Securing the Future of Energy: Analyzing the Impact of Dutch Energy Policy on their Energy Security

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Preface

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Sincerely,

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Abstract

The increasing threat of climate change necessitates an energy transition towards renewable energy sources, since energy plays a critical role in potential sustainable development. In this context, energy security, the continuous supply of affordable energy, is essential, together with effective policy. This study aims to evaluate how effective Dutch energy policies are in ensuring energy security amidst evolving geopolitical, economic, and environmental conditions. Utilizing a comprehensive framework derived from extensive literature review, the thesis assesses energy security through four dimensions: availability, affordability, acceptability, and accessibility. Each dimension is measured using specific indicators tailored to the Dutch context. The research employs a case study approach, using qualitative document analysis and the tailored framework to analyze the current Dutch energy security and the impact of policies on it. The results demonstrate an overall good energy security of the Netherlands, with strengths being the continuous supply and adaptability of the Dutch government. The weakness of the Dutch energy security are the high import dependability, net congestion and a declining trust in governmental institutions. The thesis concludes with recommendations for enhancing policy frameworks, such as a shift towards a more holistic perspective, to better secure the nation's energy future, addressing gaps identified in the analysis and suggesting areas for future research. Future policies must continue to change and grow in order to secure a sustainable energy future.

Introduction

The concept of energy is essential in contemporary society, as it propels economic development, social well-being, and environmental preservation (Asif & Muneer, 2007). Given the global challenges posed by climate change, the shift towards renewable energy sources is needed in the form of an energy transition. Climate change, caused by the release of greenhouse gasses from anthropogenic activities, causes unpredictable weather patterns, increasing global temperatures, and more severe natural disasters, highlighting the necessity for a substantial transition in energy systems away from fossil fuels (Romm, 2016; Solomon & Krishna, 2011). This transformation is not needed just for the purpose of mitigating climatic consequences, but also for the purpose of guaranteeing a sustainable future for future generations (Owusu & Asumadu-Sarkodie, 2016). Energy is closely interconnected with several Sustainable Development Goals (SDGs), including accessible and environmentally friendly energy, economic advancement, and efforts to combat climate change, making it a fundamental element for worldwide progress and stability (Owusu & Asumadu-Sarkodie, 2016; Mathez & Smerdon, 2018; United Nations, n.d.-b).

Energy security, defined by the International Energy Agency (IEA) as the continuous supply of energy at an affordable price, plays an essential role in this context (IEA, n.d.). In spite of that, energy security lacks a definitive consensus over its definition and assessment (IEA, n.d.; Ren & Sovacool, 2014; Siksnelyte-Butkiene et al., 2024; Sarkhanov & Huseynli, 2023; Hu et al., 2022). Nevertheless, it is commonly referenced in policies and strategic frameworks (Winzer, 2012). Policies are crucial in determining energy security and its influence on wider concerns such as economic stability, environmental sustainability, and social equality (Knill & Tosun, 2008). Efficient policies may reduce risks, foster innovation, and facilitate the shift towards resilient, low-carbon energy systems. Accordingly, insufficient or poorly organized policies might worsen weaknesses, resulting in energy interruptions in demand and supply and environmental decline (Knill & Tosun, 2008).

Due to the contextual nature of the factors used when measuring energy security, measuring energy security therefore requires a holistic approach that considers these various contextual dimensions, ensuring that assessments are not only accurate but also actionable. Given the contextuality and interdependencies of energy systems, there is a need for a flexible framework to assess the energy security of a country. Such a framework must accommodate the diverse and evolving nature of energy sources, technologies, and geopolitical landscapes (Sovacool & Valentine, 2013).

The Netherlands is a good example on possible energy security issues. Firstly, the reliance on imported energy and its geographical position in Europe, as emphasized with the current geopolitical tensions such as the Russian invasion of Ukraine, causes potential vulnerabilities towards import stability (Ozili, 2024). Secondly, the Dutch landscape is characterized by difficulties such as the closure of the Groningen gas field. These highlight the intricate relationship between energy security, policy, and geopolitics (Ozili, 2024; Boitz et al., 2024).

Hence, to completely understand how the relationship between energy security and policies manifests, this thesis presents the following research question: *"What is the impact of current energy policy of the Netherlands on their energy security?"*. The objective of this study is to evaluate the effectiveness of Dutch energy policy on a national level in maintaining energy security in the face of evolving geopolitical, economic, and environmental conditions.

The following section outlines the methods used for this thesis, followed by the defining and conceptualizing of energy security to determine the framework used. Then, the framework will be applied to the most recent Dutch situation, and an analysis of the Dutch energy policy is given. The thesis will culminate with a comprehensive analysis and recommendations for future policy orientations. This research also discusses its limitations, emphasizing certain areas for future research.

Methods

The following section contains the methodology for answering the research question of this study; *"What is the impact of current energy policy of the Netherlands on their energy security?"*. This study has two distinct parts that examine separate yet interconnected aspects of energy security assessment with the aim of determining the impact of Dutch energy policy on their energy security. The first part comprises an examination of the existing body of literature with the objective of addressing two primary question:

(1) What dimensions need to be considered when assessing the energy security of a jurisdiction?

(2) What indicators are used as measurements of the dimensions?

This literature review examines academic publications to identify and integrate existing knowledge regarding the central factors and indicators used to evaluate energy security from a global perspective. Using the insights gained from this literature review, a comprehensive framework for assessing energy security in the Netherlands is presented. Subsequently, the next phase of the research examines the energy security of the Netherlands by means of a case study. This section of the study employs a document analysis approach to examine the Dutch policies on energy security. Finally, utilizing the analytical framework derived from the literature review and a document analysis of the relevant policies, the research question is answered.

Developing the Framework

The initial step is to determine the present condition of the Dutch energy security. In order to accomplish this, it is necessary to implement a framework. The objective of the literature review is to ascertain the indicators of this framework. The main topic for the literature review is ‘assessing energy security’. Other key words that were used are ‘framework energy security’, ‘definition of energy security’ and ‘dimensions of energy security’. After initial literature review the key words were defined to e.g.

‘European framework energy security’, ‘Dutch energy security’, ‘measuring energy security’, ‘indicators’ AND ‘energy security’. Academic articles, journals and book chapters were used as references, and these were accessed via Google Scholar.

From this literature review, three previous extensive literature reviews came forward. This being the systematic literature review by Ren & Sovacool in 2014 (1), in which they screened 46 published peer reviewed works to determine the most meaningful dimensions and metrics of energy security. One of these works was the study by Sovacool & Mukherjee from 2011 (2). In this paper they proposed 320 simple and 52 complex indicators based on a mixed methods approach containing interviews, surveys and a systematic literature review of 40 published peer review works. The third is the systematic literature review of Siksnelyte-Butkiene et. al in 2024 (3), where they reviewed 116 papers using the SALSA methodology. This work included the literature review from Sovacool & Mukherjee from 2011, which was also included in the review from 2014. Therefore these three systematic literature reviews serve as a basis from which the framework is derived (see Table 3). The framework utilized consists of four dimensions and 24 indicators.

Data Collection Indicators Framework

In order to collect the data for the framework, various databases were utilized. Sources such as 'Our World in Data' and ‘StatLine’, the Dutch database from the Central Bureau of Statistics (CBS), were consulted to obtain insights into energy-related statistics and trends. Additionally, complementary data was sourced from Google Scholar and other reputable sources such as the governmental website to support and enhance the findings. The way the indicators are measured can be seen in Table 3.

Document Analysis Case Study

This thesis employed a qualitative document analysis (QDA) approach to explore the content, context and implications of Dutch national policies on energy security. QDA is selected for its ability to provide a detailed and nuanced understanding of policy documents, enabling the identification of themes, patterns and insights relevant to the research question. The inclusion criteria of the policies are listed in Table 1.

Table 1.

Inclusion criteria for document analysis

Relevance	The documents/policies must address issues related to energy security in the Netherlands. This includes documents about energy policies, due to energy security being interlinked.
Time frame	The research question asks about the current energy security and current policies. Due to the fact the energy transition is still ongoing in the Nethrelands, policies addressing the current timeframe will be considered only but not a specific year is chosen.
Language	The documents/policies must be in either English or Dutch.
Availability	The documents/policies must be accessible in full text or full source.

The Netherlands has a parliamentary structure, meaning that the policies for the Netherlands are derived from parliamentary initiatives. In turn, administrative divisions such as the provinces and the municipalities are responsible for enforcement. Therefore the scope will be national, similarly to scope of the derived framework from the literature review.

Data Collection Document Analysis

The primary data collection of the document analysis is a thorough examination of official documents that outline the energy policy of the Netherlands (Rijksoverheid). Secondary data, such as literature and reports from international organizations, provide contextual information necessary for a comprehensive analysis. Utilizing the Dutch governmental website (https://www.rijksoverheid.nl/) and the inclusion criteria the following policies that were selected can be seen in Table 2. Lastly, thematic analysis was used to identify core categories and the relevant data was extracted which is presented in the results section, followed by the discussion.

Table 2

Selected policies

Klimaatakkoord	The "Klimaatakkoord" is the Dutch Climate Agreement aimed at reducing the Netherlands' greenhouse gas emissions by 49% by 2030 compared to 1990 levels. It involves measures across five sectors, these being energy, industry, transport, agriculture, and the built environment to achieve these targets (Ministerie van Economische Zaken en Klimaat, 2019).
Energiewet	The "Energiewet" is a Dutch law that regulates the production, distribution, and consumption of energy. It aims to ensure a reliable, sustainable, and affordable energy supply. The law covers market regulations, infrastructure management, renewable energy promotion, energy efficiency standards, consumer protection, and energy security (Ministerie van Economische Zaken en Klimaat, 2022a).
Richtlijnen Europese Aanpak	The European energy and climate policy aims for climate neutrality by 2050 through the European Green Deal and 2030 Climate and Energy Framework, which targets a 55% reduction in emissions, 32% renewable energy, and 32.5% energy efficiency by 2030. Key directives include the Renewable Energy Directive (RED II), Energy Efficiency Directive (EED), and Emissions Trading System (ETS). The Clean Energy for All Europeans Package promotes renewable energy, energy efficiency, and consumer empowerment, ensuring a unified approach across the EU (Europees Parlement, 2021).

Klimaat en Energieverkenning 2023	The "Klimaat- en Energieverkenning" (KEV) is an annual report by the Dutch Planbureau voor de Leefomgeving (Environmental Assessment Agency) (PBL) that provides an overview of the country's climate and energy status and future projections. It covers greenhouse gas emissions, energy consumption, renewable energy growth, energy efficiency, and the impact of policies. The KEV helps track progress towards national and international climate goals and informs policymakers and stakeholders and is obligated in article 6 of the Energiewet (Planbureau voor de Leefomgeving, 2023).
Klimaatnota 2023	The "Klimaatnota" is an annual Dutch government report detailing the progress and plans for climate policy. It updates on national and international climate goals, the effectiveness of implemented policies, current greenhouse gas emissions, and future strategies for reducing emissions. The report informs policymakers, stakeholders, and the public about the Netherlands' climate action and future initiatives (Ministerie van Economische Zaken en Klimaat, 2023a).
IBO Financiering Energietransitie	The "IBO Financiering Energietransitie" is a Dutch interdepartmental policy study on funding the energy transition. It examines the investment needs, potential public and private funding sources. The study also assesses the economic impact of financing the energy transition and provides recommendations to the Dutch government on mobilizing the necessary financial resources to achieve sustainable energy goals (Ministerie van Financiën, 2021) .

Defining and Conceptualizing Energy Security

The following section explores the existing literature on energy security. This literature review forms the basis for the framework that is utilized in the case study of the Netherlands. Firstly, the concept of defining energy security is discussed, followed by the dimensions and indicators. Lastly, an overview of the current way in which the Netherlands deals with energy security is provided.

Defining Energy Security

The concept of defining energy security has been recognized as vague amongst scholars, despite the emphasis on energy security by most organizations and countries in policies and aims (IEA, n.d.; Ren & Sovacool, 2014; Siksnelyte-Butkiene et al., 2024). This is due to the many ideologies and inconsistencies in the various definitions of energy security, demonstrating the subjectivity of energy security and context dependency (Brown & Sovacool, 2007; Sovacool & Valentine, 2013; Marhold, 2021; Mara et. al, 2022; Wang & Fang, 2024; Sarkhanov & Huseynli, 2023; Hu et al., 2022). Energy security assessments usually focus on one energy source in the country's energy mix, such as oil or electricity. For example, the IAE has a strong focus on resilience and possible disruptions, due to their members (31 member countries and 11 association countries, mainly OECD) being obliged to maintain a set of regulations and/or policies that provide a framework for emergency oil stockholding and data reporting in case of a severe oil supply disruption (IEA, n.d.). This again demonstrates the subjectivity of defining energy security (Kisel et al., 2016; Jakstas, 2020; Rodriguez-Fernandez et al., 2022; Fang et al., 2018; Cervan et al. 2022; Khan and Dhakal, 2022; Siksnelyte-Butkiene et al., 2024; Cherp & Jewell, 2014).

Over the last years, the conceptualizing of energy security has been expanded to an interdisciplinary approach also covering issues of climate change, environmental degradation, globalization, national security, policy and the well-being of people. This approach can lead to an overall development of the entire energy system (Kisel et al., 2016; Jakstas, 2020; Rodriguez-Fernandez et al., 2022; Fang et al., 2018; Cervan et al. 2022; Khan and Dhakal, 2022; Siksnelyte-Butkiene et al., 2024;

Cherp & Jewell, 2014, IEA, n.d.). Another definition of energy security was given by Sovacool & Valentine in 2013. They focus on the resilience, availability and affordability of energy services just like the IEA, but also on efficiency, environmental and acceptability factors of those services, resulting in a more holistic and interdisciplinary approach due to the many disciplines energy security touches. Therefore , Sovacool & Valentine (2013) argue that energy security is defined as equitably providing available, affordable, reliable, efficient, environmentally benign, proactively governed and socially acceptable energy services to end-users. This means that therefore energy security fuses traditional conceptions of national security with emerging concepts of human rights, sustainable development, and individual security (Sovacool & Valentine, 2013; Ren & Sovacool, 2014). Besides that, their systematic literature review and the IEA acknowledge that the definitions of energy security encompass different dimensions depending on the focus and scope, i.e. energy security of oil or the energy mix, and are country specific.

It seems that energy security is defined by which dimensions it represents, i.e. IEA defines it by affordability and availability and Sovacool & Valentine define it besides affordability and availability also with reliability, efficiency, acceptability, environmentalism and governance. Within energy security studies, the most common starting point when conceptualizing energy security (and therefore consequently the dimensions used when assessing energy security) are the four A's, being availability, affordability, accessibility and acceptability. Availability and affordability are the oldest of the four, being mentioned in the IEAs definition and in one of the earliest energy security studies by Deese in 1979 and Yergin in 1988. They first mentioned energy security after the first energy crises (oil) occurred. Since most countries developed substantive policies regarding their economy and therefore their energy, more policies and goals regarding energy security came to life. This is where the other two A's (Acceptability and Accessibility) became connected to energy security due to the developing interdisciplinary approach in academic discourse as i.e. seen by Sovacool & Valentine (2013). Both were global energy goals by the World Energy Council in the Millennium Declaration and were finally connected to energy security in the 2007 Asia Pacific Energy Research Centre (APERC) report (WEC, 2000; Cherp, 2014).

It is probable that these terminologies were adopted from other disciplines and used in the context of energy and energy security. Penchansky and Thomas (1981) presented the comprehensive "A-framework" in a paper on the "5As of health care access." The UN frameworks for human rights, education, and food exhibited similarities as documented by the Office of the High Commissioner for Human Rights in 2000 and the UNESCO Secretariat in 2002. APERC organized their 2007 energy security report on Asia using the A-framework, which integrates the factors of 'availability' and 'affordability' with 'acceptability' and 'accessibility'. The study lacked references to previous research, empirical findings, or logical reasoning to support the four A's. The statement does not indicate that the four A's are a universal energy security concept or fundamental attributes. Nevertheless, the literature on energy security has embraced the model of the four A's (Ren & Sovacool, 2014; Siksnelyte-Butkiene et al., 2024). Chester (2009) referenced the APERC research in his seminal work on the four "dimensions" of energy security: availability, adequacy, affordability, and sustainability. He described energy security as elusive and multifaceted. According to Siksnelyte-Butkiene et al. (2024), this argument hindered the pursuit of a comprehensive energy security concept and promoted the development of alternative 'multi-dimensional' definitions, similar to the discourse on human right frameworks. This can be seen back in the definition by Sovacool & Valentine in 2013, where they fuse the common energy security definitions with other interdisciplinary concepts, much like how the concept of energy security developed itself.

Measuring and Assessing Energy Security

Just like the vagueness in defining energy security, there is also vagueness in how to measure the dimensions of energy security. For instance, in the study by Chester in 2009 it was not explicitly stated if his method pertained to values, dangers, or another aspect to measure it. The same goes in the study by Hughes in 2012. Here, Hughes defines energy security by the availability, affordability and acceptability dimensions and proposes a model to measure energy security which is derived from system analysis techniques. It explains how the indicators and metrics can be applied to a jurisdiction´s energy system and its constituent parts and that the same method can be used for determining the potential outcomes of energy policies, allowing competing initiatives to be compared and estimated in their energy security (Hughes, 2012). Nevertheless, despite the more dynamic approach, the model is very much focussed on quantitative data, one of the shortcomings that was mentioned in the paper by Ren & Sovacool (2014) and in the paper by Chester (2009).

The focus on quantifying all the metrics can shift the balance as well, losing out on the social elements and make it inherently complex (Ren & Sovacool, 2014; Siksnelyte-Butkiene et al., 2024; Sovacool & Mukherjee, 2011). Other shortcomings when assessing energy security are discussed in the systematic literature review from Ren & Sovacool (2014). They argue that most papers on energy security had a few common shortcomings, being the topical focus (i.e. IEA focussing more on sustainable development than energy security), scope and coverage (i.e. the focus on electricity and not including trade flows), transparency (i.e. the need of modeling skills) and continuity (i.e. only a snapshot of a particular point). Therefore they propose to use both quantitative and qualitative data to assess energy security. They determined four dimensions and 24 metrics based on their previous systematic literature review based on their latest literature review (Sovacool & Mukherjee, 2011; Ren & Sovacool, 2014). However, within this framework, no specification on the measurement of the indicators.

But is every metric and indicator equally important? Ren & Sovacool used Fuzzy Decision-making Trail and Evaluation Laboratory (DEMATEL)[1] to determine the most meaningful and important metrics of energy security and the most common shortcomings and challenges, on a global scale. From the analysis, they conclude that not all of the four selected dimensions of energy security - affordability, availability, acceptability, and accessibility - are equally significant. Their research suggests that availability and affordability are especially influential factors that have more effect on other aspects of energy security. This observation emphasizes the necessity for governments worldwide to give priority to investing in their own energy resources and implementing laws that provide universal access to

[1] DEMATEL is a type of structural modeling approach that is useful in analyzing the cause and effect relationships among the constituents of a system

affordable electricity. In this manner, the remaining, less significant dimensions may develop automatically. In addition, the authors highlight a significant tradeoff between the accessibility and cost-effectiveness of renewable energy resources. They note that while the growth of such resources might increase accessibility, it may also decrease affordability. Therefore, this balance must be maintained. Furthermore, the authors propose a change in strategy towards energy security, recommending a hierarchical structure instead of treating all measures and dimensions as equal due to this balance. The framework suggests classifying energy security indicators into categories based on their causes and effects, giving priority to those that have a higher impact, measuring it both qualitatively and quantitatively.

The extensive systematic literature review conducted by Siksnelyte-Butkiene et al. in 2024, identified the gap towards sustainability and energy security. Therefore they analyzed and ranked energy security indicators and frameworks based on their Bellagio Sustainability Assessment and Measurement Principles (STAMP)[2]. From the literature review they found the same conclusions as Ren & Sovacool (2014), being that there are many different dimensions and indicators used and no universal framework can therefore exist, nevertheless, they also underscored the needed development of the concept of energy security towards the interdisciplinary, sustainable approach. Sustainability in this context is defined by their STAMP method, which defines sustainability as a holistic, inclusive, and adaptive concept that integrates environmental, social, and economic dimensions to guide and assess long-term societal well-being and development. From their method they assessed four different energy security dimensions, these being similar to Ren & Sovacool (2014). The results showed that although there are several sets of indicators that measure energy security, they frequently do not accurately reflect changes in the energy market, such as adjustments in the economy, policy, international commerce, and other macroeconomic variables. However, the existence of several evaluation frameworks that examine various elements indicates the need of an interdisciplinary approach to tackle the difficulties of energy security, despite of

[2] The Bellagio STAMP method aims to measure sustainable development and comprises of eight indicators: (1) Guiding vision, (2) Essential considerations, (3) Adequate scope, (4) Framework and indicators, (5) Transparency, (6) Effective communications, (7) Broad participation, and (8) Continuity and capacity.

the complexities. They contend that energy security should not be simply characterized merely by the accessibility and cost of energy resources and that sustainability should have a place too in energy security.

Energy Security in the Netherlands

The Netherlands now employs a comprehensive strategy to address energy security, which involves the integration of several policies and initiatives. The objective is to guarantee a dependable, cost-effective, and environmentally-friendly energy supply, particularly in light of the urgent requirement for an energy transition (Ministerie van Algemene Zaken, 2024). There is no single entity that is solely committed to this role. Instead, major stakeholders including government agencies, network operators like TenneT, and municipalities collaborate to execute energy policy and tackle difficulties pertaining to energy security (Prins et al., 2017; Ministerie van Algemene Zaken, 2024). The policies aim to improve the dependability of the supply, encourage the use of renewable energy, and enhance the resilience of the infrastructure (Ministerie van Algemene Zaken, 2024). They specifically address concerns like congestion in the grid and the shift towards renewable energy sources. The Dutch strategy underscores the interdependence of energy security with wider societal and economic goals, stressing cooperation and coordination among many parties to traverse the intricacies of the energy sector and attain long-term sustainability targets. However, the Dutch approach also highlights the complexity of conceptualization and measuring energy security (Ren & Sovacool, 2014; Siksnelyte-Butkiene et al. in 2024).

The Framework

The framework utilized to evaluate the energy security of the present energy policy in the Netherlands is derived from the literature study conducted by Ren & Sovacool in 2014 (Ren & Sovacool, 2014). In this way, the conceptualizing of energy security has been affirmed by previous academic literature. The measurement of the indicators are complemented and more specifically defined by the paper by Sovacool & Mukjerhee (2011). In order to tailor this framework to the Netherlands, the indicators need to be adapted to the main issues in the Netherlands. These more tailored indicators are addressing equity not in the sense of depending on fossil fuels or wood to generate electricity and heat, but on the affordability of renewable energy sources. Besides this indicator, sustainability will be included in the acceptability of environmental factors to affirm the framework to the literature review by Siksnelyte-Butkiene et al. (2024).

The Netherlands has no specific measure in place in order to assess energy security, as established before. In the Netherlands, the current societal and economic objectives mainly encompass environmental sustainability, social equity and inclusion, economic growth and competitiveness, energy independence, quality of life and well-being and international cooperation and leadership (CBS, n.d.-a). Therefore, the measurement of the indicators have shifted towards these focuses, diverting from the original framework. The indicators and dimensions remain similar to the original framework by Ren & Sovacool. The indicators in this framework are measured both qualitatively and quantitatively, and consider not only one specific energy facet, but rather the full energy mix and the energy in mobility, trade and consumption. The framework consists of four dimensions and 24 indicators in total (Table 3). Certain indicators are regarded as qualitative indicators in the original framework. These consist of interviews and/or separate studies on its own (Sovacool & Mukjerhee, 2011; Ren & Sovacool, 2014). Due to the scope of this thesis, these indicators have been simplified to the ‘simple’ indicators (Sovacool & Mukjerhee, 2011). These have been marked with an x.

Availability relates to the physical or geological existence of energy resources and the ability for a given community or country to secure those resources (Ren & Sovacool, 2014). Availability is one of the most important and influential dimensions of energy security, as seen in the literature review (Ren & Sovacool, 2014). This dimension is shaped by factors that influence the energy resources and security of energy supply for a given country. There are five metrics in this dimension.

Affordability consists primarily of factors which influence energy prices for households and industries. It generally means to investigate lower prices (Hafezi & Alipour, 2020). An affordable energy source should propose an equitable price associated with income to tackle poverty and stable transparent prices which can provide estimations about future trends. In the Netherlands, a household is seen in energy poverty when more than 10% of their income is used for paying the energy bill (Centraal Bureau voor de Statistiek, 2023). This dimension goes hand in hand with availability, and it is therefore not surprising that it is the second most influential dimension of energy security according to the framework (Ren & Sovacool, 2014). It consists of six metrics.

Acceptability refers to the environmental and social consequences of energy production and use and refers to the degree in which energy policies and projects are accepted and supported by the public and stakeholders. It is one of the relatively newest dimensions added to assess energy security and has the lowest influence on energy security, together with accessibility (Ren & Sovacool, 2014). It has five metrics. The final five metrics all relate to accessibility, and they emphasize geopolitical and resilience aspects of national energy systems. It refers to the ability of a country to reliably obtain energy when and where it is needed, regardless of external factors.

Table 3.

The framework, containing four dimensions and 24 indicators. In the case of simplification (S) of the indicator, they are marked with an x.

Dimension	Indicator	Measurement	Approach	S	Data source
Availability	Security of supply *The adequacy of supply in meeting national demand*	$Ratio = \frac{Total\ Energy\ Consumption}{Total\ Energy\ Production}$ In petajoule (PJ)	Quantitative		CBS
	Self-sufficiency *The dependency on imported energy and reflects the resilience to the interruption of imported energy*	$Ratio = \frac{Total\ Energy\ Consumption}{Total\ Imported\ Energy}$ In petajoule PJ	Quantitative		CBS
	Diversification *The diversity of used energy sources for energy supply and the ability to mitigate the risk caused by overdependence on major energy sources*	Shannon Wiener Index (H) $H = -\sum_{j=1}^{S} p_i \ln p_i$ S = total number of energy sources P_i = proportions of each energy source	Quantitative		CBS; IEA; Ministerie van Economische Zaken en Klimaat; OEC; Statline
	Renewable energy *The share of renewable energy sources in the total primary energy supply*	$Ratio = \frac{Renewable\ Energy\ Production}{Total\ Energy\ Consumption} \times 100\%$ In petajoule PJ	Quantitative		CBS

Dimension	Indicator	Measurement	Approach	S	Data source
	Technological maturity *The overall reliability and reflects to some extent the state of national energy infrastructure*	Description of the national energy infrastructure and current developing plans	Qualitative		TenneT, TSO, Rijksoverheid
Affordability	Price stability *The stability of the energy market and can reflect the resilience to market risks and soundness of national energy policies*	$Total\ Absolute\ Deviation = \sum_{i=1}^{n} \lvert Pg - Pnl \rvert$ Where n = 12 months P_g = Global Energy Price in EUR P_{nl} = Dutch Energy Price in EUR	Quantitative		CBS, IEA
	Dependency *Assesses imported energy per capita (EpC)*	$EpC = \frac{Total\ Imported\ Energy}{Total\ Population}$ In petajoule PJ	Quantitative		CBS
	Market liquidity *The ability of energy sources to be sold without causing a significant movement in the price and with minimum loss of value*	Description of the ability to be sold and its consequences	Qualitative	x	TenneT, Rijksoverheid
	Decentralization *The extent to which distributed generation (DG) and smaller-scale energy systems (SSES) are utilized*	$DG\&SSES = \frac{Energy\ DG\&SSES}{Total\ Energy\ Production} \times 100$ In petajoule PJ	Quantitative		CBS
	Electrification *The percentage of population that has access to reliable grid connections*	The percentage of population with access to the grid	Quantitative		Our World in Data, Rijksoverheid

Dimension	Indicator	Measurement	Approach	S	Data source
	Equity *The percentage of household being able to afford sustainable energy sources*	Percentage of household with access to subsidies, percentage of energy poverty and the GINI coefficient of energy use	Quantitative		TNO, Divosa, Our World in Data
Acceptability	Environment *The negative impacts on the environment*	Trend of Greenhouse Gas (GHG) Emissions, percentage of general pollution factors (pesticides, chemical discharges)	Quantitative	x	Our World in Data, RIVM
	Social satisfaction *The public attitudes and perceptions of energy systems*	Description of public attitudes and percentage of population accepting the energy transition	Quantitative and qualitative	x	CBS, ACM, NOS, Rijksoverheid, TNO, IEA, TenneT
	National governance *The ability to which national institutions can properly govern and regulate the energy sector*	The World Bank Regulatory Quality Index (percentile rank, 0-100)	Quantitative	x	World Bank
	International governance *The degree to which a country meets international norms of good governance such as rule of law and minimal corruption*	The Human Development Indicators, State Fragility Index (0-120, with 0 being the most stable and 120 being the most fragile)	Quantitative	x	Freedom House, United Nations, Fragile State Index
	Transparency *The transparency of energy information and the extent of public knowledge about energy systems*	Transparency International Corruption Index (0-100, with 0 being very corrupt and 100 being very clean)	Quantitative and qualitative	x	Transparency International

Dimension	Indicator	Measurement	Approach	S	Data source
	Efficiency *The utilization level of energy evaluating the loss of energy*	$Energy\ Intensity = \frac{GDP}{Total\ Energy\ Consumption}$ In petajoule PJ per EUR	Quantitative		IEA
	Innovation *The advancement of energy technologies*	Investment in research and technology in EUR	Quantitative	x	CBS
	Investment and employment *The sunk investment and jobs contributed by the development of the energy industry*	Percentage of people working in energy industry	Quantitative	x	CBS
Accessibility	Import stability *The stability of energy imports from foreign countries*	Brief description of stability of energy imports	Qualitative	x	Energie Nederland
	Trade *The international politics and international relations that influence energy trade*	Number of transnational pipelines, ports, and foreign direct investment in EUR in the energy sector	Quantitative	x	Rijksoverheid
	Political stability *The durability and stability of domestic political institutions*	Percentage of adult population satisfied with policy and planning mechanisms	Quantitative	x	CBS
	Military power *The overall safety and security of a nation*	Number of attacks or acts of piracy on flagged marine vessels carrying energy fuels and/or equipment	Quantitative	x	Rijksoverheid

Dimension	Indicator	Measurement	Approach	S	Data source
	Safety and reliability *The resilience of the energy system to risks, terrorism and natural disasters*	The scope of the National Security Strategy Energy Focus	Qualitative	x	Rijksoverheid

Case Study: The Netherlands

The Netherlands' energy landscape includes a subtle interaction of multiple energy sources, demonstrating a comprehensive approach to reconciling the imperatives of security, sustainability, and economic feasibility in energy provision (Ministerie van Algemene Zaken, n.d.). This landscape is dominated by a diverse energy mix that includes fossil fuels, renewable energy, and nuclear power, each of which represents a separate path toward achieving the country's energy needs (CBS, n.d.).

Historically, fossil fuels, particularly natural gas and oil, have made up a significant share of the Dutch energy mix (Our World in Data, n.d.). The Netherlands has long been a major producer and exporter of natural gas, particularly through the successful Groningen gas field (Beauchampet & Walsh, 2021). However, concerns about environmental degradation and seismic activity have motivated a deliberate shift toward renewable energy options, resulting in a progressive decline in natural gas significance within the energy matrix. Furthermore, the recent decision to close the Groningen gas field owing to seismic concerns, as well as geopolitical tensions, climate change, reinforces the importance of shifting away from fossil fuels (Van Der Voort & Vanclay, 2015; Ministerie van Algemene Zaken, n.d.).

Renewable energy sources such as wind, solar, biomass, and hydropower have emerged as components in the Dutch energy transition, representing a deliberate effort to diversify energy sources and reduce reliance on fossil fuels. The Netherlands has made significant investments in offshore wind energy, as seen by large wind farms covering the North Sea, harnessing the country's strong wind potential (Taminiau & Van Der Zwaan, 2022). Furthermore, a thriving solar energy sector has emerged, fueled by government incentives and legislative frameworks targeted at promoting renewable energy production. Nuclear power, while just a modest component of the Dutch energy mix, is significant as a steady and low-carbon energy source. The Borssele nuclear power station is the country's only nuclear facility, generating electricity from uranium fuel and directly contributing to the national energy system (Autoriteit Nucleaire Veiligheid en Stralingsbescherming, 2023). Nonetheless, with increasing electrification driven by the energy transition, additional issues such as net congestion emerged. This means the grid network in the Netherlands is overwhelmed (TenneT Holding B.V., 2023). In the following sections, the framework is applied to the Netherlands and the QDA of the policies is given, followed by a discussion.

Availability

Security of supply

In 2023, the domestic total primary energy production in the Netherlands was approximately 1,261 petajoules (PJ), while the total primary energy consumption was around 2,875 PJ (CBS, n.d.). This results in a production-to-consumption ratio of roughly 0.44, meaning that the Netherlands produced about 44% of the energy it consumed.

Self-sufficiency

In 2023, the net import of energy in the Netherlands was 2,182 PJ. Given that the total primary energy production was 1,261 PJ, the corrected total primary energy consumption would be the sum of the net import and the total production, resulting in 3,443 PJ (CBS, n.d.; Statista, n.d.). Consequently, the ratio of imported energy to total consumed energy would be approximately 0.634. This means that about 63.4% of the total energy consumed in the Netherlands was imported. This demonstrates the high dependency on energy imports to meet the energy demand.

Diversification

Using the proportions of the energy mix CBS data for 2023, the Shannon-Wiener Index (H) is approximately 1.593 for 2023. This is an increasing trend from 1.333 in 2010 (CBS, 2023b). This suggests a moderate degree of variety in the energy composition. The score indicates that the Netherlands possesses a well-balanced mix of energy sources, hence enhancing energy security through the reduction of dependence on any one energy source. However, the indicator also shows the ability to mitigate risks associated with excessive dependence. The significance of the preceding number greatly influences the importance of the variety of sources. It is crucial to be aware of the nations from which the Netherlands imports, due to international relations and agreements such as the European Union. These countries are primarily located in Europe, with the notable exception of Russia (CBS, n.d.). The reliance on Russia has seen considerable changes in recent years due to geopolitical tensions. In 2022, the Netherlands imported

34% of total energy imports, with 30% of these being Russian crude oil. The Dutch government aimed to curb energy imports from Russia, and no Russian crude oil has entered the country since December 2022. The Netherlands is one of the least vulnerable oil-dependent countries in the EU due to its reserves.

Diversification Imports. Gas imports were 15% in 2022, with Russian gas accounting for 25% and 30% of LNG imports. The Dutch government is doubling gas imports from Belgium and increasing imports from the United Kingdom, while investing in increasing LNG capacity. The percentage of Russian LNG imports is down, but the volume of imports remains the same. The Netherlands experienced a 5% growth in power imports in 2023, with 19 billion kWh, mainly due to Norwegian hydropower facilities. Groningen gas share was phased out in 2018, and the fields are set to close in October 2024. Coal imports were 3% in 2022. The Netherlands exported 25 billion kilowatt-hours of electricity, with Germany, Belgium, and the United Kingdom receiving the majority. The Netherlands' net export balance of over 5.7 billion kWh in 2023 demonstrates its vital position in the European energy market, effectively managing its energy requirements by maintaining a balance between importing and exporting.

Renewable Energy

According to Our World in Data, the share of primary energy consumption from renewable energy sources was 14.9% in 2022. This is an increasing trend, with the share of renewable energy sources being 3.14% in 2010 (Ritchie et. al, 2024).

Technological Maturity

In 2023, the Netherlands had a remarkably high level of electricity security. The national transmission system operator, TenneT, reported that the availability of high voltage networks was 99.99993% (TenneT TSO B.V., 2021). Nevertheless , the energy system and electricity market are now experiencing substantial transformations, resulting in a more dynamic equilibrium between supply and demand due to the source of the energy production. This requires the introduction of innovative concepts such as energy storage and improved adaptability in the system (International Dependency on Security of Electricity Supply Calls for More Cross-border Coordination, n.d.). TenneT supports the promotion of greater use of electricity and collaboration between energy supply and demand, highlighting the significance of storage and flexibility in ensuring the reliability of energy supply. According to the operator's forecast, the Netherlands would rely on imported power for 593 hours a year by 2030, highlighting the importance of strong coordination between countries (TenneT TSO B.V., 2021). Starting in 2025, the security of supply is predicted to decrease due to uncertainties in production due to the dependability of renewable energy sources on variables such as weather and storage restrictions (TenneT TSO B.V., 2021).

The fast rate of electrification is surpassing the growth of the energy system, resulting in congestion problems. The existing grid infrastructure is inadequate to facilitate the shift towards renewable energy, as it lacks the necessary flexibility to effectively manage the balance between energy supply and demand (TenneT Holding B.V., 2023; Ministerie van Algemene Zaken, 2024b). Furthermore, it is necessary to enhance the resilience of the grid by upgrading it to resist harsh weather occurrences (TenneT Holding B.V., 2023). Grid congestion is presently resulting in delays for new and increasing consumers, and comparable problems may occur on the demand side when power cannot be efficiently transmitted to necessary sites (TenneT Holding B.V., 2023). To tackle these issues, it is necessary to embrace collaborative methods that demand adaptability in both manufacturing and consumption, particularly during periods of high demand. The Dutch government is implementing a law that mandates firms with a demand of more than 1 MW to take part in congestion management. Furthermore, there are ongoing investments being made in large-scale battery systems in order to fulfill the increasing demand (TenneT Holding B.V., 2023).

TenneT is making investments in STATCOMs (A STATic synchronous COMpensator) to control voltage at connection points and maintain the grid in the face of increased input of renewable energy (TenneT Holding B.V., 2023). In addition, the Netherlands is making investments in hydrogen hubs, such as LionLink, which aim to link offshore North Sea energy sources to the onshore high-voltage grid. This would not only improve the security of energy supply but also enhance spatial and cost efficiency. (TenneT Holding B.V., 2023).

Affordability

Price Stability

In 2023, the Dutch energy market exhibited significant volatility, as reflected in the substantial deviation of domestic energy prices from the global mean. According to CBS and IEA, the average monthly energy price in the Netherlands was 342.17 €/MWh, while the global mean value was 100 €/MWh. The total absolute deviation for the first five months of 2023 amounted to 1210.85 €/MWh, indicating a high level of price instability. This sharp increase in prices can be attributed to geopolitical events, such as Russia's invasion of Ukraine, and supply-demand imbalances exacerbated by the lingering effects of the COVID-19 pandemic (Mullin, 2022). This shows the challenges faced by the Dutch energy market in maintaining price stability and underscore the importance of resilient national energy policies and effective government interventions to mitigate market risks and ensure a steady energy supply (CBS Statline, 2024; IEA, 2023). To mitigate the increasing prices, the Dutch government introduced a price cap for electricity and gas. The price cap meant that up to a certain amount of energy usage the price was known and set, and up from that the consumer had to pay extra. This also incentivized consumers to use less energy. Besides this, the Single-Day Ahead Coupling (SDAC) market coupling suppressed the prices (Michal, 2024).

Dependency

For the Netherlands in 2023, the dependency on imported energy can be assessed by calculating the imported energy per capita. With a total imported energy of 2,182 PJ and a population of approximately 17.3 million people, the imported energy per capita is approximately 126.13 GJ in 2022 (CBS Statline, n.d.). This means that the imported energy per capita is higher than the consumed energy per capita, reflected in i.e. importing more for bunkering purposes and similarly exporting excess energy to neighboring countries (CBS, n.d.; Boerman, 2023).

Market Liquidity

The energy market in the Netherlands is highly liquid, with active participation from several stakeholders, including energy producers, dealers, and consumers. Adequate liquidity is essential for facilitating seamless and efficient trading operations and establishing precise valuations for various energy resources, therefore promoting transparency and fostering robust competition. This guarantees that energy sources may be traded without creating substantial fluctuations in prices and with minimum depreciation in value. Initiatives like market coupling and integration, supported by stakeholders like TenneT, enhance market liquidity by fostering collaboration and standardization in the European energy market. The combination of several energy sources improves market liquidity by providing customers with a wide array of options to fulfill their energy needs. In addition, the Dutch energy markets benefit from significant trading activity, tight bid-ask spreads, deep market liquidity, moderate price fluctuations, high turnover rates, efficient trade execution, active market participation, and a favorable regulatory framework. The presence of sophisticated trading platforms, robust international connections, and a wide variety of players guarantees a constant flow of cash and energy commodities in and out of the market. The Ministry of Economic Affairs and Climate Policy and data from CBS emphasize the stable regulatory framework, which demonstrates the market's resilience and efficiency. This is supported by a strong grid and dependable energy providers (CBS Statline, 2024; Ministerie van Economische Zaken en Klimaat, 2024).

Decentralization

For the Netherlands in 2022 (2023 data is yet unknown), the fraction of total energy generated by renewable energy systems was approximately 34.98%. This calculation is based on a total domestic energy production of 1,031.8 PJ and renewable energy production amounting to 360.9 PJ. This indicates that about 35% of the country's energy production came from renewable sources. According to a pre-published article by CBS, in 2023 48% of the country’s electricity production came from renewable energy sources (CBS, 2024).

Electrification

As mentioned before, the security of supply of the electricity grid is 99.999%, making it reliable. The accessibility of the energy grid is 100% in the Netherlands (Our World in Data, n.d.). Nevertheless, as Our World in Data argues, the number does not represent energy poverty issues (Ritchie et al., 2024). They propose the new Modern Energy Minimum of 1000 kWh per person per year to be a more accurate representation of access to electrification in developed countries, inclusive of both household and non-household electricity consumption (Moss, 2021; Ritchie et al., 2024). Currently, there is no specific data available on the precise number of households in the Netherlands that consume less than 1,000 kWh per year. Nevertheless, it is known that average energy consumption per family typically surpasses this quantity, with households having a substantially higher mean energy use, with an average of around 3,090 kWh per year according to the CBS in 2023.

Energy poverty, as defined by the Dutch government, refers to the condition in which households lack the financial means to access sufficient energy services, leading to inadequate heating, cooling, lighting, and the inability to operate essential devices. Generally speaking, a household is energy poor in the Netherlands when more than 10% of their income is needed towards energy bills. This issue frequently impacts low-income households residing in inadequately insulated residences, resulting in disproportionately high energy expenses compared to their income. Consequently, many households experience considerable economic pressure, which affects their overall welfare and standard of living. Recent data indicates that some 550,000 households in the Netherlands have fallen into energy poverty, accounting for 6,5% of total households. (Rijksoverheid, 2023; CBS, 2023).

Equity

Calculating the percentage of households with access to subsidies is too substantial for this study. Therefore, a proxy is used, namely the amount of people in energy poverty applying for energy allowance from the Dutch government. According to Divosa, a coalition of municipality workers, 90% of people that had the right to an allowance also applied for one. This high number of applicants was not expected by the government and caused shortages of funds from the municipalities, who were responsible for the allocation of the allowances (Financiële Toereikendheid Van De Energietoeslag, 2024). The amount of households experiencing energy poverty was previously mentioned. The study by TNO in line with CBS reported that between 2020 and 2022 energy poverty increased by 90.000 households (from 6,4% to 7,4% total households). They also estimated that if the government did not apply the financial compensation and the price cap, the number of energy poor households would have increased to 12,5%. Besides this, energy reduction by households also is estimated to have led to 0,5% of the households being classified as energy poor. The GINI-coefficient was 0.26 in 2022, according to Our World in Data. This is a relatively stable number and indicates that there is relatively low inequality in the Netherlands compared to the world (Hasell & Roser, 2023).

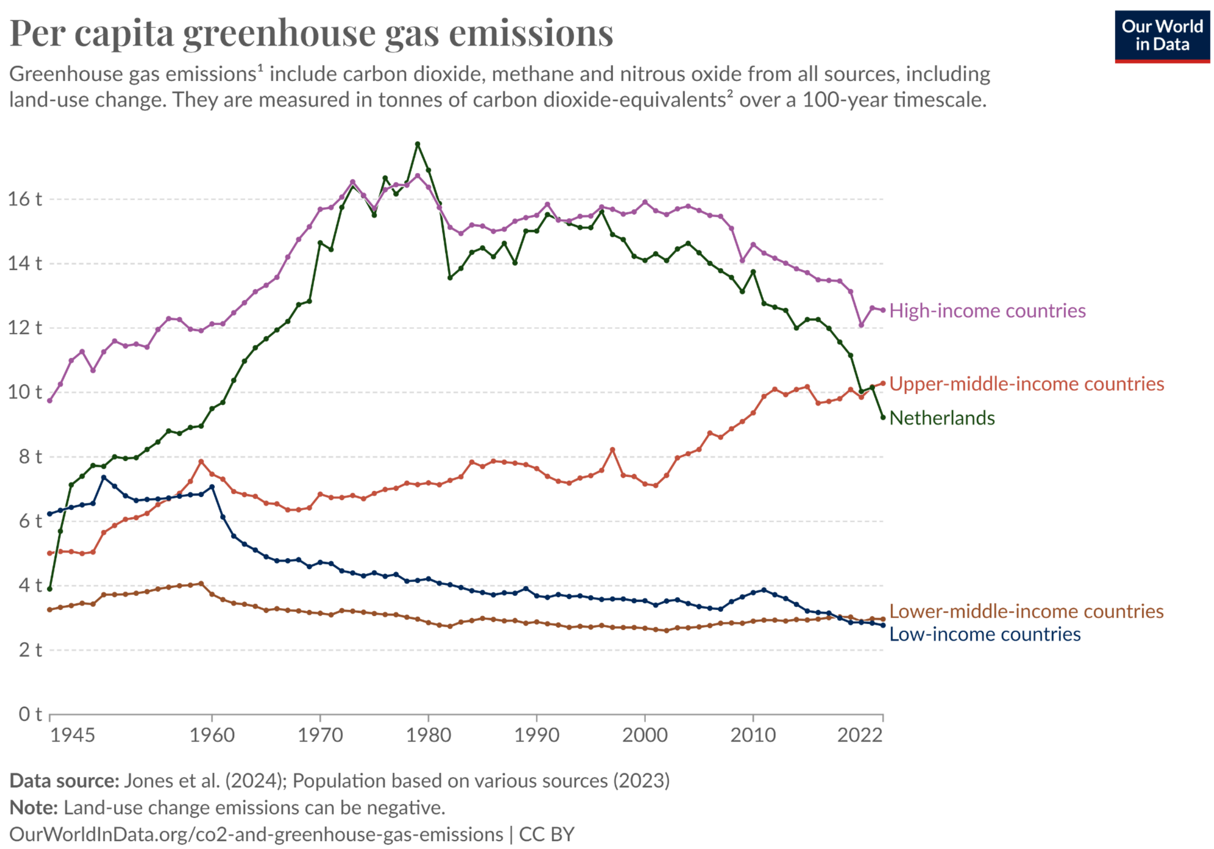
Acceptability

Environment

Greenhouse Gas Emissions. The GHG emissions can be seen in figure 1 (Ritchie et al., 2023). The Netherlands is ranking 26th contributor to GHG emissions globally, nevertheless, they are now also ranking 8th in the CCPI index, meaning that they do show a transition towards less GHG emissions (PhilipSchmitz, 2023).

Figure 1.

Greenhouse gas emissions (GHG) of the Netherlands, displaying the trend of emissions compared to the average of high-income countries, upper-middle-income countries, lower-middle-income countries and low-income countries. Greenhouse gas emissions include CO2 and CO2 equivalents, meaning a gas' potential to global warming value (GWP) is taken into account. For further reference please see Our World in Data on GHG emissions.



General Pollution Factors. The Netherlands has a substantial level of pesticide consumption, being among the top consumers of pesticides per hectare in Europe. CBS reports that Dutch agriculture has been using around 9 million kg of active pesticide chemicals each year in recent times, resulting in them being accountable for 50% of the nitrogen deposition on land. The National Institute for Public Health and the Environment (RIVM) has said that around 50% of the surface water monitoring locations in agricultural regions have surpassed the established water quality requirements for pesticides.

Additionally, a research conducted in 2022 revealed that 25% of the groundwater samples studied had pesticide residues (CBS, n.d.; RIVM, n.d.).

Social Satisfaction

According to a survey conducted by CBS, almost 60% of the population expresses contentment with the existing energy system, attributing its dependability and accessibility as significant advantages. According to a study and monitor conducted by CBS and Autoriteit Consument & Markt (ACM), 72% of the Dutch households are content with their energy supplier, and 50% are content with the current energy prices in 2023 (CBS, n.d.). Both numbers declined, with the content of energy supplier 5% and the energy prices 8% from 2022. Since they started monitoring in 2022, no trend can be calculated.

There is an increasing focus on promoting environmental sustainability. Newspaper reports and a CBS survey show that around 70% of the Dutch population is in favor of transitioning to renewable energy sources (CBS, n.d.). Concerns about the environmental effect of fossil fuels, as well as a desire to combat climate change, reinforce this support. This stance is seen by the regular protests carried out by organizations such as Extinction Rebellion, who have demanded an immediate cessation of subsidies for fossil fuels (NOS, 2023). The demonstrations indicate a significant popular desire for more assertive measures in achieving a sustainable energy transition. While energy dependability is generally satisfactory, there are also increasing concerns over the economic implications of energy usage. According to CBS research, 55% of households express concern over the increasing cost of energy, leading them to investigate energy-saving methods and sustainable energy options such as solar panels (CBS, n.d.; NOS, 2024). Nevertheless, this is seen as an investment which not every household can make. Newspaper stories demonstrate the growing public interest in government subsidies for renewable energy installations and household energy efficiency upgrades (NOS, 2024a).

The closure of the Groningen gas field, which was once one of the biggest natural gas reserves globally, has had a substantial impact on public sentiment (NOS, 2024b). The shutdown, prompted by concerns over induced seismic activity and environmental consequences, is in line with the increasing public and governmental trend towards decreasing dependence on fossil fuels and improving energy security through renewable sources (Ministerie van Algemene Zaken, 2024c). Besides the dependence on fossil fuels, there is a social shift of becoming less reliable on imported energy sources, to prevent situations like the previous dependency on Russia.

To achieve energy goals, four characteristics are required from an energy governance perspective according to the United Nations Development Programme (UNDP) (Verma, 2021). These are a legal and regulatory framework, civic engagement and empowerment, appropriate oversight and inclusive and effective institutions. Although the overall trust in the government has decreased in the last years (CBS), frameworks are put in place that promote renewable energy and private investments, i.e. subsidies to become more sustainable and electric vehicles in mobility (ISDE grants, SDE++, Subsidies, Energy Investment Tax Credit) (Rijksdienst voor Ondernemend Nederland, 2022; Rijksdienst voor Ondernemend Nederland, 2019). Nevertheless, enforcement mechanisms with clear responsibilities and obligations to ensure protection are not as effective as they could be, i.e. Groningen gas & recent shift in uncertainty in subsidies (CBS, n.d.; Verma, 2021). Public engagement and empowerment is increasingly getting a more prominent role in the energy transition in the Netherlands, with participation being obligatory in the new *Omgevingswet* (Ministerie van Infrastructuur en Waterstaat, 2024). There is appropriate oversight, i.e. the existence of national parliaments and committees, independent agencies doing research such as CBS, IEA, TNO, TenneT, Our World in Data, United Nations (CBS, n.d.; IEA, 2020; TNO, 2024; TenneT; 2023; UN, n.d.; Our World in Data, n.d.)

A more recent issue developing in the Netherlands is the energy advisement agencies that are hired by municipalities to do assignments and developing policies. With this they take away the role of municipalities and governance institutions to create knowledge policies themselves, implying incompetence in the governmental positions, aiding the decline of trust in the government (Van Schelven et al., 2019; Van Hest & Vugts, 2023).

National Governance

The World Bank Regulatory Quality Index for the Netherlands was 97 in 2022 (World Bank Group, 2024; *World Bank Open Data*, n.d.). The previously mentioned decrease of trust in the government and the social discontent regarding Groningen and other instances, such as the Toeslagenaffaire (2018), can be seen back in this index in Figure 2.

Figure 2

The World Bank Regulatory Quality Index of the Netherlands from 1996-2022. Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development (World Bank Group, 2024). For further reference please see the accompanying report from the World Bank on Worldwide Governance Indicators.

International Governance

According to Freedom House, an NGO, the Netherlands scored 98% on political rights and civil liberties. The 2% deficit resulted due to migration policies and polarization around cultural identities (Freedom House, n.d.). The Human Development Index (HDI) of the Netherlands is 0.946 in 2022. This illustrates the international position of the Netherlands and reflects the effectiveness of national policies (United Nations, n.d.).

The Netherlands ranks low on the State Fragility Index (26 out of 120), reflecting its strong and stable governance structures, robust economic performance, and higher levels of social cohesion. The State Fragility Index, which assesses a country's vulnerability to conflict or collapse, consistently places the Netherlands among the most resilient nations globally. This ranking is underpinned by effective government institutions, a high standard of living, comprehensive social welfare systems, and a well-functioning legal framework. Low levels of corruption, high public trust in government, and effective law enforcement contribute to this stability. Additionally, the Netherlands' strong international alliances and participation in global governance further reinforce its stability (Fragile States Index, n.d.).

Transparency

The Transparency International Corruption Index score (CPI) of the Netherlands went from 84 in 2012 to 79 in 2023, with 100 representing no corruption and 0 being fully corrupt. This decline implies a slight increase in perceived corruption throughout the previous ten years. Despite this decrease, the Netherlands is among the top countries in terms of openness and low corruption rates, which reflects a quite strong and transparent government structure (Transparency International, 2024).

Efficiency

The energy intensity of the Netherlands is 2216 GJ per million euros of GDP in 2022 according to the IEA, indicating a relatively efficient use of energy in generating economic output. From the years

2000-2022, the energy intensity has seen a 38% decrease, demonstrating the country's effort to enhance energy efficiency in generating economic output (IEA, n.d.).

Innovation

According to CBS, 2,3% of the Dutch GDP is allocated towards research and development (R&D) (CBS, n.d.). Although no specific number can be said without creating more complexity, this relatively high percentage of GDP and investments do demonstrate the broader strategy to transition towards a more sustainable government (CBS, n.d.).

Investment and Employment

According to CBS, investments in energy-related activities in the Netherlands have generated approximately 100,000 jobs. This includes roles in renewable energy, energy efficiency, and energy networks. In 2018, about 97,000 full-time jobs were linked to these investments, with 57,000 related to renewable energy and energy savings (CBS, 2020).

Accessibility

Import Stability

The import stability of the Netherlands is generally high due to its strong infrastructure, diversified energy sources, and strategic geographical location. The country imports a significant portion of its energy, including natural gas, oil, and electricity, from various countries. Its integration into the European energy market and extensive network of pipelines and interconnectors enhances its import stability. Additionally, the Netherlands' commitment to renewable energy sources and investments in energy storage and grid infrastructure further reinforce its ability to manage and stabilize energy imports. Previously, the Netherlands was dependent on Russia for gas. The current main five importers and exporters are European (Norway, United Kingdom, Germany, Belgium, Denmark) (Energie Nederland, n.d.).

Trade

The trade infrastructure of the Netherlands is strengthened by its large system of transnational pipelines, strategically located ports, and significant Foreign Direct Investment (FDI). The country accommodates four vital pipelines (Norg, BBL, IUK, Nord Stream) that bolster the stability of energy trade (Ministerie van Algemene Zaken, 2024b). The Port of Rotterdam, which is the largest port in Europe, handles more than 440 million tonnes of cargo per year, while the port in Amsterdam manages around 100 million tonnes (Ministerie van Algemene Zaken, 2024b). Furthermore, the Netherlands has successfully obtained €400 billion in FDI as of 2022, indicating its significant position as a prominent global trading center (Berkenbos et al., 2023).

Political Stability

According to the CBS Monitor on Broad Prosperity and Sustainable Development Goals 2023, a significant percentage of the adult population in the Netherlands is pleased with policy and planning systems. According to the study, almost 70% of adults in 2022 are happy with the way the government is performing in these areas, demonstrating a generally high trust and confidence in the country's administration. Nevertheless, this is a negative development (CBS, n.d.-a).

Military Power

There are eight reported attacks or acts of piracy in the period of 2010-2023. This low number can be contributed towards the safety measures the Netherlands takes, on both international and national waters and ports.

Safety and Reliability

The Netherlands' National Security Strategy focuses on protecting the country from a variety of dangers through proactive threat management, strong critical infrastructure protection, and effective crisis response (Ministerie van Justitie en Veiligheid, 2022). It involves conducting continual threat assessments, improving cybersecurity, and safeguarding critical infrastructure such as energy plants. The plan emphasizes the need of maintaining an uninterrupted and reliable energy supply, safeguarding energy infrastructure from possible threats, and increasing resilience to disturbances. This involves protecting important energy infrastructure, keeping strategic energy reserves, and guaranteeing the security of energy imports and domestic production. The strategy also underlines the significance of strong cybersecurity measures to defend the energy sector from digital attacks, as well as international collaboration to secure energy supply chains (Ministerie van Justitie en Veiligheid, 2022).

Policies in the Netherlands

In the next section, the results from the thematic analysis of the previously identified policies are divided in the core dimensions in line with the framework. Due to the nature of policies the indicators from the framework will be regarded as a composite measure rather than on an individual basis. This allows for a more nuanced interpretation of the findings.

Availability

The availability of energy resources is a recurring theme across the various policies analyzed. The Klimaat en Energieverkenning 2023 emphasizes future developments in wind and hydrogen energy, aiming to increase the share of renewable energy. This is similar to the focus found in the Energiewet, which ensures a stable energy supply through a gas protection and recovery plan and effective gas import management. The Klimaatakkoord also addresses stability in the energy supply during the transition, emphasizing significant investments in smart grids and energy storage solutions. The European Approach mirrors this by significantly reducing dependence on Russian gas, diversifying sources, and investing in energy storage solutions and robust infrastructure. The IBO Financiering Energietransitie underscores the importance of creating stable and long-term financial frameworks to ensure continuous investment in renewable energy projects, which complements the broader European and national efforts to maintain availability.

Affordability

Affordability is another well-addressed aspect by the policies. The Klimaat en Energieverkenning 2023 ensures that surrounding communities can benefit from energy initiatives, highlighting the importance of keeping costs manageable. Similarly, the Energiewet focuses on cost management through energy-saving campaigns and financial incentives designed to prevent energy poverty. The Klimaatakkoord aims to make the renewable energy transition affordable by targeting an increase in GDP of no more than 0.5% annually, providing subsidies and incentives to support the adoption of energy-efficient technologies. The European Approach is designed to be cost-effective, leveraging public funds to attract private investments, with various financial instruments and subsidies supporting investments in energy efficiency and renewable projects. The IBO Financiering Energietransitie also proposes measures to keep the transition affordable, including subsidies and tax incentives, ensuring economic feasibility and spreading costs effectively across consumers and businesses.

Acceptability

The acceptability of energy policies is addressed through environmental and social considerations. The Klimaat en Energieverkenning 2023 emphasizes the government's leading role in providing financial support where necessary to increase public acceptance and prevent delays in execution, focusing on participation and local governance. The Energiewet aligns with national and EU environmental goals, promoting renewable energy sources and reducing greenhouse gas emissions, enhancing its acceptability. Similarly, the Klimaatakkoord aligns with the Paris Agreement, promoting sustainable practices focused on energy-related activities. The European Approach aims for significant greenhouse gas emissions reductions by 2030, with collaborative efforts to phase out fossil fuel subsidies and promote global climate action, thereby enhancing policy acceptability. The IBO Financiering Energietransitie involves various stakeholders to build broad support for the transition, aligning with national and EU climate targets to ensure that the transition is environmentally acceptable and widely supported.

Accessibility

Accessibility is a key focus across the analyzed policies. The Klimaat en Energieverkenning 2023 highlights the involvement of citizens, companies, and stakeholders to speed up the energy transition, facilitated by European emergency regulations. The Energiewet promotes the development of renewable energy sources and electric vehicle charging stations, supporting technological innovations in hydrogen production and Carbon Capture and Storage (CCS). The Klimaatakkoord ensures that renewable energy is accessible to all sectors by balancing the distribution of costs and supporting innovation in energy technologies. The European Approach ensures that renewable energy and energy-efficient technologies are accessible to all sectors of society, with a strong emphasis on public-private collaboration to enhance accessibility. The IBO Financiering Energietransitie ensures that renewable energy technologies are accessible to all societal sectors, promoting innovation through financial support for research and development, making sustainable energy solutions widely available.

Discussion

In the following section, the results from the framework and the document analysis will be discussed. The framework analysis findings demonstrate both the positive and negative aspects of Dutch energy security. The strengths lie in the ongoing initiatives to enhance domestic renewable energy generation and providing stability in energy costs, and the ability to overcome external shocks with adaptive governance. Nevertheless, the vulnerabilities that have been identified include net congestion, heavy dependence on imports, a diminishing level of public confidence in governmental organizations and volatile energy prices.

The rapid incorporation of renewable energy and existing energy demand have resulted in notable grid congestion problems. The current strategies to address this issue generally concentrate on increasing capacity, but they lack a comprehensive strategy. The Dutch energy policies seek to tackle this issue by allocating funds towards enhancing grid capacity and implementing advanced energy management technology. Their main focus is on ensuring that energy is readily available and affordable. This demonstrates the overall economic perspective, which can be explained by the ministry responsible for the policies and climate, this being the Ministry of Economics and Climate. Nevertheless, the main focus on affordability and availability aligns with the literature findings, which demonstrates that these dimensions are the most important and influential of the four (Ren & Sovacool, 2014).

The policies overall aim to decrease reliance on fossil fuels, increase the variety of energy sources, and strengthen the durability of energy infrastructure. The focus on energy efficiency and economy fails to adequately address the overall adequacy and decrease in energy usage. Efficiency methods have a role in reducing energy usage, but additional regulations promoting decreased consumption and sustainable practices are necessary to account for a sharper decrease and a possible rebound effect (Greening et al., 2000). A more all-encompassing approach might be used as a resolution, encompassing the decentralization of industrial zones, engaging stakeholders in the creation of varied solutions, and shifting the emphasis towards energy sufficiency rather than just efficiency. This has the potential to mitigate congestion in a more efficient and sustainable manner.

Another weakness is the substantial reliance on imported energy in the Netherlands. The policies seek to diminish this reliance by substantially increasing domestic renewable energy generation and establishing price stability through mechanisms such as price controls and subsidies. The Klimaatakkoord and Energiewet initiatives have played a central role in enhancing the generation of renewable energy, with the goal of reducing reliance on imports and enhancing energy accessibility. However, the shift towards renewable energy involves financial burdens, and present approaches mostly emphasize improving efficiency and providing subsidies, without offering concrete solutions to substantially decrease prices for all customers and households. This aligns with the findings of the literature (Sovacool & Brown, 2007).

Another weakness is the decline of public trust in governmental institutions. Complications arising from issues with public trust and governance hinder the implementation of energy policy. The Klimaatakkoord relies on initiatives aimed at enhancing transparency, promoting public engagement, and strengthening local government. Nevertheless, the task of restoring public confidence continues to be a major obstacle. Policies are being implemented to tackle this issue, including the requirement for compulsory participatory involvement in new infrastructure projects (Omgevingswet) and the cessation of operations in the Groningen gas fields. While these measures have helped to build trust, they have also resulted in increased reliance on imported energy and greater volatility in energy production due to the shift towards renewable sources, thereby reducing energy security. Establishing inclusive governance and restoring public confidence are essential for effectively implementing energy policy and attaining sustainable energy security.

Concerns about climate change and the need for cleaner energy sources are driving a social demand for a quicker transition to renewable energy. However, the need to ensure its dependability and cost tempers the ambition to achieve this transformation. The existing grid infrastructure has to be able to handle a larger share of renewable energy sources while ensuring that the costs remain affordable for the people. While policies recognize the need for social and economic fairness, there is a lack of a comprehensive strategy to ensure that energy is accessible for all parts of society. Financial assistance options such as subsidies and tax incentives assist in reducing the burden on low-income households, although the shift still disproportionately impacts disadvantaged people.

The Klimaatakkoord recognizes that it is crucial to make efforts to enhance transparency, encourage public engagement, and strengthen local government. Nevertheless, the persistent erosion of public confidence in governmental institutions continues to pose a substantial obstacle. Establishing public confidence and guaranteeing equitable governance are essential for effectively executing energy policy and attaining energy security.

Recommendations for enhancing policies in the Netherlands include implementing a comprehensive strategy to address grid congestion through the decentralization of industrial zones, energy sufficiency, and engaging stakeholders in the process of establishing solutions, meaning that policies should maintain their existing trajectory, but adopt a more comprehensive approach. Policies should prioritize the goal of ensuring that renewable energy is accessible to all sectors of society by implementing targeted subsidies, minimizing initial expenses, and stabilizing energy prices. The increase of renewable energy sources also mitigates the risk posed by the high energy dependence.

Conclusion

This thesis examined the impact of the Dutch energy policy on energy security using an interdisciplinary approach, incorporating perspectives from economics, environmental science, political science, and sociology. The research question, *"What is the impact of the Netherlands' current energy policy on their energy security?*", was investigated through a comprehensive assessment of existing literature, analysis of policies, and examination of a specific case study.

The findings suggest that the Netherlands has an overall sufficient level of energy security, mostly due to significant advancements in the integration of renewable energy and the implementation of legislative measures such as the Klimaatakkoord and Energiewet. Nevertheless, the research also revealed weaknesses such as substantial grid congestion, a high reliance on energy imports, and a decrease in trust in the government. These problems provide obstacles to attaining a reliable and cost-effective energy supply for all users. Existing policies prioritize the expansion of renewable energy capacity, the enhancement of energy efficiency, and the provision of financial incentives. Suggestions for further enhancement include resolving grid congestion by decentralizing industrial zones, arguing for energy sufficiency, and involving businesses in developing holistic solutions. In addition, regulations should guarantee that renewable energy is available to all consumers and households by adopting specific subsidies and stabilizing energy costs.

This research illustrates the complex connection between international and national factors and the multidisciplinary nature of ensuring the availability and reliability of energy resources. The energy strategy of the Netherlands is shaped by worldwide trends such as the shift towards renewable energy and efforts to mitigate climate change. At the same time, it also takes into account local difficulties such as building public confidence and improving grid infrastructure. The interaction across different disciplines underscores the fact that the present-day issues in energy security cannot be resolved by a simple, individual solution and that therefore a holistic approach is required.

The thesis' limitations stem from its dependence on simple, quantified indicators, which may not comprehensively encompass the intricacies of energy security elements as seen in the literature. In order to get a deeper understanding of the relationship between various aspects of energy security and to explore potential vulnerabilities and preventive measures for digitized energy infrastructure, future research should utilize mixed-methods methodologies. By implementing these suggestions, future research can enhance the comprehension of energy security and contribute to more efficient policies. This comprehensive strategy will guarantee that all aspects of energy security, such as availability, cost, acceptability, and accessibility, are sufficiently taken into account. In addition to these aspects, it is important to investigate other possible relevant elements, such as cyber security. Furthermore, more particular attention should be placed on mobility and commerce in order to analyze their effects.

To better understand the connections between the many facets of energy security, mixed-methods research approaches should be used in future studies. This comprehensive strategy will offer a more thorough evaluation of energy security, covering aspects such as the availability, affordability, acceptability, and accessibility of energy, as well as addressing new issues like cybersecurity and the more detailed effects of mobility and commerce.

In conclusion, Dutch energy policy is making progress in improving energy security and sustainability. However, it still needs ongoing adjustments to effectively tackle the complex difficulties it encounters. The Netherlands can create a resilient and sustainable energy future that serves all its residents by promoting innovation, implementing inclusive government, and prioritizing economic and social fairness. This thesis provides useful insights for policymakers, stakeholders, and future research efforts, enhancing our understanding of the intricate relationship between energy policy and energy security.

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