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Navigating risks in multi-stage translations for sustainability communication in the age of Artificial Intelligence

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Aim: In teaching and science, texts are translated from different languages. In this context, the present study investigates the potential distortions and systemic risks that arise when a source text on energy transition and sustainability is translated multiple times across different languages and by different agents, including professional translators and AI-based translation models. The research aims to analyze how these translations impact meaning, tone, and factual integrity, particularly in the context of complex topics like energy transition and related systemic risks. By comparing multiple versions of a text across English, Polish, and German, the study assesses the implications of translation-mediated communication in sustainability discourse.

Design / Methodology: First, an English source text was created, summarizing two scientific articles on the urgent need for energy transition and related system risk of such a transition. This text was translated into Polish by AI (text A) and by two professional translators (text B and C). The analysis of complexity (using Jasnopis) showed that the Polish texts were more complex (7/7, 7/7 and 6/7) for respectively texts A, B and C, than the English original text (O, 5/7). Text C was selected for translation into German by AI and by two professional translators. For comparison, the English source text was translated into German. The

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complexity of these translations was compared to the source text and the Polish versions. Afterwards, linguistic and semantic comparisons were carried out, evaluating shifts in meaning using cosine similarity (TF-IDF) and Levenshtein distance (edit distance). Furthermore, changes in emphasis, severity, and emotional tone across translations were analyzed.

Findings: This study shows that multi-stage translations in sustainability communication introduce significant distortions, affecting meaning, tone, and emphasis. AI translations tend to neutralize urgency and emotional intensity, while human translations introduce biases, either amplifying or softening risk perceptions. Additionally, differences in sentence complexity and terminology shift the focus of sustainability discourse. These findings highlight the risks of translation-mediated miscommunication in critical topics like energy transition and systemic risks.

Research limitations: The article presents a case study based on a small sample of translations. The results should be the basis for a more detailed research, comparing a larger group of AI translation and professional translations due to translator's bias, language-specific issues and the complexity of sustainability related notions.

Originality / Value: This research contributes to the sustainability communication discourse by focusing on the risks of multi-stage translations, where small wording changes can lead to significant distortions in meaning of notions and key-concepts, where miscommunication can impede decision-making and stakeholder involvement.

Keywords: translation accuracy, sustainability communication, multi-stage translation, systemic risks in translation, AI vs. human translation, computational linguistics, language education.
JEL: Q54, Z13, O33, C63.

1. Introduction

All over the world, research institutes, universities and policy makers deal with challenges of sustainable development (Leal Filho et al. 2023; Lozano et al. 2013). The notion of sustainability is grounded in theories of complex systems (Meadows 1998, 1999), which as such is difficult to understand for individuals (Kahneman 2011). The concepts of sustainability and sustainable development itself have multiple definitions, based on, for example, focus on environmental, social or economic aspects (Rao 2000), reflecting the contested nature of these concepts (Stough 2023). Furthermore, worldviews (Platje et al. 2022) as well as view on the limitations of resources and resilience of ecosystems (Gladwin et al., 1995) lead to great controversies in scientific and policy discussions. An additional challenge is that although much of the research is published in English, the authors have different linguistic backgrounds, and therefore educational materials and policy documents are written in multiple languages.

This study investigates the potential distortions and systemic risks that arise when a source text on energy transition and sustainability is translated multiple times across different languages and by different agents, including professional translators and AI-based translation models. The research aims to analyze how these translations impact meaning, tone, and factual integrity, particularly in the context of complex topics like energy transition and related systemic risks. By comparing multiple versions of a text across English, Polish, and German, the study assesses the implications of translation-mediated communication in sustainability discourse.

For the aim of this study, an English source text summarizing two scientific articles on the urgent need for an energy transition and its associated system risks was translated into Polish using Artificial Intelligence (AI) (text A) and by two professional translators (texts B and C). These translations were analyzed for complexity (using Jasnopis), semantic shifts (cosine similarity, TF-IDF, Levenshtein distance), and sentence-level differences, before being translated into German for further comparison.

The analysis shows that translation introduces meaning shifts, particularly in emphasis and severity, with AI and professional translations differing in phrasing choices, and stylistic preferences influencing accuracy—ultimately increasing systemic risks in sustainability communication across multiple translation layers.

2. Translation accuracy in sustainability communication

AI driven translation of texts has rapidly increased in importance during the last few years. Similar to human translations, mistranslations can lead to misinterpretations of sustainability regulations, and standard translation of key notions becomes elementary (Spahiu et al., 2024). For example, the notion "sustainable development" has many translations in Polish, depending on the focus of the author. Legally, it has been translated as "zrównoważony rozwój," as expressed in the country's constitution (Dz.U. 1997, No. 78, item 483). "Zrównoważony rozwój" literally means "balanced growth," which, while being the most cited definition of the notion, for example, does not reflect the meaning of sustainability itself. Sustainability can, for example, be perceived from the point of view of resilience, and following ecological economics focuses rather on preventing the collapse of ecosystems, social systems, political systems and economic systems. The translation "ekorozwój" (eco-development) tends to focus on the ecosystem as the basis for a society's sustainability (see Gladwin et al., 1995), strongly related to ecological economic theory and so-called strong sustainability. Natural resources cannot be replaced by physical and human capital, and thus limited environmental resources lead to the assumption that economic growth reduces the available natural resource base by reducing non-renewable resources and overusing renewable resources (see Georgescu-Roegen 1971; Daly 1996). On the contrary, balanced growth seems to assume continuous economic growth, implicitly assuming weak sustainability, adhering to the idea that technology and innovation can lead to the replacement of (scarce) natural resources (see Rao 2000; Gladwin et al. 1995).

When comparing machine translation (MT) and human experts, MT may not capture nuances and specific theoretical issues (Klosi et al. 2024a;b). Furthermore, AI tools might be able to translate but are not designed for the specific purpose of translations, therefore could provide differences in nuance and interpretation. For example, when asking AI tools questions on sustainability issues, it does not clearly relate to system risk. This risk that an economic system, a market, a logistic chain or another system loses its resilience and collapses (Platje et al. 2022) needs to be specifically addressed in prompts. MT may focus on mainstream knowledge used as an input, and as a result is biased towards mainstream interpretation of key notions (Yao 2024). While distorted translations may lead to wrong risk assessment (Ramadilla, Surbakti 2025), they also may lead to system risks. For example, in a serious situation of conflict a wrong word or translation may have serious irreversible consequences. It has been argued that the nuclear bombing of Hiroshima and Nagasaki on 6 and 9 August was triggered by a mistranslation of the Japanese word "*mokusatsu.*" In 1945 the Japanese Prime Minister Kantarō Suzuki responded to the Potsdam Declaration using the word *mokusatsu*. This word can mean either "to ignore with contempt" or "to withhold comment." Supposedly, Western translators interpreted it as a complete rejection. This would have led the Allies to believe Japan refused to surrender, triggering the decision to drop the atomic bombs on Hiroshima and Nagasaki. However, Naimushin (2024) argues that it is rather politics than linguistics that is relevant for the decision-making. He argues that when looking at the whole text, the message was clear, and that the bombs were dropped for other reasons.

These are examples of miscommunication regarding single notions and words. It shows that sustainability related terms, like the ones used in this study ("renewable energy transition," "system risk") are sensitive to linguistic adaptation and misinterpretation. This can lead to ambiguities in different languages. Multi-stage translations tend to increase such problems, an issue widely discussed (e.g., Biel 2017; Matulewska, Wagner 2021; Chidlov et al. 2014). However, the impact of multi-language translation distortions on energy transition and related system risk concerning decision-making for sustainable development, remains relatively underexplored.

Some studies have reported on the importance of considering linguistic and cultural contexts when discussing (and implementing) sustainability. Using South Korea as a case study, Baek and Ko (2015) address the difficulties in translating "sustainable development" into non-Western languages. The authors argue that direct translations often fail to capture the term's comprehensive meaning, leading to misunderstandings and misapplications in policy and practice. They suggest that without culturally and linguistically appropriate translations, the implementation of sustainability initiatives may be compromised. Also, within the African context, Ulmer et al. (2023) point towards the lack of equivalent terms for "sustainability" in local languages. This causes lack of effective communication and understanding, and a gap in awareness among the general population.

Furthermore, within a business context, discourse studies have shown that sustainability as a term has been translated and adapted in order to "fit" the narrative of the sector. For example, focusing on the Norwegian salmon farming industry, Aarset et al. (2020) explore how the ambiguous concept of sustainability is interpreted and legitimized by industry stakeholders. In other words, firms employ various discursive strategies to justify their (un)sustainable practices (e.g. Zappettini, Unerman 2016). While the literature refers to these business practices as discursive strategies, the underlying effects related to misinterpretations arising from direct translations can lead to ineffective policies and practices as well, highlighting the need for culturally sensitive approaches to sustainability discourse.

However, whereas mistranslation seems to be unavoidable in the context of AI translation, it may also occur in human translation. As Tabakowska observes, one of the relevant aspects of translation consists in "the translator's decision making process" (2014: 132). Therefore, mistranslation may occur simply due to the inaccurate decisions made by translators. Significant differences may appear between translations of the same Source Text conducted by different translators, insofar as the process of rendering a text into another language is also a subjective process, relying on the individual knowledge and experiences of the translator, who filters the translated text through his or her own perception (Tabakowska 2014: 132). Additionally, whereas the risk of mistranslation increases in the case of multi-staged translations, it may also occur in the context of direct translation, which was discussed for example by Catford (1965). The author observes that certain departures from the original text are unavoidable due to differences between languages, which results in the so called "translation shifts" (1965: 73).

Furthermore, direct translation may not always be possible due to structural or metalinguistic differences between languages or in the situation when there is no corresponding concept in the target language. In this case, oblique translation involving methods such as transposition or modulation is applied. Whereas transposition generally does not change the meaning of the message, modulation, for example, may distort the receiver's understanding of the given concept, insofar as it involves the change of point of view with respect to a given concept in the Source Language (Vinay, Darbelnet 1995: 84-89). Therefore, while "every translation is an interpretation" (Skwara 2019: 30), with respect to texts referring to issues such as sustainability or system risk, the subjectivity of translators shall be reduced to minimum, insofar as it may have serious consequences, as illustrated by the aforementioned example concerning Hiroshima and Nagasaki.

3. Method

The issue of system risk was chosen for analysis, as it concerns the base line of sustainable development—system resilience and survival. This is an issue that is mentally difficult to grasp in a society focused on growth and innovation, as it requires the precautionary principle, withhold from action when the consequences can lead to irreversible collapse of a system or organization. Excerpts from two articles on this issue by one of the authors of this article (Platje et al. 2022, 2024) were selected (see Appendix 1). With help of AI (Gemini), these texts were integrated and summarized, expressing the main message of system risks in energy transition. Afterwards, two professional translators and AI translated the English text into Polish. These texts were compared with regard to their complexity using the program "Jasnopis." The second professional translation was selected as the basis for the translation into German, as it had the lowest level of complexity (6 out of 7, compared with 7 out of 7 for the other translations). The original text and the translations into Polish and German can be found in the Appendix (Tables A and B).

In order to analyze the differences between the English translation into Polish, and one of the Polish translations into German, three methods were used: complexity analysis, semantic similarity analysis (cosinus similarity), translation accuracy Levenshtein similarity.

First, an analysis of the text difficulty (readability) was carried out, using the Polish programme Jasnopis (www.jasnopis.pl). While Jasnopis analyzes word complexity (rare and difficult words), syntax complexity and specialized vocabulary, it does not account for the average length of sentences.

The cosine similarity (TF-IDF) (Manning 2008) measures semantic similarity between texts based on word distribution. However, it does not detect word order changes and can be affected by the use of synonyms. The Levenshtein similarity method (Levenshtein 1966) measures character-level differences, reflecting structural similarity. It does not consider meaning, and is sensitive to word order changes. The cosine similarity method measures on a scale from 0 to 1 the word frequencies and similarities, where closer to 1 means greater semantic similarity. This is done in order to assess whether the meaning remains in the translation process and to measure the translation accuracy. Levenshtein similarity (edit distance) measures structural and formatting differences through the number of insertions, deletions, or substitutions needed to translate a text.

Furthermore, changes in emphasis, severity, and emotional tone across translations were analyzed.

4. Results and discussion

German and Polish languages tend to be more complex than English language (Morciniec 2016). The analysis of complexity (using Jasnopis) showed that the Polish texts were more complex (7/7, 7/7 and 6/7 for respectively texts A, B and C), than the English original text (5/7). This means that the Polish text is understandable for people with specialist knowledge. This creates a significant challenge in communicating system risk and related issues of resilience and the precautionary principle. The Polish translations had longer average sentence length (17.5 (text A), 17.88 (text B), 17.22 (text C) than the original text (16.75). German texts (D, E, F) have the highest sentence length (20.75 for D, the AI generated translation, 19.5 for E and 18.8 for F). The longer sentences created by AI for the German translation, 20.75 words per sentence, stand against the length of the direct English-German translation with average 18.1 words per sentence.

The results of the cosine similarity test and the Levenshtein similarity test are presented in Table 1. A value of cosine similarity closer to 1 indicates a stronger similarity in the meaning. The results range between 0.5 and 0.58 for the respective three Polish versions and the four German versions. This can be interpreted as moderate similarity. A similarity of 0.5 means that about 50% of the key terms in the compared texts overlap. The difference of maximum 0.07 between the texts as such is not very significant. The meaning is similar, but the style, wording, sentence structure, phrasing and word order differ. The result for D-G, a cosine similarity of 0.572, is an indication that direct translation leads to less significant loss of meaning. While this probably does not change the core message, it shows potential differences in emphasis, severity, and emotional tone. The change in meaning between different languages cannot be analyzed sensibly with the cosine similarity test.

For the Levenshtein Similarity, a higher value (closer to 1) means that the structure of the text is more similar. While the translation by AI of the original text into Polish (O-A) has a value of 0.85, the values for the translation from Polish (text C) into German range between 0.7 and 0.8. This is not such a surprising result of indirect translation, where similarity is lost. The German texts are more similar than the Polish texts.

Table 1. Cosine similarity score and Levenshtein similarity

	Cosine similarity score	Levenshtein similarity (Edit Distance)
O-A	--	0.851
O-B	--	0.827
O-C	--	0.794
O-D	--	0.695
O-E	--	0.757
O-F	--	0.760
O-G	--	0.775
A-B	0.511	0.972
A-C	0.575	0.933
B-C	0.508	0.960
C-D	--	0.876
C-E	--	0.954
C-F	--	0.957
C-G	--	0.977
D (German AI) - E (German prof. 1)	0.515	0.918
D (German AI) - F (German prof. 2)	0.555	0.915
D (German AI) - G (German translated from original English by AI)	0.572	0.897
E-F	0.566	0.997
E-G	0.554	0.977
F-G	0.547	0.980

Source: analysis with use of Scholar GPT.

There are important limitations in the use of AI in text analyses. In the analysis using Chat GPT 4o, differences were observed in the analysis process. Although this may be because of ambiguous prompts, with same prompts minor differences were observed. Reasons provided by Chat GPT 4o for differences in the calculation of cosine similarity were – the standardization process (lowercasing, removing excess spaces) may differ, the TF-IDF vectorization process (Term Frequency-Inverse Document Frequency, a statistical measure used to evaluate how important a word is within a document relative to a collection of documents) may differ across runs and stop word effects and tokenization artifacts may appear.

Changes in emphasis, severity, and emotional tone across translations

Translations are likely to alter the original meaning (Morciniec 2016). In the context of system risks in energy transition, which can lead to irreversible collapse scenario's, severity, urgency and consequences embraced in the text are relevant. For example, the analysis shows that the original English text has a slightly negative tone (-0.05 polarity).[1] This disappears in the translations to Polish and also German. In other words, the emotional intensity is removed. This can, on the one hand, mean that the translations tend to make the argument more objective and neutral. However, the original source was a scientific test on the need of an energy transition, as there are pressing problems such as expected increased energy scarcity and climate change, both likely to destabilize society as we know it. A neutral tone may not communicate the existing dangers properly.

Interestingly, the emphasis change is visible in the translation of the title. As presented in Table 3, the severity and urgency depend on the translator. AI translations tend to stay close to the original. The translator may have cognitive biases influencing the urgency, like with the German translation E, strengthening the fear factor.

[1] Polarity measures whether the overall emotional tone is negative, neutral of positive, while subjectivity measures the level of factuality (Morciniec 2016).

Table 3. Changes in severity and urgency in the translated title

Title	**Changes in severity and urgency**
English (O): “Looming Catastrophes: the Urgent Need for Renewable Energy”.	Alarmist tone: “looming catastrophes” suggests imminent danger.
Polish A (AI): „Nadchodzące katastrofy: pilna potrzeba odnawialnych źródeł energii” (close translation).	Close translation of the original.
Polish B: „Widmo nadciągających katastrof: energia odnawialna jest nam coraz pilniej potrzebna” (stronger emphasis on impending disaster).	Amplifies the fear factor by using “widmo” (specter, looming threat)—a metaphor that enhances the sense of doom.
Polish C: „Katastrofy na horyzoncie: nagląca potrzeba przejścia na energię odnawialną” (slightly softer wording, more distant „on the horizon”).	Softens the tone slightly, with “katastrofy na horyzoncie” (disasters on the horizon) suggesting something expected but not yet urgent.
German D (AI translation via Polish C): “Katastrophen am Horizont: die dringende Notwendigkeit des Übergangs zu erneuerbaren Energien”.	Weaker alarmism, similar to Polish C.
German E (translation via Polish C): “Ein Schreckgespenst drohender Katastrophen – erneuerbare Energien werden immer dringender benötigt” (most dramatic, “Schreckgespenst” means “scary specter”).	The most fear-inducing—it adds “Schreckgespenst” (ghostly terror), making the disaster feel almost haunting.
German F (translation via Polish C): “Drohende Katastrophengefahr: erneuerbare Energie immer dringender benötigt” (implies dangerous situation, but removes metaphorical aspect).	More neutral, removing the metaphoric specter and making the tone more factual.
German G (direct AI translation from English): “Drohende Katastrophen: Die dringende Notwendigkeit erneuerbarer Energien” (most faithful to English).	Stays closest in urgency and alarm.

Table 4. Change in focus of the translation

	Changes in focus: causes and consequences	**Example shift in causal emphasis:**	**The Fukushima disaster example: interpretation differences**
English (O):	Focuses equally on causes (fossil fuels) and consequences (catastrophes).	"Fossil fuels have fueled economic growth, but their limited resources and depletion pose a dire threat of future economic collapse and environmental catastrophe."	"The Fukushima disaster tragically exemplifies how neglecting these factors can culminate in man-made catastrophes."
Polish A (AI):	Tend to highlight economic consequences more than environmental ones.	„Paliwa kopalne napędzały wzrost gospodarczy, jednak ich ograniczone zasoby i wyczerpywanie się stanowią poważne zagrożenie przyszłym załamaniem gospodarczym i katastrofą środowiskową" (economic collapse is emphasized before environmental disaster).	
Polish B:	Tend to highlight economic consequences more than environmental ones.	Similar to Polish A.	
Polish C:	Tend to highlight economic consequences more than environmental ones.	Similar to Polish A.	„Katastrofa w Fukushimie jest tragicznym przykładem tego, jak zaniedbanie tych czynników może doprowadzić do katastrofy zawinionej przez człowieka".“Katastrofa zawiniona przez człowieka" (human-caused disaster) explicitly blames human error, making the argument more accusatory than the English version.

Table 4. Cont.

German D (AI translation via Polish C):			"Die Katastrophe von Fukushima ist ein tragisches Beispiel dafür, wie die Vernachlässigung dieser Faktoren zu einer von Menschen verursachten Katastrophe führen kann." Similar to Polish C but slightly softer: "von Menschen verursacht" (caused by humans) sounds less directly accusatory than "zawiniona".
German E (translation via Polish C):	Emphasize the catastrophic dangers more (leaning into risk perception).	"Fossile Brennstoffe sind zwar der Wachstumsmotor unserer Volkswirtschaften, doch ihre endlichen und schwindenden Ressourcen stellen eine ernste Gefahr künftiger wirtschaftlicher Zusammenbrüche und Umweltkatastrophen dar". (Economic threats are more central, while environmental risks are secondary.)	
German F (translation via Polish C):	Emphasize the catastrophic dangers more (leaning into risk perception).		
German G (direct AI translation from English):	Follows the original most closely in balance.		

It can be argued that while the Polish translations seem to focus more on neglect of environmental threats, the base line of sustainability, the German translations seem to soften the accusation of human cause of system risk. While the English original contains a balanced mix of urgency, risk and factual discussion, the Polish translations tend to focus on economic risk and human error. The German translation E has a tendency to amplify the fear aspect, which seems to be more neutral in the two other German translations (D, F). The direct English (O) German translation (G) is closest in tone and meaning. Translations into Polish show some shifts in emphasis, influencing severity perception. If the goal is maximum urgency, English O, Polish B, and German E are the most alarmist. If the goal is factual neutrality, Polish C and German F are the most objective translations.

5. Discussion and conclusion

This study focused on the challenges posed by multi-stage translations in the context of sustainability communication, particularly regarding the energy transition. The findings demonstrate that both human and AI-based translations introduce distortions that can change the meaning, severity, and focus of critical sustainability concepts. The cosine similarity and Levenshtein similarity showed differences in meaning and structural accuracy between languages. Not surprisingly, in multiple stage translations something is “lost in translation.”

AI translations are more neutral regarding emotional intensity and urgency. This is also not surprising, as AI in translation processes itself does not show cognitive biases related to the mindset. However, the input for the learning processes of AI is biased, as it was created by human beings. As each individual differs in mindsets, worldviews, values, and perceptions regarding sustainability (e.g. Caniëls et al. 2021), differences can be expected. This can either amplify or soften risk-related narratives.

Furthermore, there exists the risks of relying solely on AI-based translation models, which, while efficient, may prioritize linguistic coherence over contextual precision, reinforcing mainstream narratives at the expense of nuanced, system-level discussions. Translation goes beyond linguistic transfer. The transformation of meaning is influenced by cultural, cognitive, and technical factors. This influences the emotional load, changing the urgency. This, in turn, can impact decision-making processes, which is a topic of further research. This distortion in risk perception poses a serious challenge in crisis situations, where accurate communication of system risks is essential for timely intervention. If a translation minimizes the urgency of a potential collapse scenario, decision-makers may underestimate the need for precautionary measures, leading to inadequate policy responses. Conversely, an exaggerated emphasis on risk could result in alarmist reactions, diverting resources inefficiently or fostering public distrust in sustainability initiatives.

The emergence of advanced AI translation systems will profoundly influence the translation profession, which triggers calls for reflection of translation automation in light of sustainability (cf. Moorkens et al. 2024; Xiaoying 2024). Translators are increasingly faced with machine translations that they have to edit, which requires new skills and competences (Çetiner 2021; Liu et al., 2022). Furthermore, in the context of sustainability, specific competencies (e.g. Birdman et al. 2022; Brundiers et al., 2021; Cebrian et al. 2019; Lambrechts 2019; Lambrechts, Van Petegem 2018) and knowledge (e.g. Stough et al. 2023) is needed to grasp the complexity, uncertainty and urgency of sustainability issues. Identifying and further conceptualising competencies in the context of translation education, as well as how such competencies could be integrated in translation curricula and study programs, is a recommendation for future research. Furthermore, integrating sustainability knowledge into translation education is essential to deepen understanding of students (future translators) of sustainability and societal challenges (Kim 2005), as well as raising awareness about potential risks in translation approaches when dealing with complex challenges.

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Appendix 1. The original text before AI summarizing (from Platje et al. 2022, 2023)

From Platje et al. (2024):
The world economy has been heavily dependent on fossil fuels for the last decades (United Nations 1992). Economic growth has been based on technological development, increasing the dependency on non-renewable fossil fuels (United Nations 1997; Smil 2022). There are physical limitations to the global fossil fuel energy reserves. The expected shortages of fossil fuels in the future are expected to lead to a rise and increase in the volatility of fossil fuel prices (Servigne, Stevens 2020). This creates a threat to global economic growth. Furthermore, the use of fossil fuels is strongly connected to the threat of global climate change. Global climate change is a long-term process, characterized by increasing average temperatures as well as a statistically significant increased number and intensity of extreme events such as heat waves, droughts, floods, and hurricanes (United Nations 1997; Smil 2022). In order to prevent a climate catastrophe and economic crises, an energy transition towards renewables is required (United Nations 1997; Smil 2022). In order for the energy transition to be sustainable, it should be directed toward locally-governed, resilient systems based on renewable energy supply (Ecker et al. 2017).
Energy transitions involve a high level of uncertainty. In general, transitions are extremely slow processes that may take decades (Sovacool 2018). This inertia is due to technological and economic lock-ins in the highly complex energy supply chains (Andersen 2013; Servigne, Stevens 2020). These complex integrated global supply chains also entail vulnerabilities (Taleb et al. 2014). Therefore, autarkic (e.g. decentralized and independent) solutions become attractive (Culley et al. 2013). These solutions also make the consumer less dependent on oligopolistic producers (Gattie 2020; Berg et al. 2021).

From Platje et al. (2022):

There are many reasons for ignorance of different types of risk. Ignorance can be rational (Downs 1957), or be a result of a focus on short-term myopic goals (Alvesson, Spicer 2012), or due to the structure of the human brain (focus on cause-consequence explanations, quick decision-making based on emotions, etc.) (Swaab 2015; Beck 2017), difficulties in understanding probabilities, statistical data and uncertainties (Kahneman 2011). People tend to have difficulties in grasping the non-linear aspects of the existing threats (Sterman 2000), such as runaway processes in climate change (Allen, Frame 2007) or chain reactions in, e.g., large scale systems of nuclear plants having the potential to create a large-scale catastrophe (Taleb et al. 2014). In risk assessment models, the importance of unexpected events as a threat to systems sustainability is often neglected, denied, or poorly understood. Random events and processes play an important role, not only as a probabilistic driver of change (Lem 1968; Mandelbrot 2008). They also reveal the vulnerabilities and fragilities in a system (Taleb 2012). It can be argued that it was only a matter of time that the Fukushima Daiichi Nuclear Power Station accident in March 2011 would happen. Like most disasters (Casti 2013), this disaster was man-made as "international best practices and standards" were not followed, and information "of large tsunamis inundating the region surrounding the plant about once every thousand years" was ignored (Acton, Hibbs 2012: 1).

Appendix 2. Texts developed and selected in our study

Table A. The texts for research and analysis of the level of difficulty - Polish translation

Original text (O)	Gemini translation (Text A)	Professional translation 1 (Text B)	Professional translation 2 (Text C)
Looming Catastrophes: the Urgent Need for Renewable Energy Fossil fuels have fueled economic growth, but their limited resources and depletion pose a dire threat of future economic collapse and environmental catastrophe. A rapid transition to renewable energy is essential to avert these disasters. This shift is complex due to entrenched energy systems and human decision-making biases. Decentralized renewable sources offer greater control and security compared to traditional, centralized systems, which are vulnerable to single points of failure. Ignoring these risks, including potential shortages and system risks, can be due to short-sightedness, cognitive limitations,	**Nadchodzące katastrofy: pilna potrzeba odnawialnych źródeł energii** Paliwa kopalne napędzały wzrost gospodarczy, jednak ich ograniczone zasoby i wyczerpywanie się stanowią poważne zagrożenie przyszłym załamaniem gospodarczym i katastrofą środowiskową. Szybka zmiana na odnawialne źródła energii jest niezbędna, aby uniknąć tych katastrof. Przejście na energię odnawialną jest złożone ze względu na utrwalone systemy energetyczne i ludzkie błędy poznawcze w podejmowaniu decyzji. Zdecentralizowane źródła odnawialne oferują większą kontrolę i bezpieczeństwo w porównaniu z tradycyjnymi,	**Widmo nadciągających katastrof: energia odnawialna jest nam coraz pilniej potrzebna** Co prawda paliwa kopalne napędzają wzrost naszych gospodarek, ale ich ograniczone i wyczerpujące się zasoby stanowią poważne zagrożenie w postaci przyszłego załamania gospodarczego i katastrofy ekologicznej. Aby zapobiec tym katastrofom, konieczne jest szybkie przejście na energię odnawialną. Jest to złożona kwestia z powodu skostniałych systemów energetycznych i ludzkich uprzedzeń decyzyjnych. Zdecentralizowane źródła odnawialne oferują większą kontrolę i bezpieczeństwo w porównaniu do tradycyjnych, scentralizowanych systemów,	**Katastrofy na horyzoncie: nagląca potrzeba przejścia na energię odnawialną** Paliwa kopalne od dawna są siłą napędową wzrostu gospodarczego, jednak ich ograniczone i coraz bardziej kurczące się zasoby stanowią poważne zagrożenie i mogą w przyszłości doprowadzić do załamania gospodarki oraz katastrofy ekologicznej. Aby zapobiec tym czarnym scenariuszom, niezbędne jest szybkie przejście na energię odnawialną. Wprowadzenie tej zmiany będzie niezwykle skomplikowane ze względu na utrwalone wzorce energetyczne oraz liczne uprzedzenia w procesach podejmowania decyzji. Zdecentralizowane źródła odnawialne zapewniają

or a failure to consider unpredictable events, potentially leading to catastrophic consequences. The Fukushima disaster tragically exemplifies how neglecting these factors can culminate in man-made catastrophes. This disaster, entirely preventable, underscores the urgency of a global shift to renewable energy sources.	scentralizowanymi systemami, które są podatne na awarie pojedynczego punktu. Ignorowanie tych ryzyk, w tym potencjalnych niedoborów i ryzyka systemowego, może wynikać z krótkowzroczności, ograniczeń poznawczych lub zaniedbania uwzględnienia nieprzewidywalnych zdarzeń, co może prowadzić do katastrofalnych skutków. Katastrofa w Fukushimie jest tragicznym przykładem tego, jak zaniedbanie tych czynników może doprowadzić do katastrofy spowodowanej przez człowieka. Ta całkowicie możliwa do uniknięcia katastrofa podkreśla pilną potrzebę globalnego przejścia na odnawialne źródła energii.	które są podatne na punktowe awarie. Ignorowanie tych zagrożeń, w tym potencjalnych niedoborów i zagrożeń systemowych, może wynikać z krótkowzroczności, ograniczeń poznawczych lub nieuwzględnienia nieprzewidywalnych zdarzeń, potencjalnie prowadząc do katastrofalnych w swojej skali konsekwencji. Katastrofa elektrowni w Fukushimie jest przykładem tego, jak zaniedbanie tych czynników może doprowadzić do tragicznych skutków spowodowanych czynnikiem ludzkim. Katastrofa ta, której można było całkowicie zapobiec, podkreśla pilną potrzebę globalnego przejścia na odnawialne źródła energii.	większą kontrolę i bezpieczeństwo w porównaniu z tradycyjnymi, scentralizowanymi systemami, które są podatne na punktowe awarie. Ignorowanie tych zagrożeń, w tym potencjalnych niedoborów i ryzyka systemowego, może wynikać z krótkowzroczności, ograniczeń poznawczych lub nieuwzględnienia niedających się przewidzieć zdarzeń, które mogą prowadzić do zgubnych konsekwencji. Katastrofa w Fukushimie jest tragicznym przykładem tego, jak zaniedbanie tych czynników może doprowadzić do katastrofy zawinionej przez człowieka. Tragedia ta, której można było w pełni zapobiec, uwypukla pilną potrzebę globalnego przejścia na odnawialne źródła energii.

Source: developed based on excerpts from Platje et al. (2022, 2023).

Table B. The texts for research and analysis of the level of difficulty - German translation

Professional translation 2 (Text C)	Scholar GPT translation (Text D)	Professional Translation 1 (Text E)	Professional translation 2 (Text F)	Scholar GPT translation English-German (Text G)
Katastrofy na horyzoncie: nagląca potrzeba przejścia na energię odnawialną. Paliwa kopalne od dawna są siłą napędową wzrostu gospodarczego, jednak ich ograniczone i coraz bardziej kurczące się zasoby stanowią poważne zagrożenie i mogą w przyszłości doprowadzić do załamania gospodarki oraz katastrofy ekologicznej. Aby zapobiec tym czarnym scenariuszom, niezbędne jest szybkie przejście na energię odnawialną. Wprowadzenie tej zmiany będzie niezwykle skomplikowane ze względu na utrwalone wzorce energetyczne oraz liczne uprzedzenia w procesach podejmowania decyzji. Zdecentralizowane źródła odnawialne zapewniają	**Katastrophen am Horizont: Die dringende Notwendigkeit des Übergangs zu erneuerbaren Energien** Fossile Brennstoffe waren lange Zeit die treibende Kraft des wirtschaftlichen Wachstums, doch ihre begrenzten und zunehmend schrumpfenden Ressourcen stellen eine ernsthafte Bedrohung dar und könnten in Zukunft zu einem wirtschaftlichen Zusammenbruch sowie zu einer ökologischen Katastrophe führen. Um diese düsteren Szenarien zu verhindern, ist ein rascher Übergang zu	**Ein Schreckgespenst drohender Katastrophen - erneuerbare Energien werden immer dringender benötigt** Fossile Brennstoffe sind zwar der Wachstumsmotor unserer Volkswirtschaften, doch ihre endlichen und schwindenden Ressourcen stellen eine ernste Gefahr künftiger wirtschaftlicher Zusammenbrüche und Umweltkatastrophen dar. Um diese Katastrophen zu verhindern, ist ein schneller Übergang zu	**Drohende Katastrophengefahr: erneuerbare Energie immer dringender benötigt** Zwar treiben fossile Brennstoffe das Wachstum unserer Wirtschaftszweigen an, aber ihre begrenzten und ausgelaugten Ressourcen stellen eine ernsthafte Bedrohung in Form eines zukünftigen wirtschaftlichen Zusammenbruchs und einer ökologischen Katastrophe dar. Um diese Katastrophen zu vermeiden, ist ein unverzüglicher Übergang zu erneuerbaren Energien unerlässlich.	**Drohende Katastrophen: Die dringende Notwendigkeit erneuerbarer Energien** Fossile Brennstoffe haben das Wirtschaftswachstum angetrieben, doch ihre begrenzten Ressourcen und Erschöpfung stellen eine ernste Bedrohung für einen zukünftigen wirtschaftlichen Kollaps und eine Umweltkatastrophe dar. Ein rascher Übergang zu erneuerbaren Energien ist unerlässlich, um diese Gefahren abzuwenden. Dieser Wandel ist jedoch komplex, da bestehende Energiesysteme tief verwurzelt sind und menschliche Entscheidungsprozesse oft von Verzerrungen beeinflusst werden.

większą kontrolę i bezpieczeństwo w porównaniu z tradycyjnymi, scentralizowanymi systemami, które są podatne na punktowe awarie. Ignorowanie tych zagrożeń, w tym potencjalnych niedoborów i ryzyka systemowego, może wynikać z krótkowzroczności, ograniczeń poznawczych lub nieuwzględnienia niedających się przewidzieć zdarzeń, które mogą prowadzić do zgubnych konsekwencji. Katastrofa w Fukushimie jest tragicznym przykładem tego, jak zaniedbanie tych czynników może doprowadzić do katastrofy zawinionej przez człowieka. Tragedia ta, której można było w pełni zapobiec, uwypukla pilną potrzebę globalnego przejścia na odnawialne źródła energii.	erneuerbaren Energien unerlässlich. Die Umsetzung dieses Wandels wird äußerst komplex sein, da etablierte Energiemuster sowie zahlreiche Vorurteile in Entscheidungsprozessen bestehen. Dezentralisierte erneuerbare Energiequellen bieten im Vergleich zu traditionellen, zentralisierten Systemen, die anfällig für punktuelle Ausfälle sind, eine größere Kontrolle und Sicherheit. Die Ignorierung dieser Bedrohungen, einschließlich potenzieller Engpässe und systemischer Risiken, kann auf Kurzsichtigkeit, kognitive Einschränkungen oder die Nichtberücksichtigung	erneuerbaren Energien notwendig. Aufgrund veralteter Energiesysteme und einer menschlichen Voreingenommenheit bei Entscheidungen handelt es sich hierbei um ein komplexes Problem. Dezentrale und erneuerbare Energien bieten im Vergleich zu herkömmlichen, zentralisierten Systemen, die anfällig für Ausfälle sind, mehr Kontrolle und Sicherheit. Das Ignorieren dieser Risiken, zu denen auch potenzielle Engpässe und systemische Bedrohungen zählen, kann auf eine Kurzsichtigkeit, kognitive Einschränkungen oder die Nichtberücksichtigung	Aufgrund starrer Energiesysteme und menschlicher Entscheidungsvorurteile ist das jedoch ein komplexes Problem. Dezentrale erneuerbare Energiequellen bieten mehr Kontrolle und Sicherheit im Vergleich zu traditionellen, zentralisierten Systemen, die anfällig für Stellenausfälle sind. Das Ignorieren dieser Bedrohungen, darunter potenzieller Engpässe und systemischer Gefährdung, kann aus Kurzsichtigkeit, kognitiver Einschränkungen oder Nichtberücksichtigung unvorhersehbarer Ereignisse resultieren und maßstäblich zu katastrophalen Nachfolgen führen. Die Katastrophe des Kernkraftwerks in Fukushima ist ein Beispiel dafür, wie die	Dezentrale erneuerbare Energiequellen bieten mehr Kontrolle und Sicherheit im Vergleich zu traditionellen, zentralisierten Systemen, die anfällig für einzelne Ausfallpunkte sind. Die Ignorierung dieser Risiken, einschließlich möglicher Engpässe und Systemrisiken, kann auf Kurzsichtigkeit, kognitive Einschränkungen oder das Versäumnis zurückzuführen sein, unvorhersehbare Ereignisse zu berücksichtigen – was potenziell katastrophale Folgen haben kann. Die Fukushima-Katastrophe ist ein tragisches Beispiel dafür, wie die Vernachlässigung dieser Faktoren in menschengemachten Katastrophen gipfeln kann. Diese vollständig vermeidbare Katastrophe unterstreicht die Dringlichkeit eines

	unvorhersehbarer Ereignisse zurückzuführen sein, die verheerende Konsequenzen haben könnten. Die Katastrophe von Fukushima ist ein tragisches Beispiel dafür, wie die Vernachlässigung dieser Faktoren zu einer von Menschen verursachten Katastrophe führen kann. Diese Tragödie, die vollständig vermeidbar gewesen wäre, unterstreicht die dringende Notwendigkeit eines globalen Übergangs zu erneuerbaren Energiequellen.	unvorhersehbarer Ereignisse zurückzuführen sein und möglicherweise katastrophale Folgen haben. Die Nuklearkatastrophe von Fukushima ist ein Beispiel dafür, wie die Vernachlässigung dieser Faktoren zu tragischen, vom Menschen verursachten Folgen führen kann. Diese völlig vermeidbare Katastrophe unterstreicht die dringende Notwendigkeit einer weltweiten Umstellung auf erneuerbare Energiequellen.	Vernachlässigung dieser Faktoren zu tragischen Folgen durch menschliches Versagen führen kann. Diese Katastrophe, die ganz und gar zu vermeiden war, betont die dringende Notwendigkeit eines globalen Übergangs zu erneuerbaren Energiequellen.	weltweiten Übergangs zu erneuerbaren Energiequellen.

Source: developed based on excerpts from Platje et al. (2022, 2023).