54	0.50	0.00	0.40	0.73	0.73	0.72	-0.57	0.72	0.00	0.70	0.72	0.54	0.00	0.50
2	0.26	0.11	0.70	0.80	0.90	0.81	0.87	0.75	0.81	0.75	0.79	0.70	0.88	-0.64	0.40	0.00	0.78	0.65	0.73	-0.04	0.66
3	0.26	0.06	0.84	0.90	0.94	0.90	0.95	0.76	0.99	0.84	0.82	0.53	0.75	-0.70	0.10	0.00	0.83	0.50	0.79	-0.11	0.70

Table 19. Figures of scenario 3

Step	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21
0	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
1	0.39	0.73	0.53	0.50	0.50	0.49	0.54	0.50	0.00	0.40	0.73	0.73	0.72	-0.57	0.72	0.50	0.70	0.72	0.54	0.00	0.50
2	0.27	0.11	0.71	0.80	0.90	0.81	0.88	0.75	0.81	0.74	0.84	0.70	0.88	-0.82	0.52	0.45	0.71	0.65	0.77	-0.26	0.66
3	0.26	0.05	0.84	0.91	0.94	0.90	0.95	0.77	0.99	0.83	0.84	0.53	0.75	-0.88	0.17	0.49	0.78	0.49	0.83	-0.49	0.70

Table 20. Figures of scenario 4

Step	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
1	0.54	0.00	0.53	0.50	0.50	0.50	0.54	0.50	0.00	0.48	0.61	0.50	0.00	-0.57	0.50	0.50	0.73	0.50	0.53	-0.05	0.50
2	0.43	0.00	0.71	0.77	0.89	0.81	0.89	0.71	0.81	0.77	0.76	0.44	0.00	-0.81	0.35	0.51	0.76	0.39	0.76	-0.33	0.66
3	0.33	0.00	0.84	0.90	0.93	0.89	0.96	0.73	0.99	0.83	0.84	0.41	0.00	-0.88	0.16	0.55	0.80	0.37	0.83	-0.56	0.70

Table 21. Figures of scenario 5

Step	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.50	0.00	0.65	0.69	0.50	0.70	0.61	1.00	0.96	0.44	0.63	0.50	0.00	0.00	0.46	0.00	0.50	0.50	0.53	-0.05	0.50
2	0.37	0.00	0.83	0.89	0.90	0.89	0.92	1.00	0.99	0.78	0.84	0.46	0.00	0.00	0.17	0.00	0.71	0.38	0.73	-0.13	0.67
3	0.29	0.00	0.87	0.91	0.94	0.93	0.97	1.00	1.00	0.84	0.88	0.43	0.00	-0.14	0.06	0.00	0.76	0.35	0.80	-0.22	0.71
4	0.26	0.00	0.87	0.91	0.94	0.93	0.98	1.00	1.00	0.84	0.87	0.44	0.00	-0.32	0.05	0.00	0.78	0.36	0.81	-0.30	0.72
5	0.26	0.00	0.87	0.91	0.94	0.93	0.98	1.00	1.00	0.84	0.86	0.45	0.00	-0.48	0.05	0.00	0.80	0.36	0.82	-0.37	0.73
6	0.25	0.00	0.87	0.91	0.94	0.93	0.97	1.00	1.00	0.84	0.85	0.45	0.00	-0.61	0.05	0.00	0.82	0.36	0.82	-0.43	0.73
7	0.25	0.00	0.87	0.91	0.94	0.93	0.97	1.00	1.00	0.84	0.84	0.45	0.00	-0.69	0.05	0.00	0.84	0.36	0.82	-0.48	0.73

UNIVERSITY OF TWENTE
Drienerlolaan 5
7522 NB Enschede

P.O.Box 217
7500 AE Enschede

P +31 (0)53 489 9111

info@utwente.nl
www.utwente.nl