

Master's Thesis

For the degree programme Business and Engineering

Enhancing Human Decision-Making in Energy Transformation of Industrial and Energy Companies by Leveraging Large Language Models

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Abstract

Energy transformation is crucial for sustainable energy management. With the advancement of AI technologies, large language models (LLMs) are emerging as potential drivers of enhanced energy transformation. In this context, this study examines the role of LLMs in enhancing human decision-making in the energy transformation of industrial and energy companies. The study is conducted as part of the “enefit” project, funded by the European Union under the Europäischer Fonds für regionale Entwicklung (European Regional Development Fund) in Bavaria.

The study employed a qualitative methodology using semi-structured interviews with eleven decision-makers in Germany to obtain first-hand participant insights. These insights were analyzed through thematic analysis using a deductive approach, guided by eight pre-defined themes.

To evaluate and validate the study hypotheses, a triangulation approach was adopted by integrating semi-structured interviews, ChatGPT answers, and literature evidence. In this regard, participant responses were also compared with ChatGPT’s answers to the questions in the study context to identify conflicts and contradictions between the two sides, and to better understand the practical competence and potential of LLMs in real-world implementations.

Overall, the findings are largely in line with the existing literature on the study context, but also uncover a gap between the potential of LLMs, as described in ChatGPT answers and the literature, and the reality of LLMs, as perceived by participants. In this regard, participants were more cautious about the role and reliability of LLMs in the energy transformation context than ChatGPT answers and some optimistic accounts in the literature. This practical stance offers a more conservative contrast to theoretical scenarios in which LLMs might take a more central decision-making role in energy transformation implementations.

The study finally presents various direct and actionable recommendations for practitioners and policymakers, aiming to facilitate the responsible and strategic integration of LLMs and to foster more effective human–LLM collaboration for enhanced human decision-making.

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1 Introduction

Decarbonization of industrial sectors is essential for maintaining competitiveness in a low-carbon future, as regulatory pressures and market dynamics increasingly favor low-emission technologies. In this regard, energy transformations not only reduce operational costs but can also enhance a firm's market position by complying with stringent environmental regulations (Garrone et al., 2017: 50).

According to Rosenow et al. (2017: 95), however, “energy transitions are complex and long-term processes”. Correspondingly, Fresner et al. (2017: 1650) indicate that numerous affordable energy efficiency solutions exist, yet they remain unexecuted because of various efficiency barriers, including financial reasons, a lack of information, and limited in-house skills. In this regard, Agrawal et al. (2023: 3) state that as time passes, the factors and challenges regarding the adoption of energy-saving measures vary; therefore, consensus on the factors and challenges has not been reached previously.

As a result, when assessing the sustainability of energy systems, numerous variables must be taken into account. Because when considering even the same system scope; and assuming major key assumptions are similar, the results in energy system parameters might vary significantly between different scenarios (Hottenroth et al., 2022: 1). Therefore, “assessing decarbonization pathways for energy systems requires a holistic perspective, as considered under the concept of sustainable development” (Hottenroth et al., 2022: 2). Hence, this situation raises the question: how can decision-makers effectively manage decision-making processes in their organizations through the complexities of energy transformation?

This study, which emerged from this question, was conducted as part of the “enefit” project, funded by the European Union under the Europäischer Fonds für regionale Entwicklung (European Regional Development Fund) in Bavaria. The project is led by the Institute for Sustainable Energy Systems (IN-SYS) at the Technische Hochschule Würzburg-Schweinfurt (THWS). “enefit” supports small and medium-sized enterprises (SMEs) in Mainfranken in implementing energy efficiency and decarbonization measures. A key objective is the development of an AI-based chatbot to assist companies in identifying their needs and exploring energy-efficient solutions through data-driven decision support.

2 State of the Art

According to Jaiswal et al. (2022: 1), efficient, eco-friendly, and sustainable energy management has become increasingly important as conventional energy resources run out and concerns regarding climate change increase. In this context, Kaur et al. (2024: 3) indicate that energy decisions have a major

impact on the environment, making informed decisions crucial to minimize adverse effects. Hence, “in the field of energy management, sustainability is based on sound decision-making” (Kaur et al., 2024: 3).

Steyvers and Kumar (2023: 722), who presented an interdisciplinary perspective based on recent empirical and theoretical findings, state that “artificial intelligence (AI) has the potential to improve human decision-making by providing decision recommendations and problem-relevant information to assist human decision-makers”. Correspondingly, Ahmad et al. (2021: 20) indicate that through the development of innovative technology, AI has emerged as a key player in transforming sustainable energy management decision-making.

The evolution of strategic management processes, as discussed by Stipić (2021), underscores the importance of AI in a decision-making process. The study suggests that a strategic planning methodology that includes AI can greatly impact corporate profitability and overall success (Stipić, 2021: 134). In this regard, the incorporation of AI into strategic planning is essential for organizations to successfully navigate intricate business landscapes and make informed decisions that lead to positive business results (Stipić, 2021: 134).

According to Ferreira and Monteiro (2020: 1), who aimed to assess fairness in decision process with AI by developing an evidence-based explanation design, and Abdul et al. (2018: 1), who investigated how HCI (human–computer interaction) researchers can help to develop accountable systems, the use of AI is growing exponentially, and with that, the opportunities and challenges of it. Correspondingly, Steyvers and Kumar (2023: 722) indicate that the complete realization of the potential of human–AI collaboration still encounters numerous obstacles. According to Sinha and Lee (2024, para. 6), who aimed to identify and analyze the multifaceted challenges of integrating AI into industrial environments, “the transition from conceptual AI solutions to their operational integration in industrial settings is fraught with hurdles, including data acquisition, system compatibility, safety, ethical considerations, and regulatory compliance”. In this regard, successful interaction with AI in decision-making necessitates a greater understanding of how it operates and its potential impacts (Ferreira and Monteiro, 2021: 1).

In the literature, regarding the implementation of AI models in the decision-making process of energy transformations, numerous studies have been conducted. In this regard, Kaur et al. (2024: 1) conducted a comprehensive examination of the critical aspects relating to the AI and sustainable energy collaboration. Similarly, Ahmad et al. (2021: 1) focused on the use of AI techniques within the energy industry to establish a practical baseline that enables researchers and readers “to compare their AI efforts, ambitions, new state-of-the-art applications, challenges, and global roles in policymaking”. In

this regard, this study discussed the use of AI to support decision-making and manage complicated power systems. Additionally, the study conducted by Kaggwa et al. (2024: 1) aimed to explore the emergence and evolution of AI in the context of business strategy, exploring its impact on transforming conventional decision-making frameworks and improving business flexibility. Furthermore, Rojek et al. (2023: 5) discussed an AI-based computational model in energy markets' sustainable transformation, aiming to establish a basis for further development using computational models (AI/ML-based), specifically addressing existing limitations and key areas for future research. Lastly, Danish and Senjyu (2023: 1) aimed to analyze various challenges that the integration of AI in the energy sector presents through an exhaustive examination of energy policy procedures by cautiously focusing on the decision-making process during the development stage of them.

Table 1 shows and summarizes these existing studies in the literature, presenting the determined key measures. In this regard, the application context of the studies and the covered AI models in these studies are indicated for a better comparison. Then, the inclusion or exclusion of "decision-making focus" and "energy transformation focus" are demonstrated for a better understanding of the scope of the studies.

Table 1 - Related studies regarding the implementation of AI models in decision-making and energy transformations

Literature	Application Context	Covered AI Models	Decision-Making Focus	Energy Transformation Focus
Kaur et al. (2024)	Sustainable Energy Management	AI Models (General), Optimization Algorithms, Predictive Analytics	✓	✓
Ahmad et al. (2021)	Sustainable Energy Industry	AI Models (General), Machine Learning, Deep Learning	✓	✓
Kaggwa et al. (2024)	Business Strategy and Management	AI Models (General)	✓	✗
Rojek et al. (2023)	Sustainable Energy Market Transformation	AI Models (General), Machine Learning	✗	✓
Danish and Senjyu (2023)	Policy and Energy Systems	AI Models (General), Machine Learning, Deep Learning	✓	✓

Various use cases also exist for the applications of AI in real-life situations. In this context, for instance, the Hong Kong Exchange has used Nasdaq ML for compliance and market surveillance (DeFrancesco,

2016, para. 6). In addition, IBM has a compliance solution called Watson Compare & Comply, which uses “NLP approaches to extract data from documents for classification, detecting and managing risks” (Al-Shabandar et al., 2019: 4). Moreover, an AI platform developed by Ayasdi applies “topological analysis to identify and extract correlations in data” which is used in financial services to predict and simulate regulatory risk (Al-Shabandar et al., 2019: 4). Lastly, Compliance.ai helps financial organizations manage and monitor their regulatory compliance by utilizing machine learning and natural language processing (Al-Shabandar et al., 2019: 4-5).

This research, which will build upon these stated studies, will cover large language models (LLMs), as a type of AI model with a specific focus in the study. Minaee et al. (2024, para. 5) define large language models (LLMs) as “large-scale, pre-trained, statistical language models based on neural networks”. According to Sha et al. (2023: 2), LLMs can interpret highly due to their visual thought process, which allows them to think like humans and reason about novel situations by merging common sense. Hence, the abilities and accomplishments of LLMs are intriguing, showcasing their capacity for human-like thinking and their ability to generalize human common-sense (Sha et al., 2023: 2).

Despite this undeniable functionality of LLMs, it is not possible to discuss the existence of a sufficient number of studies in the literature that address the role and impact of LLMs in a decision-making process for energy transformations. In this regard, the relationship between decision-makers and LLMs can play a crucial role in a decision-making process for successful energy transformation and their relationship offers an interesting field of study to examine.

In the literature, Arslan et al. (2024: 1) introduced “an energy chatbot which is a sustainable IS that utilizes large language models (LLMs) integrated with multi-source retrieval augmented generation (RAG)”. The energy chatbot aimed to improve decision-making for SMEs by delivering detailed insights into the energy sector through a question-answering (QA) system. Additionally, with a specific focus on the electric energy sector, Majumder et al. (2024: 1544) conducted an exploratory study of the capabilities and limitations of large language models. This commentary study aimed to identify efficient directions in this regard. Moreover, Mounsif et al. (2023: 123) presented a novel approach for incorporating LLMs into energy demand simulation, highlighting both the significance and existing challenges in intricate systems and decision-making processes, along with more precise energy demand forecasting for developing sustainable energy strategies. Furthermore, Buster et al. (2024: 1) presented a method for utilizing LLMs to streamline the extraction of siting ordinances from legal documents, allowing database to keep precise up-to-date information in the rapidly changing energy policy landscape. This study lays the groundwork for automated large-scale energy policy research by revealing improvements in the extraction and analysis of legal documents utilizing LLMs. Lastly, Zhang et al. (2024: 1) investigated the innovative integration of LLMs with building energy modeling software,

concentrating particularly on the merging of ChatGPT with EnergyPlus. In this regard, three case studies in the study demonstrated the potential of large language models in automating and enhancing building energy modeling tasks, highlighting the crucial importance of artificial intelligence in promoting sustainable building practices and improving energy efficiency.

Table 2 shows and summarizes these existing studies in the literature regarding the implementation of LLMs for a decision-making process in energy transformation. In this regard, the application context of the studies and the inclusion or exclusion of “decision-making focus” and “energy transformation focus” are demonstrated for a better understanding of the scope of the studies.

Table 2 - Related studies regarding the implementation of LLMs in decision-making and energy transformations

Literature	Application Context	Covered AI Models	Decision-Making Focus	Energy Transformation Focus
Arslan et al. (2024)	SME Energy Transition Initiatives	Large Language Models (LLMs)	✓	✓
Majumder et al. (2024)	Electric Energy Sector	Large Language Models (LLMs)	✓	✗
Mounsif et al. (2023)	Behavioral Simulation in Energy Transition	Large Language Models (LLMs)	✓	✓
Buster et al. (2024)	Energy Policy Research and Siting Ordinance Management	Large Language Models (LLMs)	✓	✓
Zhang et al. (2024)	Building Energy Modeling & Engineering	Large Language Models (LLMs)	✗	✓

3 Objectives

In this study, within the scope of the integration and implementations of LLMs in human decision-making for energy transformation of industrial and energy companies, the following objectives will be addressed. By achieving these objectives, it is aimed to obtain valid findings that can contribute to the study field.

To begin with, the main objective of this study is to explore how large language models (LLMs) can successfully assist and guide decision-makers in a decision-making process for energy transformation

of a company. In this regard, the study will examine the relationship between decision-makers and LLMs by studying the factors affecting the adoption and efficiency of LLMs among decision-makers. In this context, different conditions that can support and determine complementarity (i.e., situations in which the performance of a decision maker with LLMs exceeds the performance of LLMs working alone or an unassisted decision-maker) will be studied. Thus, this can help better understand the circumstances optimizing the most effective human-LLM collaboration.

In addition, the study also aims to explore if LLMs can enhance human capabilities in energy transformation projects by supporting decision-makers in interpreting and implementing new strategies and regulations tailored to specific company needs. According to Sinha and Lee (2024: 13), a well-defined and transparent regulatory framework is essential for the responsible and effective incorporation of AI within industries, and companies should adhere to existing regulations while proactively participating in the development of new ones. Hence, regulatory compliance plays an important role in interpreting and implementing new strategies and regulations by AI models.

In this regard, it will be studied how LLMs can successfully identify specific areas that need to be addressed (e.g., regulatory compliance and the adoption of renewable energy sources). Based on the identified requirements, it will be studied how they can suggest practical solutions (e.g., recommending specific compliance standards and renewable energy options). Finally, it will be studied how they can interpret different situations and outcomes based on various implementation strategies, helping decision-makers evaluate the potential impact and effectiveness of different approaches.

Finally, the study also aims to explore how LLMs can not only improve decision-making but also foster ethical considerations and personal growth, because AI integration in sustainable energy systems raises several ethical issues that must be carefully considered. In this regard, Kaggwa et al. (2024: 433) indicate that as AI systems become more crucial (and also more complex) in decision-making, organizations must ensure that these AI systems are equitable, responsible, open, and sustainable. Similarly, Attard-Frost et al. (2023: 396) bring an ethical perspective to the discussion and highlight that although AI has the potential to enhance a decision-making process, it is important to take into consideration the ethical issues that may arise. Consequently, this study will also take into consideration the topic from an ethical perspective and try to analyze and understand the role of LLMs in fostering ethical considerations and personal growth.

Hence, by addressing enhancing human capabilities in interpreting and implementing new strategies and regulations, assisting and guiding in decision-making, and fostering ethical considerations and personal growth, this study refers to “human enhancement” concept in terms of improving an existing

human ability (interpreting and implementing new regulations and strategies, and improving decision making), and making a person a “better” person (ethical considerations and personal growth).

4 Concrete Research Question

This study examines the research question: “How can interviews show the potential of LLMs to support decision-makers in energy transformation?” It aims to explore the supporting role of large language models (LLMs) for decision-makers, based on the defined study objectives, particularly through the use of semi-structured interviews.

According to Adeoye-Olatunde and Olenik (2021: 3), “semi-structured interviews are the preferred data collection method when the researcher's goal is to better understand the participant's unique perspective rather than a generalized understanding of a phenomenon”. Hence, this qualitative research method can generate deeper insights of decision-makers by enabling a detailed exploration of how they perceive the role of LLMs in supporting their decision-making processes.

To be able to provide a comprehensive answer for the stated research question, different sub-questions will also be studied, each addressing a specific aspect of LLMs’ role and effect on decision-makers.

Firstly, the sub-question “What are the factors affecting the adoption and efficiency of LLMs among decision-makers in energy transformation processes?” will be studied. This sub-question aims to explore the various internal and external factors that influence the adoption and effectiveness of LLMs. It is vital to comprehend these factors as they determine the convenience with which decision-makers can incorporate LLMs into their workflow within an operational efficiency. By identifying these factors, this study seeks to highlight potential barriers or enablers in the adoption process, which could inform strategies to optimize the integration between decision-makers and LLMs.

In addition, the sub-question “Under what circumstances can human-LLMs collaboration be most effective in complementing decision-makers?” will be studied. This sub-question aims to explore the situations in which the LLMs should be integrated and leveraged. In this regard, conditions like the timing of LLM assistance and the amount of model information that should be presented to the human decision-maker will be studied.

Besides, the sub-question “What are the key challenges associated with human-LLMs collaboration in an energy transformation process for decision-makers?” will also be studied. Identifying possible difficulties and hurdles plays an important role in successful human-LLM collaboration. In this regard, this sub-question will examine collaboration-related issues, such as AI interpretability, security, and trust for the exploration of possible strategies and solutions to overcome them.

Furthermore, the sub-question “What are the practical outcomes of LLMs adoption on decision-makers and energy transformation processes?” will be studied. This sub-question aims to explore the possible effects of LLMs on energy efficiency loss, regulatory compliance, and the determined company strategy, to evaluate the overall effectiveness of LLM implementations among decision-makers in energy transformation process.

Lastly, the sub-question “How do LLMs contribute to expanding the knowledge base of the company and decision-makers?” will be studied. By analyzing the potential effects of LLMs on knowledge accumulation within the company and among decision-makers, this sub-question aims to explore the role of LLMs in knowledge expansion for a successful energy transformation implementation.

5 Theory & Sensitizing Concepts of the Study

The Working Hypothesis conceptual framework, introduced by Casula et al. (2021: 1703), offers a framework that provides a structured approach to guide deductive reasoning while maintaining the flexibility required for exploration. In this regard, for this study, which includes qualitative hypothesis testing as a deductive research, this approach is adopted.

Casula et al. (2021: 1709) define the working hypothesis as “first and foremost a hypothesis or a statement of expectation that is tested in action”. Hence, the working hypothesis might be interpreted as a statement or group of assertions that respond to a research question (Casula et al., 2021: 1709). In this regard, “it “works” to move purposeful inquiry forward as it is a tool in an ongoing process of inquiry” (Casula et al., 2021: 1709).

This study will also include the Knowledge-Based View (KBV) of the Firm as a theoretical framework. According to Spender (1996: 46), “since the origin of all tangible resources lies outside the firm, it follows that competitive advantage is more likely to arise from the intangible firm-specific knowledge which enables it to add value to the incoming factors of production in a relatively unique manner”. Thus, based on this theoretical framework, it is possible to state that it is the firm's knowledge, and its ability to generate knowledge, that lays at the core of a firm as the most strategically significant resource.

In the context of industrial and energy companies undergoing energy transformation, the integration of LLMs can be seen as a key strategy to enhance the knowledge base of the decision-makers and the company, thereby supporting more informed and effective decision-making processes. Correspondingly, researches in the strategic management field identified the knowledge base as the most significant factor for the success of strategic decision-making (Hickson et al., 2003: 1803) and demonstrated

that algorithms outperform managers in various decision-making situations (Dawes, 2008: 571; Kahneman et al., 2016, para. 6; Yeomans et al., 2019: 1).

In this regard, LLMs can enable decision-makers to make more informed choices regarding energy transformation strategies by identifying specific areas that need to be addressed, suggesting practical solutions, and simulating different scenarios and outcomes based on various implementation strategies. Therefore, the KBV can provide a robust theoretical framework for understanding how LLMs can guide and assist decision-makers by expanding the company's knowledge resources for the decision-making processes in energy transformation.

Hence, in the study, this theoretical framework will be used to examine how LLMs contribute to expanding decision-makers' knowledge for more informed decisions in energy transformation, as large language models (LLMs) can be viewed as tools that enhance decision-makers' access to relevant information and insights, thus expanding the company's and decision-makers' knowledge base.

6 Hypotheses Development

Based on the stated objectives, and theory and sensitizing concepts of the study, the following hypotheses were developed and systematically investigated and tested throughout the research.

"LLMs serve as vast storehouses of abundant information and knowledge acquired from numerous texts, much like the human brain" (Cui et al., 2024: 902). Considering this similarity of LLMs to human memory, they may play an important role for decision-makers in decision-making with their knowledge accumulation. Thus, with a focus on LLMs' impact on a decision-making process, the following hypothesis was formulated:

H1: *Large language models (LLMs) effectively assist and guide decision-makers in a decision-making process.*

"Significant progress has been made in completeness and compliance checking of legal requirements and software related regulatory artifacts through the application of traditional machine learning algorithms and LLMs" (Hassani et al., 2024: 434). In this regard, LLMs may provide an advantage for decision-makers to develop new strategies and regulations related to energy transformation processes. Hence, with a focus on LLMs' role in strategy development and regulatory compliance, the following hypothesis was formulated:

H2: *LLMs improve decision-makers' ability to interpret and implement new energy strategies and regulations tailored to specific company needs.*

“As artificial intelligence (AI) systems become increasingly ubiquitous, the topic of AI governance for ethical decision-making by AI has captured public imagination” (Yu et al., 2018, para. 1). In this regard, LLMs’ influence on decision-makers regarding ethical decision-making is another important aspect of the topic. With a focus on LLMs’ impact on ethical considerations and personal growth, the following hypothesis was formulated:

H3: *LLMs foster ethical decision-making and promote personal growth among decision-makers.*

A study for comprehensive exploration of factors driving AI language model adoption, conducted by Jo (2023, para. 6), indicates that “although there is an increasing body of research on the factors influencing the adoption and usage of AI chatbots in various contexts, several research gaps still exist”. In this regard, perceiving the factors affecting the adoption of LLMs among decision-makers correctly is vital for a successful energy transformation implementation. Therefore, with a specific focus on organizational culture, AI literacy, and complementarity of human–LLM collaboration as possible factors in the study, the following hypothesis was formulated:

H4: *The adoption of LLMs among decision-makers is influenced by organizational culture, AI literacy, and complementarity of human–LLM collaboration.*

According to Steyvers and Kumar (2023: 728), “the questions of what, when, and how much information should be presented to a human decision-maker highlight the need to develop theoretical frameworks that infer the impact of AI aids on human cognition and observed performance”. In this regard, several studies have investigated the impact of presenting AI assistance at different times throughout the decision-making process. These adjustments have aimed to enhance individuals' cognitive drive to interact with the answers and recommendations provided by AI assistance (Buçinca et al., 2021: 1). Besides, considering the restricted cognitive resources that may be accessible for processing AI suggestions, particularly in urgent (time-constrained) scenarios, it is crucial for the AI to modify its responses (e.g., by providing explanations at the right time and level of detail) (Steyvers and Kumar, 2023: 728). In this regard, conveying excessive information can negatively impact a decision-making process (Poursabzi-Sangdeh et al., 2021, para. 1; Schaffer et al., 2019: 249). Therefore, AI systems have to be made to accommodate decision-makers' cognitive limitations (Cummings, 2017: 1). Hence, with a focus on circumstances optimizing the most effective human-LLMs collaboration, the following hypothesis was formulated:

H5: *Human-LLMs collaboration is most effective when large language models provide timely assistance and present information tailored to the decision-maker’s cognitive preferences and task-specific needs.*

According to Kasneci et al. (2023: 2), “while large language models have made great strides in recent years, there are still many limitations that need to be addressed”. The lack of interpretability is a significant constraint as it is challenging to comprehend the logic underlying the model's predictions. (Kasneci et al., 2023: 2). There are also some ethical considerations, such as concerns about trust, bias, and data privacy issues (Kasneci et al., 2023: 2). In this regard, it is possible to state that various challenges can negatively affect the integration and implementation of LLMs regarding the energy transformation processes. Hence, the following hypothesis was formulated:

H6: *The integration of LLMs into energy transformation is negatively affected by various challenges related to AI interpretability, trust, data privacy concerns, etc.*

By improving energy system efficiency and lowering transition costs, artificial intelligence (AI) can enhance the energy transition (Nižetić et al., 2023: 1). Hence, as technology continues to evolve, the capability of AI to aid in energy transformation and reduce emissions keeps growing (Wang et al., 2024: 1). In this regard, LLMs, as a type of AI models, may be an effective way to improve energy transition implementations and to provide fewer energy efficiency loss issues. Thus, with a focus on LLMs' practical outcomes on energy transformation and efficiency, the following hypothesis was formulated:

H7: *Companies that adopt LLMs in energy transformation strategies experience improved energy transition implementations and fewer energy efficiency loss issues.*

According to Keding (2021: 93), preliminary research suggested that AI might serve as a decision support tool, gathering expert insights and guiding organizational actions, rather than acting as a sole decision-making authority due to its limitations at the strategic level. However, “current research streams clarify that the real value of AI is to perform data analysis autonomously across various sorts of data, to access tacit knowledge and to create new knowledge by itself” (Keding, 2021: 93). In this regard, LLMs may enhance the company's and decision-makers' knowledge base, resulting in a competitive advantage in energy transformation and market position. Hence, within the context of the Knowledge-Based View of the Firm as a theoretical framework, and with a focus on LLMs' role in expanding the knowledge base of the company and decision-makers, and its contribution to competitive advantage, the following hypothesis was formulated:

H8: *Companies that leverage LLMs enhance the organization's and decision-makers' knowledge base, resulting in a competitive advantage.*

Table 3 summarizes the determined hypotheses with their specific focus points on different aspects of the topic.

Table 3 - Determined hypotheses and their focus points

Hypothesis	Focus
H1: Large language models (LLMs) effectively assist and guide decision-makers in a decision-making process.	LLMs' impact on decision-making process
H2: LLMs improve decision-makers' ability to interpret and implement new energy strategies and regulations tailored to specific company needs.	LLMs' role in strategy development and regulatory compliance
H3: LLMs foster ethical decision-making and promote personal growth among decision-makers.	LLMs' impact on ethical considerations and personal growth
H4: The adoption of LLMs among decision-makers is influenced by organizational culture, AI literacy, and complementarity of human–LLM collaboration.	Factors influencing the adoption of LLMs
H5: Human-LLMs collaboration is most effective when LLMs provide timely assistance and present information tailored to the decision-maker's cognitive preferences and task-specific needs.	Circumstances optimizing the most effective human-LLMs collaboration
H6: The integration of LLMs into energy transformation is negatively affected by various challenges related to AI interpretability, trust, data privacy concerns, etc.	Challenges and hurdles associated with human-LLMs collaboration
H7: Companies that adopt LLMs in energy transformation strategies experience improved energy transition implementations and fewer energy efficiency loss issues.	Practical outcomes of LLMs adoption
H8: Companies that leverage LLMs enhance the organization's and decision-makers' knowledge base, resulting in a competitive advantage.	LLMs' role in expanding the knowledge base of the firm and decision-makers

7 Research Methodology

7.1 Research Field

The research field of this study is based on industrial and energy companies located in Germany. With its significant industrial base, sustainable practices, and advanced technologies, Germany is particularly suitable and relevant for examining the role of LLMs in supporting decision-makers regarding the energy transformation operations of industrial and energy companies.

The selected companies in this research field were either in the process of exploring or planning to leverage LLMs for transitioning to more sustainable energy systems or have already employed LLMs to assist in their transformations. The selected companies ranged from small-scale to large-scale, with the aim of exploring the role of LLMs in enhancing decision-making processes related to energy trans-

formation, particularly in how decision-makers interact with and leverage LLMs to meet specific regulatory and strategic objectives within their organizations. In this regard, the research could also provide a clear understanding of how LLM adoption is influenced by characteristics of a company, with the distinct company samples.

7.2 Participants and Data Collection

The primary data for the study were collected through semi-structured interviews with key decision-makers from the selected industrial and energy companies in Germany. According to Longhurst (2003: 143), “semi-structured interview is a verbal interchange where one person, the interviewer, attempts to elicit information from another person by asking questions”. In this regard, even though the interviewer has a set of pre-planned questions, the discussion should develop in a natural way, allowing participants to delve into topics they consider significant (Longhurst, 2003: 143). Hence, the decision to use semi-structured interviews in this study was based on the need to explore the complex, context-rich insights related to the study topic, allowing participants to share their experiences, insights, and perspectives on LLMs’ role in a decision-making process.

The participants for the semi-structured interviews were individuals directly involved in energy transformation projects within their organizations. In this regard, the participants were selected using a purposive sampling technique to ensure that they have relevant experience and knowledge in both energy transformation and LLMs integration. The selection criteria included factors such as the participant’s role in the company and the extent of AI adoption within their organization.

The sample size of the full-scale study included 11 participants, which aimed to achieve saturation in qualitative research, ensuring that the collected data were rich, detailed, and reflective of the broader context.

To ensure data privacy and to protect participants’ and their organizations’ anonymity, all the collected data were anonymized. In this regard, neither participants’ names nor their companies’ names were disclosed in the final outputs of the study. All information remained confidential and used strictly for academic purposes.

Table 4 summarizes the participants’ roles/positions in their organizations, the duration of time they have been in those roles/positions, and their organizations’ short descriptions.

Table 4 - Participant and organization information

Participant	Role/Position	Experience in Particular Role/Position	Organization
Participant 1	Technical Project Manager	2+ years	A French Energy Management Company
Participant 2	Renewable Energy Engineer	2 years	A German Renewable Energy Company
Participant 3	Expert Operations	10 months	A German Energy Technology Company
Participant 4	Head of M&A Germany and Northern Europe	11 months	A Spanish Renewable Energy Company
Participant 5	Head of Energy & Climate Change Centre	5 years	A German Automotive Systems Manufacturer
Participant 6	Lead Energy Engineer	5+ years	A Lebanese Power Solutions Provider
Participant 7	Expert / Deputy Head Innovation & Design	8 months	A German Solar Energy Company
Participant 8	Product Manager for Energy & Grid Services	1+ year	A German Industrial Technology Company
Participant 9	Project Management Office Manager	2 years	A Swiss-Japanese Energy Solutions Company
Participant 10	Energy Engineer	1+ year	A Chinese Solar Inverter Manufacturer
Participant 11	Energy Engineer	2+ years	A German Automotive Manufacturing Company

The interview sessions with these participants were designed to cover the determined key themes based on the research question and objectives of the study. In this regard, the interview sessions were conducted on online platforms (via Zoom or Microsoft Teams) and the interviews were audio recorded, with participants' consent. The data were securely stored in accordance with data protection regulations.

The interview sessions were conducted based on the determined interview guide. Before conducting the data analysis, the data obtained from semi-structured interviews were transcribed. In this regard, the recorded interview audio contents were first transcribed on TurboScribe by TurboScribe (2025). After that, the transcripts were checked manually for confirmation. It also should be indicated that all interviews were transcribed using a verbatim transcription style, preserving participants' original speech patterns, including grammatical errors, pauses, and filler words. This approach was chosen to

maintain the authenticity of participant responses. Appendix A includes the transcripts of the interview sessions conducted throughout the study.

7.3 Data Analysis

The qualitative data collected from the interview sessions were first analysed manually to identify patterns, themes, and insights in the dataset. Afterwards, in order to effectively organize the generated codes and subthemes based on thematic analysis approach, MAXQDA, developed by VERBI Software (2023), was also used. Braun and Clarke (2006: 79) define thematic analysis as “a method for identifying, analysing and reporting patterns (themes) within data”. Kiger and Varpio (2020: 847) indicate that a notable characteristic of thematic analysis is its adaptability to various theoretical and epistemological frameworks and its applicability to a diverse array of research questions, methodologies, and sample sizes.

In this study, a deductive thematic analysis approach was adapted. According to Braun and Clarke (2006: 84), deductive thematic analysis, also referred to as "theoretical thematic analysis", is based on a pre-existing theory or framework that directs the development of the themes and coding. Correspondingly, Elo and Kyngäs (2008: 111) indicate that deductive coding is a top-down approach in which the data analysis is guided by pre-existing theories, models, hypotheses, or codes.

In the study, Braun and Clarke’s (2021) traditional six-step process is used as interpreted by James et al. (2023: 97). Table 5 demonstrates the steps of this deductive thematic analysis approach.

Table 5 - Six-step deductive thematic analysis

Six-Step Deductive Thematic Analysis
(1) Becoming familiar with the data
(2) Coding according to the previously known themes
(3) Creating new themes inductively of data that did not match previous themes
(4) Reviewing naming of the new themes
(5) Defining the themes
(6) Writing the report

Within the scope of the working hypothesis conceptual framework, Casula et al. (2021: 1714) state that the foundation of deductive research lies in theory. Essentially, empirical deductive analysis tests theory. In this context, Oppenheim and Putnam (1958: 25) indicate that “by a ‘theory’ (in the widest

sense) we mean any hypothesis, generalization or law (whether deterministic or statistical) or any conjunction of these". In this regard, determined terms and keywords for deductive research frequently match existing theoretical concepts or hypotheses that help classify the data (Naeem et al., 2023: 11).

Based on this, the hypotheses of this study were used as the foundation for the deductive thematic analysis. Hence, the hypotheses were used to determine the pre-defined themes to guide the deductive thematic analysis. This approach can be particularly suited for research areas where existing theoretical frameworks are limited or absent, as is the case with the role of LLMs in energy transformation decision-making.

Based on the determined hypotheses of the study, the pre-defined themes are as shown in Table 6.

Table 6 - Pre-defined themes

Pre-Defined Themes
Theme (1) LLMs' impact on decision-making process
Theme (2) LLMs' role in strategy development and regulatory compliance
Theme (3) LLMs' impact on ethical considerations and personal growth
Theme (4) Factors influencing the adoption of LLMs
Theme (5) Circumstances optimizing the most effective human-LLMs collaboration
Theme (6) Challenges and hurdles associated with human-LLMs collaboration
Theme (7) LLMs' practical outcomes
Theme (8) LLMs' role in expanding the knowledge base of the firm and decision-makers

7.4 ChatGPT

After conducting the semi-structured interviews, for a better determination and evaluation of the realistic potential of LLMs in supporting decision-makers, the predetermined interview questions were adjusted and asked to an LLM. Thus, by comparing participant responses with LLM answers, it was aimed to analyze whether decision-makers' perception of LLMs' potential in energy transition differs from LLMs' own perception. In this regard, possible conflicts and contradictions between LLM responses and the first-hand insights obtained through these interview sessions could be determined for a better understanding of the competence and potential of LLMs in real-life situations.

In this study, ChatGPT, a variant of the GPT (Generative Pre-Training Transformer) language model developed by OpenAI (2022), was determined as the LLM to be used, as “it is one of the most important and latest innovations in the field of artificial intelligence” (Singh et al., 2023: 1).

In this regard, according to a report by Liu and Wang (2024), in which the World Bank Group tracked the most visited, top 40 AI tools in March 2024, ChatGPT stands out as the undisputed leader, capturing over 82.5% of the total traffic, with over two billion global visits and 500 million users each month. By taking into account this prevalence and popularity of ChatGPT among AI tools, it was the chosen large language model for this study.

7.5 Hypotheses Testing

The determined hypotheses were tested and evaluated in accordance with the established methodology in the study. In this regard, to ensure the credibility and confirmability of the hypotheses evaluation, the triangulation method was applied. According to Patton (1999: 1193), triangulation is the process of employing various methods or data sources in qualitative research to gain a thorough understanding of phenomena. Triangulation is also considered a qualitative research technique that uses the convergence of information from various sources to assess validity (Carter, 2014: 545).

With the given exploratory design and the triangulated methodology, this study tested whether the hypotheses were valid, semi-valid, or invalid within the scope of interviews with decision-makers, ChatGPT’s self-assessment, and literature evidence. In this context, a hypothesis is considered valid when all three data sources fully align with the hypothesis and show a full support. Correspondingly, a hypothesis is considered semi-valid when at least one of the three data sources shows only partial support. Finally, when none of the three data sources support the hypothesis, it is considered to be invalid.

To be able to enhance the clarity of the evaluation, the number of participants who supported or doubted a particular hypothesis was specified in the hypothesis testing results. Within this context, in order to have a clearer and comparable assessment of the hypotheses, each hypothesis was also explicitly connected to three data sources (e.g., ChatGPT responses (valid), participant insights (semi-valid), and literature (semi-valid)), along with brief descriptive "evidence highlights" for each data source.

8 Interview Guide

8.1 Interview Sessions

SmithBattle (2014: 2142) indicates that before conducting a semi-structured interview, researchers create a predetermined list of questions as an interview guide. The set of questions serves as a guide but does not dictate the interview. In this regard, every semi-structured interview guide should be developed in alignment with the objectives of the study and the sampling criteria defined for it (Oerther, 2021: 2142). The following part includes the planned interview guide, which is based on the stated objectives and hypotheses of the study.

Firstly, the interview guide includes an introductory part that explains the purpose of the study and asks for the consent of the participants. In the core part of the guide, eight key topics exist based on the determined hypotheses, which address the different aspects of the research. For each key topic, one or two different questions are asked for a better understanding of the insights and perspectives of the participants. The sessions end with wrap-up questions and a conclusion part. The general structure of the interview guide is as follows:

Introduction

Thank you for taking the time to participate in this interview session.

My name is Mehmet Çelik, and I am currently a master's student at the Technical University of Applied Sciences Würzburg-Schweinfurt. With my supervisor, Prof. Scheller, I am conducting a research study, which is "Enhancing Human Decision-Making in Energy Transformation of Industrial and Energy Companies by Leveraging Large Language Models".

The aim of this interview session is to explore your insights and thoughts on large language models and their role in your decision-making and strategy development processes regarding the energy transformation of your organization. Your perspective and insights will help us to better understand the interpretation and implementation of LLMs in those processes.

With your consent, I would like to record the conversation to ensure accuracy in capturing your insights. Please be assured that your and your organization's anonymity will be protected, and your and your organization's names will not be mentioned in any of the reports or presentations. All information will remain confidential and will be used strictly for academic purposes.

Please feel free to bring up anything that a question reminds you of, or anything you think is relevant. Also, you don't have to answer any question you don't want to.

Introductory questions

- 1. Can you briefly describe your role in the company and particularly your involvement in the energy transformation projects?*
- 2. Do you think artificial intelligence, particularly large language models (LLMs), have a transformative potential for your company and broader industry?*

Core questions

I. LLMs' Impact on Decision-Making Process

- 1. Are you currently using or strategically planning to use large language models (LLMs) to support your decision-making in your company's energy transformation processes? Which specific LLMs do you use?*
- 2. How has the use of LLMs influenced the speed, accuracy, and quality of decisions made in your energy transformation projects?*

II. LLMs' Role in Strategy Development and Regulatory Compliance

- 1. In your experience, how do LLMs assist in interpreting and implementing energy strategies and regulations tailored to your company's needs?*
- 2. Do you feel LLMs provide clear and accurate information for successful regulatory compliance and strategic planning?*

III. LLMs' Impact on Ethical Considerations and Personal Growth

- 1. Do you believe that the use of LLMs can help promote ethical considerations in developing and implementing energy-related strategies?*
- 2. Do you believe that the use of LLMs can help decision-makers explore diverse perspectives for their personal growth?*

IV. Factors Influencing the Adoption of LLMs

1. *What factors influenced your decision to adopt or not adopt LLMs in the energy transformation projects?*
2. *How does your organizational culture and AI literacy influence the adoption and use of LLMs?*

V. Circumstances Optimizing the Most Effective Human-LLMs Collaboration

1. *In your experience, does the way information is presented by LLMs (e.g. reports tailored to your cognitive preferences and task-specific needs) impact your ability to make effective decisions?*
2. *How does the timing of LLM-generated insights affect their usefulness in your decision-making processes?*

VI. Challenges of Human-LLMs Collaboration

1. *What challenges have you encountered in collaborating with LLMs, particularly regarding interpretability, trust, or data privacy concerns? What were their impacts, and what strategies or solutions have you considered to overcome those issues?*

VII. Practical Outcomes of LLM Adoption on Energy Transformation

1. *Have you observed improvements in energy transition implementation or reduction in energy efficiency loss after adopting LLMs? What were the other practical outcomes of LLMs adoption?*

VIII. LLMs' Role in Expanding the Knowledge Base of the Firm and Decision-Makers

1. *How do LLMs help your organization and decision-makers enhance their knowledge base, particularly in the context of energy transformation?*

Wrap-up questions

1. *Is there anything else you want to add that my questions have not addressed?*

Conclusion

Thank you for your valuable insights today. Your contributions will help shape the research in understanding how large language models are being integrated into decision-making and strategy development regarding the energy transformation of companies. If you have any additional thoughts later, please feel free to reach out. Thank you again for your time.

Prompts:

Can you briefly explain.....?

Do you think that.....?

Do you have anything more to add?

Can you tell me.....?

Do you believe that?

By employing this determined interview guide, the study aims to generate deeper insights into the role of LLMs in supporting decision-makers regarding the energy transformation of industrial and energy companies. In this regard, the study focuses on decision-makers' perceptions of LLMs, which were obtained by these semi-structured interviews.

In this context, the perceived impacts of LLMs were examined by questioning how LLMs have affected participants' decision-making effectiveness and how the process has evolved with the integration of these AI models. Hence, this research process aimed to help obtain a meaningful analysis of the topic through semi-structured interviews by gathering qualitative insights from decision-makers.

8.2 ChatGPT Query

After conducting the interview sessions, to be able to address the research question successfully, participant responses were then compared with ChatGPT's answers. Thus, by determining the differences in participant and LLM responses, semi-structured interviews could show the realistic competence and potential of LLMs to support decision-makers in energy transformation.

ChatGPT utilizes a pre-trained transformer language model, enabling it to generate responses that are contextually relevant for multiple applications (Gude, 2023: 222). The effectiveness of the GPT-oriented approach depends largely on the quality of the instructions or "prompts" provided to it (Fiannaca et al., 2023: 7). In this regard, first of all, in order to obtain valid results, the scope of ChatGPT was determined with a suitably prepared prompt. Thus, the compatibility and the relevance of the answers were ensured. The used prompt is as follows:

"I would like to explore your competence and potential in enhancing human decision-making in energy transformations of industrial and energy companies in Germany."

In order to receive concise and comprehensive answers and to avoid overly long and irrelevant answers, the following prompt was also used:

"Please don't answer the questions with too long texts or bullet points. Give descriptive and concise answers."

Apart from these two and the interview question prompts, there were no any other directing or intervening prompts for ensuring the reliability and validity of the study.

In the study, the standard version of ChatGPT-4o is used. In order to keep the comparison meaningful, the limitations of ChatGPT-4o and this chosen methodology must also be taken into account. "ChatGPT is an AI model which is designed to generate human-like conversational dialogue in response to textual input by predicting answers from a vast database of publicly undisclosed resources including websites, books, and articles" (Kuşcu et al., 2023: 2). In this regard, rather than an independent view or opinion, ChatGPT's answers should be interpreted as a reflection of data contained in it.

In any case, this situation still offers a chance to question ChatGPT's ability to perceive and interpret questions and real-life situations, to generate answers, and the consistency of those answers with real-life insights obtained through semi-structured interviews. Thus, in this study, it was questioned if the statements made by ChatGPT fully align with the insights of decision-makers. This comparison also offers a chance to detect any possible conflicts and contradictions between those responses.

In this regard, the questions of the interview sessions were adjusted to make them suitable for questioning ChatGPT's perspective on its role in supporting decision-makers in the energy transformation. Table 7 includes the questions used in the ChatGPT query.

Table 7 - Questions used for ChatGPT query

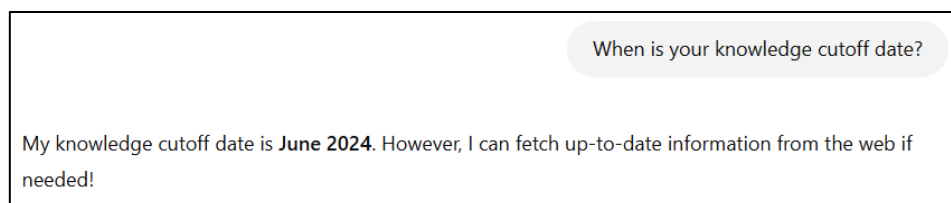
-
- Do you think you can have a transformative potential for industrial and energy companies, and broader industry?
 - How the usage of you can influence the speed, accuracy, and quality of decisions made in energy transformation projects?
 - How do you assist in interpreting and implementing energy strategies and regulations tailored to a company's needs?
 - Do you think you provide clear and accurate information for successful regulatory compliance and strategic planning?
 - Do you believe that the usage of you can help promote ethical considerations in developing and implementing energy-related strategies?
 - Do you believe that the usage of you can help decision-makers explore diverse perspectives for their personal growth?
 - What factors can influence the decision to adopt or not adopt you in energy transformation projects?
 - How does organizational culture and AI literacy influence the adoption and use of you?
 - Do you think that the way information presented by you impact a decision makers' ability to make effective decisions?
 - How does the timing of your insights affect their usefulness in a decision maker's decision-making process?
 - What challenges can you encounter in collaboration of human-LLMs, particularly regarding interpretability, trust, or data privacy concerns? What can be their impacts and what strategies or solutions can you consider overcoming those issues?
 - Do you foresee any improvements in energy transition implementation or reduction in energy efficiency loss after adopting you? What can be the other practical outcomes of your adoption?
 - How do you think you help a company and decision-makers enhance their knowledge base, particularly in the context of energy transformation?
-

Another limitation of this study can be indicated as such that the validity of the research might be compromised due to the randomness or inconsistency of ChatGPT's answers, which could affect the reliability and validity of the findings. To address this limitation and to ensure the credibility of the answers, it was tested whether ChatGPT gives similar and consistent answers or adopts a different perspective every time for a new query session. To do this, the query session was conducted five different times, each time on a new and separate chat. Besides this, Guo et al. (2023: 3) indicate that responses generated by ChatGPT can be affected by the chatting history. Therefore, it was ensured that ChatGPT's memory feature for the past chats was disabled before starting the sessions to prevent any possible influence.

At the end of five different query sessions, it can be indicated that although the answers given were not the same word for word, the answers were much the same and consistent in terms of scope and approach to the topic, and ChatGPT preserved its perspective for each session, at least on this particular study topic. In this study, the query session used during the comparison phase was the first query session, to guarantee there was no possible orientation or intervention on ChatGPT's answers caused by rest of the sessions. Appendix B includes this conducted ChatGPT query session. The sources of other conducted query sessions can also be found in Appendix B.

A further limitation of the study can be indicated as ChatGPT's knowledge cutoff date. According to ChatGPT itself, as shown in Figure 1, in the standard version of ChatGPT-4o, its knowledge cutoff date is June 2024. This situation may cause it to lack awareness of information or improvements that emerged after that date in the study field. Yet, as stated by itself, ChatGPT-4o can perform web searches to fetch up-to-date information. This can help eliminate the knowledge cutoff issue to some extent.

Figure 1 - ChatGPT's knowledge cutoff date



(OpenAI, 2025)

By taking into consideration these limitations of ChatGPT, it is aimed to be aware of them and to keep the comparison meaningful in this regard. In the following section, the outputs of the conducted sessions are presented.

9 Findings

As stated before, according to the six-step deductive thematic analysis approach of James et al. (2023: 97), after becoming familiar with the data; codes are generated based on the predefined themes, then new themes are inductively created if required, and then all themes are defined, finally the report is written.

In this regard, this section includes the generated comprehensive codes/subthemes, definition, and explanation of the themes, and the general analysis of the insights of the participants.

The study includes eight different themes, which all cover the different aspects of the topic. In this regard, a new theme, which does not match previously known themes, did not inductively emerge in

the study. Hence, steps 3 and 4 in James et al.'s (2023: 97) six-step deductive thematic analysis approach are not applied.

The main aim of this section is to provide “a concise, coherent, logical, non-repetitive and interesting account of the story the data tell” (Braun and Clarke, 2006: 93) and to demonstrate the prevalence of the themes by selecting the most distinctive and compelling individual responses (Nikitas et al., 2018: 83).

Within the scope of narrative form, key insights supported by participant quotes were presented that capture the essence of the topic. In this regard, each comprehensive code/subtheme was highlighted in bold and the selected participant quotes were presented in italics for easier findings tracking.

9.1 Overall Findings

The participants generally viewed LLMs as having significant transformative potential for their companies and the broader industry, but they also highlighted the need for cautious and responsible integration, as well as continued advancements in the technology to fully harness its benefits.

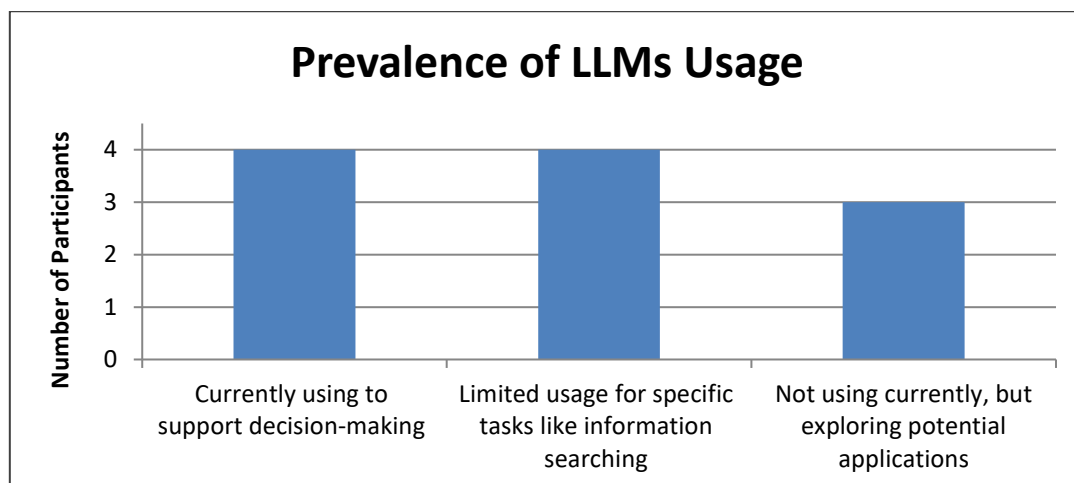
Based on the insights obtained, it is possible to state that the findings are largely in line with existing literature on factors and limitations influencing AI adoption, and conditions under which human–AI collaboration is likely to succeed. In this regard, for instance, participants identified trust and data security as major challenges, which are concerns also widely echoed in the literature. Within this scope, Afroogh et al. (2024:2) highlighted the significance of trust in AI, which serves as a regulator and could significantly control the rate of AI adoption. In addition to this, Das et al. (2025:2) emphasized the security and privacy challenges of LLMs, as these models are vulnerable to security and privacy attacks. Regarding the conditions under which human–AI collaboration is likely to succeed, Steyvers and Kumar (2023: 728) underscore the importance of the way and timing of AI assistance, highlighted also by the participants as one of the main circumstances for optimizing the most effective human-LLMs collaboration. Hence, by taking into consideration these connections between the findings and literature, it is possible to state that many results reinforce what prior research has established.

While aligning on many points, the study also uncovers a gap between LLM potential, as described in the literature, and LLM reality, as perceived by the participants. In this regard, based on the insights obtained, it can be inferred that the participants in this study were more cautious about the effectiveness and reliability of LLMs than some optimistic accounts in the literature. This practical stance causes a more conservative contrast to theoretical scenarios in which LLMs might take a more central decision-making role. Within this scope, for instance, while there existed a consensus among the partici-

participants indicating that LLMs could be used as a supportive tool rather than a sole decision-making authority, a study conducted by Liu et al. (2022:15) emphasizes that AI significantly improves the energy efficiency and AI can be a decision-maker in this regard. Correspondingly, according to Chu et al. (2024: 14), AI contributes to promoting corporate energy transition, and this could be achieved through multiple channels, such as “alleviating information asymmetry and financing constraints, adjusting corporate sustainable development concepts and practices”. Hence, the ability of LLMs to identify best practices and simulate scenarios claims that AI can optimize operations and resource use in energy systems. The differences between the participant insights and the literature underscore the importance of trust again, as noted in recent reviews, trust (or lack thereof) can significantly regulate AI adoption (Afroogh et al., 2024:2; Choung et al., 2023:1727; Jacovi et al., 2021:624; Omrani et al., 2022:2).

The prevalence of LLMs usage, and hence AI adoption, varied among the participants. Figure 2 demonstrates the total number of participants for different usage preferences.

Figure 2 - Prevalence of LLMs usage



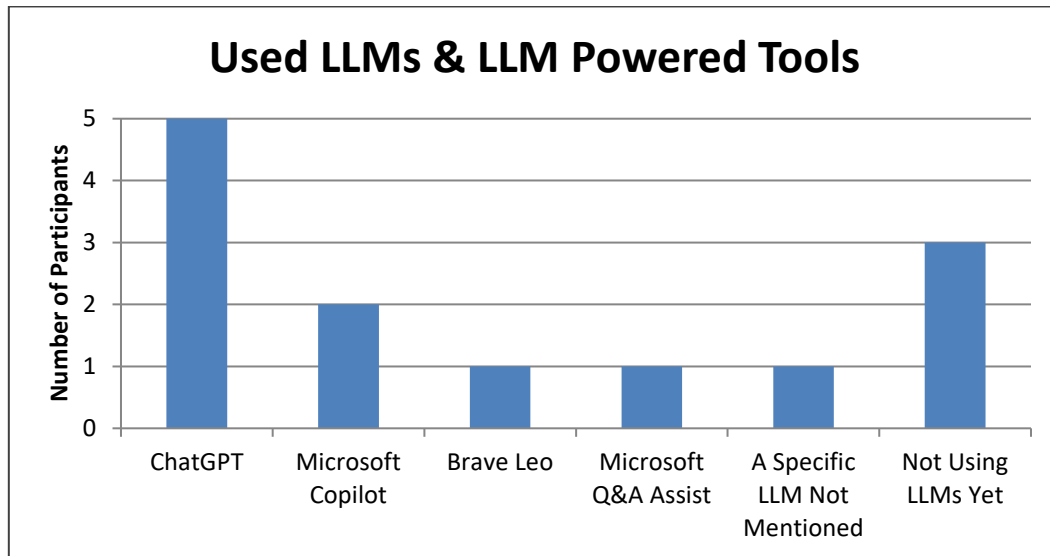
4 out of 11 participants indicated that they are currently using different LLMs to support their decision-making. Yet, they pointed out that they are using these LLMs as a supportive tool rather than a sole decision-making authority.

The same number of participants (4) expressed that their LLMs usage is restricted to specific and daily tasks like information searching, rather than using them for decision-making.

The rest of the participants (3) stated that LLMs are involved neither in their daily tasks nor in their decision-making. However, they emphasized that they are currently exploring LLMs’ potential applications in the future.

Participants’ LLM preference also varies. The distribution of the used LLMs and LLM-powered tools among the participants is as shown in Figure 3.

Figure 3 - Used LLMs & LLM powered tools



The most commonly used LLM among the participants was ChatGPT, with a total of 5 participants. Microsoft Copilot, Brave Leo, and Microsoft Q&A Assist were other LLMs mentioned by the participants. While 1 participant did not specify any LLM, 3 participants stated that they are not using any LLM yet in their work.

For a more detailed analysis of the findings, the following part includes the theme-focused analyses of the participant insights and perspectives.

9.2 Theme (1) LLMs' Impact on Decision-Making Process

This theme focuses on the role and impact of LLMs on the decision-making process. As stated before, according to Cui et al. (2024: 902), “LLMs serve as vast storehouses of abundant information and knowledge acquired from numerous texts, much like the human brain”. Considering the similarities of LLMs to human memory, they may play an important role in supporting decision-makers in decision-making processes with their knowledge accumulation.

Within this theme, a number of contributing comprehensive codes/subthemes were generated, which are prevalence of usage, perceived benefits, concerns and limitations, strategies for effective integration, and complementary role.

In the regard to **prevalence of usage**, participants expressed varied perspectives. Some participants indicated that they are currently using LLMs to support their decision-making. Nevertheless, LLMs’ usage was restricted to being a supportive tool rather than a sole decision-making authority for them:

“Maybe they can be helpful to support a decision-making, it's when you use LLMs, it's easier to find some information sometimes and maybe to automate some of your decision-

making, but eventually, definitely it will help, maybe not the decisions will not made purely based on LLMs, but they can play a role in supporting the decision.” (Participant 8)

Some participants specified that their LLM usage is mostly limited to specific and daily tasks like information gathering, unit conversion, and technical problem-solving. The rest of the participants stated that they are not currently using LLMs for decision-making, but are exploring their potential applications:

“But we use Microsoft Copilot. That is our new day-to-day companion, but we just start scratching the surface by having it deployed to a certain number of, let's say, first adapters or early movers. Let's put it this way. We are really in that stage right now to explore what Copilot can do for us.” (Participant 3)

Within the scope of **perceived benefits**, according to most of the participants, LLMs can help increase the speed and efficiency in their tasks. Some participants also mentioned that LLMs can help free up time for more strategic decision-making and also automate their repetitive tasks:

“Well, I would say speed, definitely, like I mentioned. Speed in, let's say, in making repetitive work faster, or technical drafting faster... I think different departments can use it in different ways to increase speed, and maybe even sometimes to improve quality.” (Participant 7)

The potential to provide a different perspective and identify new options is another benefit perceived by the participants:

“There are a lot of, let's say, indicators what you need to use in order to take a decision. So, an LLM could definitely help you to get this information much faster, but also maybe a change of the perspective because the LLM sees much more at the same time as a human being could do. So, that's how I see it.” (Participant 9)

Regarding the **concerns and limitations**, many participants are cautious about relying solely on LLMs for critical decision-making. They pointed out that additional verification and research are required:

“Specifically, I'm talking right now about ChatGPT, for example. Okay, it might give me answers, it's true, but I don't give 100% confidence that this is the accurate one, so I need to take a look more, I need to do more research if I want to find something new” (Participant 6)

Other concerns and limitations of the participants consist of a lack of LLMs' integration with company-specific data and systems, which limits the usefulness of LLMs, and the potential risks and legal/regulatory constraints around data security and privacy when using external LLM platforms:

“I think that if you want to use later artificial intelligence for your company, you should really do a configuration. I think even the configuration would take a lot of time or should be done by experts.” (Participant 5)

“The topic is more that we need to protect our data, meaning we cannot open it up to ChatGPT as we know it from private use, let's say, where you connect to an external server and then you're sending all the data there, coming back, analyzing it. So, that is not possible for company because we need to secure our data, but as well as the data of our customers. So, we are legally bound and that's why it's a bit of limitation in it.” (Participant 9)

In the context of **strategies for effective integration**, some participants suggested that LLMs should be configured and trained to align them with company-specific data, processes, and risk perceptions. While some others also suggested gradually exploring and experimenting with LLM capabilities to identify suitable use cases:

“At the moment, we are running a strategic project to go through all processes of the company and together with the consultant to understand which process steps can be improved or taken over by LLMs.” (Participant 11)

Within the scope of **complementary role**, participants suggested in general that LLMs should be utilized as a complementary tool. They indicated that LLMs can provide support and guidance, but human expertise, experience, and judgment are still crucial for final decision-making:

“So, for your question, to help me to make a decision, not really. I keep it as a supporting enhancement for me; I am talking about like LLMs.” (Participant 6)

Table 8 demonstrates these generated comprehensive codes/subthemes and summarizes the key insights discussed above. For a better presentation of the systematic analysis, participant numbers were also highlighted alongside the key insights.

Table 8 - Theme (1) LLMs' impact on decision making process

Comprehensive Codes/Subthemes	Key Insights
1) Prevalence of usage	<p>Some participants are currently using LLMs to support their decision-making processes (P2, P5, P8, P9)</p> <p>Some participants' usage is mostly limited to specific tasks like information gathering, unit conversions, and technical problem-solving (P4, P6, P7, P10)</p> <p>Others are not currently using LLMs for decision-making, but are exploring their potential applications (P1, P3, P11)</p>
2) Perceived benefits	<p>Increased speed and efficiency in tasks like information retrieval, summation and technical support, etc. (P1, P2, P3, P4, P7, P9)</p> <p>Potential to provide a different perspective and identify new options (P7, P9)</p>

Ability to automate repetitive tasks and free up time for more strategic decision-making (**P7, P8, P11**)

3) Concerns and limitations	<p>Participants are cautious about relying solely on LLMs for critical decision-making; additional verification and research is required (P2, P5, P6, P7)</p> <p>Lack of integration with company-specific data and systems, limiting the usefulness of LLMs (P5, P9)</p> <p>Potential risks and legal/regulatory constraints around data security and privacy when using external LLM platforms (P9)</p>
4) Strategies for effective integration	<p>Configuring and training LLMs to align with company-specific data, processes, and risk perceptions (P5, P11)</p> <p>Gradually exploring and experimenting with LLM capabilities to identify suitable use cases (P1, P3, P8, P11)</p>
5) Complementary role	<p>LLMs can provide support and guidance, but human expertise, experience, and judgment are still crucial for final decision-making (P2, P6, P7, P8, P10)</p>

9.3 Theme (2) LLMs' Role in Strategy Development and Regulatory Compliance

This theme focuses on the possible applications of LLMs in terms of strategy development and regulatory compliance. As stated before, according to Hassani et al. (2024: 434), “significant progress has been made in completeness and compliance checking of legal requirements and software related regulatory artifacts through the application of traditional machine learning algorithms and LLMs”. In this regard, this theme questions whether LLMs can provide an advantage for decision-makers to develop new strategies and regulations related to energy transformation processes.

Possible applications, potential benefits, concerns and limitations, cautious approach, and potential improvements and integrations were generated as the contributing comprehensive codes/subthemes within this theme.

Within the scope of **possible applications**, some participants indicated that LLMs can offer guidance for initial research, brainstorming, and exploring new ideas or frameworks:

“It's like giving you the first step to know what you are looking for; to know what you need to look for. I believe this is a good point for ChatGPT, for example, that it helps you to know what you need to look after. Because maybe there's something new, I need to think about it, I need to make improvements in my department to make new regulations or new policy or something.” (Participant 6)

For the participants, another possible application was using LLMs to provide a broad understanding of regulations and market conditions in different governmental bodies and regions:

“So again, if I use them for researching and understanding the markets, then it's good to use them to understand how the regulations in each market are working.” (Participant 8)

A participant suggested that LLMs can be used to make data analysis more agile and to identify risks, while another one stated that they can be used for summarizing regulations and their associated limits:

“I think that is like a potential use of this and in terms of like make more agile the analysis of the data and take decisions to take like more quickly response and also to identify risk if they are like user appropriate.” (Participant 10)

“Yes, of course. That's true. Maybe they can summarize the regulations and the limits.” (Participant 11)

Regarding the **potential benefits**, the most pointed out benefit of LLMs was providing a faster and more practical way to find information and answers compared to manual research:

“From my perspective, when determining the amount of energy used and consumed during stand-by or while working, frankly, instead of scanning the resources on the internet in detail, I can find my answer when I ask a question to ChatGPT about what the energy consumption value in stand-by should be in a more practical way. This is to my benefit.” (Participant 1)

In addition, a participant stated that LLMs help him avoid unnecessary brain power consumption on repetitive tasks, while another one claimed that LLMs can help structure and analyze large amounts of data more efficiently than humans:

“Because obviously you know such tools are much more capable of you know structuring and analyzing huge amounts of data in a much more efficient way than people are.” (Participant 4)

In terms of **concerns and limitations**, similar to Theme 1, most of the participants mentioned in this theme as well that LLMs should not be trusted 100% as the information they provide may not/cannot be accurate:

“I don't think so 100%. Of course, no information can be 100% accurate, but I think it adds speed right now. I don't think it would be healthy to rely on a tool 100%. Because the work we do ultimately affects people and if we fall outside the standards, it can cause production costs to be wasted and market losses in our products, so I don't trust it 100% and I use it as a support.” (Participant 1)

Furthermore, a participant indicated that the accuracy and reliability of LLMs depend on the data sources they are trained on. Hence, the participant claimed that LLMs don't assist in interpreting and implementing energy strategies and regulations; they just assist in trivial tasks:

"As I said before, they don't assist you in this, they assist you in trivial tasks that can be done by a machine without a human processing. So, in this one, I will say, like, the LLMs have not assisted me in interpreting or implementing energy strategies." (Participant 2)

Within the scope of **cautious approach**, it was mentioned again in this theme by most of the participants that LLMs should be used as a support tool or a starting point, but not as the sole or primary source of information for strategy and compliance:

"But would I put all my money on large language models if I had to stand up in court and defend my decision? I would rather say no. But I would still use them to get a first inclination as to what direction we want to go." (Participant 3)

Another mentioned point was that information from LLMs should be verified, cross-checked, and complemented with expert knowledge and other reliable data sources:

"So again, if I use them for researching and understanding the markets, then it's good to use them to understand how the regulations in each market are working. Eventually, I need to also double-check all the information with the experts, with experienced people on regulation topics, but at least they can give me a broad image on what to expect for each market." (Participant 8)

In the context of **potential improvements and integrations**, it was stated by some participants that frequent updates and maintaining the accuracy of the information provided by LLMs would be crucial for their effective use. In this regard, a participant pointed out that LLMs should be integrated with regulatory bodies and governmental sources to access more up-to-date and accurate information:

"I mean, as I said earlier, so it's getting much more information at the same time. What might be helpful is to connect these LLMs also to regulatory bodies. So, like governmental bodies or any others." (Participant 9)

Another participant suggested that if the databases become more universal and publicly accessible, AIs can do better:

"So for example, like imagine in Germany, the majority of the municipality documents are like a JPEG, and then you need to like transform it to an OCR and then maybe translate it if you don't like understand the term. But yeah, so like an AI will not like help you with this,

right? So, but if the databases are like universal and public access, I think the AIs will do better.” (Participant 2)

Table 9 demonstrates these generated comprehensive codes/subthemes and summarizes the key insights discussed above. For a better presentation of the systematic analysis, participant numbers were also highlighted alongside the key insights.

Table 9 - Theme (2) LLMs' role in strategy development and regulatory compliance

Comprehensive Codes/Subthemes	Key Insights
1) Possible Applications	<p>LLMs can offer guidance for initial research, brainstorming, and exploring new ideas or frameworks (P2, P3, P6, P7)</p> <p>LLMs can provide a broad understanding of regulations and market conditions in different governmental bodies and regions (P8, P9)</p> <p>Making data analysis more agile and identifying risks (P10)</p> <p>Summarizing the regulations and the limits (P11)</p>
2) Potential Benefits	<p>LLMs can provide a faster and more practical way to find information and answers compared to manual research (P1, P4, P6, P9, P11)</p> <p>LLMs can help structure and analyze large amounts of data more efficiently than humans (P4)</p> <p>LLMs can help avoid unnecessary brain power consumption and focus on more critical tasks (P2)</p>
3) Concerns and limitations	<p>LLMs should not be trusted 100% as the information they provide may not/cannot be accurate (P1, P2, P3, P5, P7, P8, P10)</p> <p>The accuracy and reliability of LLMs depend on the data sources they are trained on, which can vary in quality and coverage (P2)</p> <p>LLMs don't assist in interpreting and implementing energy strategies and regulations, they just assist in trivial tasks (P2)</p>
4) Cautious Approach	<p>LLMs should be used as a support tool or a starting point, but not as the sole or primary source of information for strategy and compliance (P1, P2, P3, P4, P7, P8)</p> <p>The information from LLMs should be verified, cross-checked, and complemented with expert knowledge, experienced personnel, and other reliable data sources (P8, P9)</p>
5) Potential Improvements and Integrations	<p>Integrating with regulatory bodies and governmental sources to access more up-to-date and accurate information (P9)</p> <p>Frequent updates and maintaining the accuracy of the information provided by LLMs would be crucial for their effective use in these domains (P5, P9)</p> <p>If the databases become more universal and public access, AI can do better (P2)</p>

9.4 Theme (3) LLMs' Impact on Ethical Considerations and Personal Growth

This theme focuses on the role and impact of LLMs on ethical considerations and personal growth. As stated before, according to Yu et al. (2018, para. 1), “as artificial intelligence (AI) systems become increasingly ubiquitous, the topic of AI governance for ethical decision-making by AI has captured public imagination”. In this regard, this theme questions: what are the possible impacts of LLMs on ethical decision-making and ethical considerations? It also questions whether personal growth can be achieved by leveraging LLMs.

Potential gains and benefits, limitations and concern factors, and required integrations and improvements were generated as the contributing comprehensive codes/subthemes within this theme.

Within the scope of **potential gains and benefits**, some participants stated that LLMs can foster ethical considerations, but only with caution and human oversight:

“I think they always need let's say at least a proper review and also the results need to be carefully sort of not only analyzed but sort of understood and not just be used you know go freely so but I think as long as that is ensured then yes I think they can promote ethical considerations.” (Participant 4)

Regarding personal growth, participants indicated that LLMs can help them explore diverse perspectives, provide efficient access to information, and expand their knowledge, facilitating personal growth:

“I feel like, yes, it provides certain career paths, personal growth possibilities. Yeah, definitely.” (Participant 7)

“Yeah, definitely. I think that it can be like potential like to explore different perspectives and also like to have different results and maybe like make more agile the selection of one that is better.” (Participant 10)

Similarly, some participants pointed out that LLMs can help individuals develop new skills and mind-sets for their personal growth:

“Oh, yes. Definitely, it can help using them in your career for decisions and to succeed in projects that will help building up your career.” (Participant 11)

Regarding the **limitations and concern factors**, according to some participants, there are some concerns about LLMs' potential for misuse or unintended consequences in ethical decision-making:

“We all know the examples where the LLMs turned into Nazis in just a short period of time, right? In terms of how they operate in an ethical way, the jury is still out. But I would

recommend caution. I would not say I believe they promote ethical considerations in any way.” (Participant 3)

Similarly, for some participants, there exist potential risks and vulnerabilities associated with using LLMs, such as data privacy and security concerns:

“Yeah, I think it could help, but also it could like put at the risk like some, for example, data as like as I hear, like if you put it like some contract or some information into these learning machines, you will have to take the information and it could be vulnerable for this. So, I think that for ethical itself depends the approach or the perspective it could support, but also it could be like a potential risk.” (Participant 10)

As a limitation, some participants pointed out that LLMs' effectiveness in promoting ethical considerations depends on the specific context, regulations, and organizational policies:

“At some point, yes, it can give support, if I'm assuming in percent, it looks like between 10 to 20 percent. However, the 80 percent, which is the major part, it relies on the company itself, the policy of the company, because you cannot make a conclusion for ethical considerations based on what you have read in your answer, because maybe the circumstances or the government itself, I mean, the governmental rules or the policies in that country doesn't fit what you are reading. So, it might be not accurate, it might be not helpful in that point.” (Participant 6)

In the context of **required integrations and improvements**, according to participants, as in the previous themes, LLMs should be used as a tool to support, not as a sole source of information or decision-making. Similarly, they indicated that caution is needed to avoid over-reliance on LLMs and maintain critical thinking. Hence, in this regard, strong review, monitoring and governance, as well as aligning LLMs with organizational ethics, are needed:

“I mean, an LLM is, I would say, the quality of it depends on how you program it or how you would train it. And by that, if you put ethical aspects in it, for sure, then you can use it also... So, that would require strong governance and also monitoring it internally. So, you have these ethical considerations in it.” (Participant 9)

Table 10 demonstrates these generated comprehensive codes/subthemes and summarizes the key insights discussed above. For a better presentation of the systematic analysis, participant numbers were also highlighted alongside the key insights.

Table 10 - Theme (3) LLMs' impact on ethical considerations and personal growth

Comprehensive Codes/Subthemes	Key Insights
1) Potential Gains and Benefits	<p>LLMs can foster ethical considerations (P1)</p> <p>Potential for LLMs to promote ethical considerations, but with caution and human oversight (P4, P5, P6, P9, P10)</p> <p>LLMs can help decision-makers explore diverse perspectives, provide efficient access to information and expand their knowledge, facilitating personal growth (P1, P2, P4, P5, P6, P7, P8, P9, P10, P11)</p> <p>LLMs can help individuals develop new skills and mindsets, such as becoming better team leader, developing design vision, cooperating with different cultures, making selections more agile (P1, P2, P9, P10)</p>
2) Limitations and Concern Factors	<p>Concerns about LLMs' potential for misuse or unintended consequences in ethical decision-making (P3, P6, P9, P10)</p> <p>LLMs' effectiveness in promoting ethical considerations depends on the specific context, regulations, and organizational policies (P6, P7, P9)</p> <p>Potential risks and vulnerabilities associated with using LLMs, such as data privacy and security concerns (P2, P4, P10)</p>
3) Required Integrations and Improvements	<p>LLMs should be used as a tool to support, not as a sole source of information or decision-making (P5, P6)</p> <p>Need for strong review, monitoring and governance, /and aligning LLMs with organizational ethics (P4, P6, P9)</p> <p>Caution is needed to avoid over-reliance on LLMs and maintain critical thinking (P3, P4, P6)</p>

9.5 Theme (4) Factors Influencing the Adoption of LLMs

This theme focuses on the possible factors influencing the adoption of LLMs among decision-makers. As stated before, according to Jo (2023, para. 6), “although there is an increasing body of research on the factors influencing the adoption and usage of AI chatbots in various contexts, several research gaps still exist”. In this regard, this theme aims to reveal those factors, particularly focusing on organizational culture and AI literacy.

Within this theme, a number of contributing comprehensive codes/subthemes were generated, which are curiosity and conviction in the technology, data security and quality concerns, organizational culture and change management, cost and perceived value, AI literacy and expertise, efficiency and productivity gains, and generational and cultural differences.

Regarding the **curiosity and conviction in the technology**, a participant indicated that he has curiosity for the improvements in the technology, and he has a conviction that LLMs are here to stay and will continue to grow in importance:

“First of all, it's the next new thing. I've been in business now for 30 years, and every couple of years, something big turned up... But I think large language models and generative AI;

they are here to stay and to grow. I think they are not just a bubble... So first of all, curiosity is definitely one factor. The second factor is a conviction that it is going to stay.” (Participant 3)

Another participant pointed out the need to keep up with the latest technology for competition in the market. Hence, for him, LLMs are the way for that as of today:

“I mean, what drives us is also to be, let's say, market leader. And by that, you need to go, let's say, you need to go with the latest technology.” (Participant 9)

In the context of **data security and quality concerns**, some participants stated that organizations may be hesitant to share sensitive information with external systems for LLMs usage, which leads to data security and privacy concerns:

“Another, the risk on the data internally from the company, like to be open for using this. I think that there should be like more close language into the company to don't be a risk, especially the data protection of the clients or like some information that is critical.” (Participant 10)

In addition, for many participants, the quality and reliability of the LLM outputs are crucial factors for the adoption:

“I guess it's also if we look at let's say specific products, it's really just the quality of the product right? I mean yeah certain tools promise to do something, and then you and it maybe works in certain applications, but then in your particular, for your particular use case it doesn't provide the desired quality, and in these cases then you would probably not adopt, and then probably stick to I don't know maybe not necessarily manual work but other alternatives that are out there.” (Participant 4)

Within the scope of **organizational culture and change management**, for most of the participants, the openness and adaptability of the organizational culture towards new technologies is a key factor for a successful LLM adoption:

“I think you need an organizational culture that is very open to change and is very let's say has the organization itself and the entire culture is about growth and then having the having this particular mindset and constantly reviews the things that are how the things are done right and whether they can be improved by using different tools and methods.” (Participant 4)

According to some participants, organizational structure and size can also influence the ease of adoption, besides the organizational culture. Some participants also mentioned that resistance to change, especially among older employees, can hinder the adoption of LLMs:

“So, like you always have to have this consciousness of like which generation you're working on. So, for a guy who is like 57 right now, they're not thinking about learning new things. They're just thinking about retirement. And they rely on the younger ones to explain to them the results, you know? So, which factors? Age, for sure.” (Participant 2)

In regard to **cost and perceived value**, a participant pointed out that the cost of implementing and using LLMs is a consideration, as organizations may weigh the potential benefits against the financial investment:

“Also the price, you know that you will have to pay to have it. Because a lot of people in the industry, you know, always there's a price and they will think...Perhaps I can, you know, use this artificial intelligence.” (Participant 5)

Many participants indicated that the perceived value and usefulness of LLMs in the context of energy transformation projects are also important factors for their adoption:

“Is it needed? Yes, or no? Is it bringing any value added to what we are doing or not? So, that is always, let's say, on the discussion board...Is there value added for us and for our customers and for the society, maybe even yes or no? And I would say, yes, it is.” (Participant 9)

For **AI literacy and expertise**, it was mentioned by some participants that a lack of AI literacy among employees can hinder the adoption of LLMs. In this regard, it was also mentioned that the level of AI knowledge and expertise within the organization, both at the management and staff levels, can impact the adoption of LLMs:

“So if people in the management team improve their literacy, they will also affect the corporate culture. Naturally, the benefits will be positive.” (Participant 1)

Regarding the **efficiency and productivity gains**, participants indicated that LLMs can help speed up work and improve efficiency. In this regard, they can be seen as a way to accelerate the energy transformation process and improve overall productivity. Hence, this can influence the adoption of LLMs among them:

“So now the question is, how can we even speed it up? So my hope, and here I'm expressing hope not knowledge, is that clever AI can help us accelerate the energy transformation. So that would be an influencing factor, acceleration.” (Participant 3)

Within the scope of **generational and cultural differences**, some participants stated that attitudes towards learning and embracing new technologies can vary across different age groups and generations within the organization. In this regard, younger employees may tend to adapt to new technologies like LLMs more quickly, while older employees may be more resistant to change:

“So, if you want to explain like, I don't know, a 50-year-old, 55-year-old engineer, German engineer, that now we're improving the process because of X result that we have in AI that is showing us that it's better, it's going to take you a while, for sure. So, I think it's about attitude of how to acquire knowledge.” (Participant 2)

In addition, it was also pointed out by some participants that cultural differences and factors also influence the adoption of LLMs:

“And I think that there was like something cultural in other countries as like, for example, United States, it's a little bit more open to integrate this type of technologies. But here in Germany, we still have to use the post for some information. So I think that definitely influence.” (Participant 10)

Table 11 demonstrates these generated comprehensive codes/subthemes and summarizes the key insights discussed above. For a better presentation of the systematic analysis, participant numbers were also highlighted alongside the key insights.

Table 11 - Theme (4) Factors influencing the adoption of LLMs

Comprehensive Codes/Subthemes	Key Insights
1) Curiosity and Conviction in the Technology	<p>Curiosity about new technologies and a conviction that LLMs are here to stay and will continue to grow in importance (P3)</p> <p>The need of keeping up with the latest technology for competition in market (P9)</p>
2) Data Security and Quality Concerns	<p>Data security and privacy concerns are important considerations in the adoption of LLMs, as organizations may be hesitant to share sensitive information with external systems (P2, P4, P10)</p> <p>The quality and reliability of the LLM outputs are crucial factors, as organizations want to ensure the accuracy and usefulness of the information provided (P4, P7, P10, P11)</p>
3) Organizational Culture and Change Management	<p>The openness and adaptability of the organizational culture towards new technologies is a key factor (P2, P3, P4, P6, P7, P8, P9, P10)</p> <p>Resistance to change, especially among older employees, can hinder the adoption of LLMs (P2, P3, P9)</p> <p>The organizational structure and size can also influence the ease of adoption (P2, P7, P11)</p>

4) Cost and Perceived Value	The cost of implementing and using LLMs is a consideration, as organizations may weigh the potential benefits against the financial investment (P5) The perceived value and usefulness of LLMs in the context of energy transformation projects are also important factors (P3, P6, P8, P9, P11)
5) AI Literacy and Expertise	Lack of AI literacy among employees can hinder the adoption of LLMs (P3, P9) The level of AI knowledge and expertise within the organization, both at the management and employee levels, can impact the adoption of LLMs (P1, P4)
6) Efficiency and Productivity Gains	LLMs can help speed up work and improve efficiency (P1, P3, P8, P11) LLMs are seen as a way to accelerate the energy transformation process and improve overall productivity (P3)
7) Generational and Cultural Differences	Attitudes towards learning and embracing new technologies can vary across different age groups and generations within the organization (P2, P3, P9) Cultural differences influence the adoption of LLMs (P2, P10)

9.6 Theme (5) Circumstances Optimizing the Most Effective Human-LLMs Collaboration

This theme focuses on the possible circumstances for optimizing the most effective human-LLM collaboration. As stated before, according to Steyvers and Kumar (2023: 728), “the questions of what, when, and how much information should be presented to a human decision-maker highlight the need to develop theoretical frameworks that infer the impact of AI aids on human cognition and observed performance”. Hence, with a specific focus on the way information is presented and the timing of it, this theme questions those circumstances.

Presentation way of information, timing of LLM-generated insights, complementary nature of human-LLM collaboration, adaptability and customization of LLM usage, and importance of user experience and familiarity were generated as the contributing comprehensive codes/subthemes within this theme.

In the scope of **presentation way of information**, participants indicated that getting an answer tailored to their cognitive preferences and task-specific needs has a positive impact on their collaboration with LLMs:

“I mean, sometimes you look to a topic, or let's say decision making in a more comprehensive manner. You would like to have a comprehensive answer from LLMs, where all, let's say, 360 degrees view is considered, means like all, from all perspectives. And I would say, this is crucial sometimes, more often actually for decision making. So the answer, yes, the way the information presented, it does actually help me.” (Participant 7)

A participant pointed out that LLMs need transparency, and they should have clear criteria for the information and answers they present:

“So to me, there must be clear transparency in terms of what are the criteria that the model offers that helps me to make a decision.” (Participant 3)

Another participant claimed that LLMs still have some problems with the presentation way of information. He stated that there can be a mismatch risk between an LLM’s answer and user preferences and needs:

“To be honest, this is one of the struggles I have with LLMs. So, I feel it doesn't always reflect what you need. So, sometimes you want a short answer and it gives you a very broad one. And sometimes you want to dive deep into a topic, but then it decides to give you a very short answer.” (Participant 8)

Regarding the **timing of LLM-generated insights**, participants had varied perspectives. Many participants indicated that they prefer to use LLMs throughout the whole decision-making process. Some of them pointed out that they prefer to use LLMs at the start of a decision-making process, while some others stated that they use LLMs at the end to just double-check their own decisions:

“So, like, whatever I can do to make it faster and make my day goes less stressful, I will use it at any point of my projects.” (Participant 2)

“I would say using it early on is I think a good way to start right because it allows you to quickly gain a perspective.” (Participant 4)

“So, if I want to use it, I use it at the end to double-check.” (Participant 6)

Within the context of **complementary nature of human-LLM collaboration**, a participant pointed out with an example that there exist potential conflicts between LLM recommendations and human judgment. Hence, it was mentioned by participants that human oversight and verification of LLM outputs are needed for complementing and optimizing effective human-LLM collaboration:

“So, it's also a bit, it could be a bit dangerous. Dangerous is what I mean is that you could cross-check people, their performance, their decision and question them. So, that is an area where it could be, where we could create conflict between an LLM or an AI and our colleagues in an organization. So, that needs to be somehow accompanied by a kind of mentor or something. So, a human being who still can judge also and say, yes, that is right or no, or the AI had much more information on it.” (Participant 9)

"It could be helpful. Yeah, it could be helpful, but you should really verify the sources, the information, but they are not always true. So, sometimes there is something that you didn't consider, and you will find it in the analysis of the LLM or something, but you should verify again and again." (Participant 5)

For optimizing human-LLM collaboration, participants stated that **adaptability and customization of LLM usage** are required. In this regard, some participants indicated LLM usage should be tailored to specific tasks and user preferences for an effective result:

"So, you're saying reports tailored to cognitive preferences, right? So, like, I will use a different AI engine for the task that I have during the day. So, if I have to write an email, I will just put in copilot...But if I have to do something more meaningful and it will have more impact, I will choose wisely which one I'm using, depending on how the information is presented to me in that engine specifically." (Participant 2)

It was also pointed out by some participants that the evolving nature of LLM capabilities may provide improvements in human-LLMs collaboration as well:

"I think that it would be better like to have the income of like several scenarios and then get back to analyze with these technologies. The best one with some considerations and have my own opinion after. But I think this will be changed in the next year when the AI gets like a little bit stronger on their answers." (Participant 10)

For some participants, the ability to adjust the level of detail and depth of LLMs' inputs and outputs is also an important factor for the success of human-LLMs collaboration:

"From what I saw, you need always to adjust again. You will have perhaps a structure, but it is always very superficial, you know. It's always general speaking. And if you want more, you have to adjust it. It will be like a base, you know. You have a base, and then you need to put more information." (Participant 5)

In regard to **importance of user experience and familiarity**, some participants pointed out the importance of getting familiar with LLMs' capabilities, and with their current limitations and room for improvement for effective human-LLMs collaboration. In this regard, a participant suggested the need for user training and guidance on effective LLM utilization for desired results:

"So, what I see is, of course, we are at the start of that. So, we have that rolled out and I think there is still a big learning curve. How to use it? So, you need also to know how to get good information out of it." (Participant 9)

Table 12 demonstrates these generated comprehensive codes/subthemes and summarizes the key insights discussed above. For a better presentation of the systematic analysis, participant numbers were also highlighted alongside the key insights.

Table 12 - Theme (5) Circumstances optimizing the most effective human-LLMs collaboration

Comprehensive Codes/Subthemes	Key Insights
1) Presentation way of information	Positive impact of getting an answer tailored to cognitive preferences and task-specific needs (P1, P2, P3, P6, P7) Potential mismatch with user preferences and needs (P8) Need for transparency and clear criteria (P3)
2) Timing of LLM-generated insights	Preference for using LLMs during the whole decision-making process (P1, P2, P8, P9, P11) Preference for using LLMs at the start of a decision-making process (P4, P7, P10) Preference for using LLMs at the end to double-check decisions (P3, P6)
3) Complementary nature of human-LLM collaboration	Need for human oversight and verification of LLM outputs (P5, P8, P9) Potential for conflict between LLM recommendations and human judgment (P9)
4) Adaptability and customization of LLM usage	Tailoring LLM usage to specific tasks and user preferences (P2, P4, P10) Evolving nature of LLM capabilities and their integration into decision-making processes (P9, P10) Adjusting the level of detail and depth of LLM inputs-outputs (P5, P8, P9)
5) Importance of user experience and familiarity	Current limitations and room for improvement (P9, P11) Need for user training and guidance on effective LLM utilization (P9)

9.7 Theme (6) Challenges and Hurdles Associated with Human-LLMs Collaboration

This theme focuses on the possible challenges and hurdles associated with human-LLMs collaboration. As stated before, according to Kasneci et al. (2023: 2), “while large language models have made great strides in recent years, there are still many limitations that need to be addressed”. In this regard, this theme examines those limitations, particularly interpretability, trust, and data privacy issues. It also questions their possible impacts and possible strategies or solutions to overcome them.

Data privacy concerns, interpretability and trust issues, lack of specificity and tailored responses, overcoming those challenges, and ethical considerations and responsible development were generated as the comprehensive codes/subthemes within this theme.

Within the context of **data privacy concerns**, most of the participants expressed concerns about data privacy when using LLMs:

“So data privacy obviously is always a key concern” (Participant 4)

*“Real challenges are more what I mentioned earlier, so that we have data privacy topics.”
(Participant 9)*

In this regard, a participant suggested that using paid, more secure versions of LLMs can be useful to mitigate data privacy risks, while another participant emphasized the need to have clear internal policies and access controls to protect sensitive data when using LLMs:

“So, it's not about me as a person or as an employee of my company, but it is more about the data, our IPP or intellectual property. So, that we will need to keep and that needs to be clear. So, where is it from? So, what we are doing is, for instance, we have clear internal instructions who has access to what data and our AI knows that and analyzing all the data where you have access to.” (Participant 9)

Regarding the **interpretability and trust issues**, participants highlighted the challenge of interpreting the outputs from different LLMs, as the accuracy and reliability of the information can be questionable:

“Definitely, there's an issue of trust because, you know, sometimes some of the information you ask for a reference and then it's not really an acceptable one or it's not really understandable how the information was developed. So, I can never purely trust the data coming from ChatGPT or any other LLM.” (Participant 8)

To be able to overcome those issues, participants pointed out the need to verify the sources and references provided by LLMs to build trust in the information. Participants also indicated that LLMs should be more transparent about the sources and reasoning behind their outputs to improve interpretability and trust:

“That's why I like the one in Brave, because Brave is actually giving you a summarized answer, and then at the end, it's saying, like, yeah, my answer is based on, like, these three articles. And then you can ask it to actually direct it to a scientific article, a peer-reviewed article, who is pointing out to your answer. And then you can read that article directly and say, like, okay, this guy is right, this guy is wrong, and you can debate with your own ideas, you know?” (Participant 2)

Within the scope of **lack of specificity and tailored responses**, some participants expressed that LLM outputs can sometimes be too broad or specific, lacking the specificity required for certain tasks or decision-making:

“...So sometimes you expect more data and then you get less and then sometimes you expect some short concise answers and you got a paragraph that you also need to analyze.” (Participant 8)

In this regard, they state that this can make human-LLMs collaboration difficult, and they suggest that LLMs should be able to provide more tailored and configured responses based on users' needs:

“...For example, you have now ChatGPT, something for everyone. But perhaps it should be like something configured, software, artificial intelligence, okay?” (Participant 5)

To overcome those challenges, the importance of understanding the capabilities and limitations of different LLMs to choose the most appropriate one for the needs is also highlighted by some participants:

“Imagine you're asking an AI to interpret a law, and it depends which one you ask. If you ask Gemini, it will be completely wrong. If you ask Copilot, it will be kind of, like, center, like, a really soft answer, whatever. If you ask Leo from Brave, it will just search the web for it. If you ask Perplexity, I think it could be more tailored, but it could also be wrong, too.” (Participant 2)

For **overcoming those challenges**, a participant recommended a gradual approach to adopting LLMs, starting with less critical tasks and gradually increasing the importance of decisions based on LLM outputs:

“It's trust and how much time does it take. To be able to overcome, I think it's just getting to used to LLMs, not directly using them maybe for core decisions you have to make, but to slowly increase the importance of decision that you base on the LLMs and then with this trust move forward in more complex topics and solutions.” (Participant 11)

Another participant highlighted the benefit of using an internally developed derivative of LLM within the company for overcoming data privacy concerns.

“Yeah, so regarding data privacy concerns, so since we have an instance of ChatGPT developed by the company, then we don't really have this issue, at least internally.” (Participant 8)

Participants also emphasized the importance of **ethical considerations and responsible development** while coping with those challenges. A participant suggested that LLM developments should consider the ethical implications of the systems, such as ensuring the information displayed is balanced:

“I think it would be great that AI's engines are also conscious about which information is being displayed... So, if the AI engines have the ethic to actually show this in a proper way,

not directed to the question, I think that's the way that we should advance in these engines.” (Participant 2)

Table 13 demonstrates these generated comprehensive codes/subthemes and summarizes the key insights discussed above. For a better presentation of the systematic analysis, participant numbers were also highlighted alongside the key insights.

Table 13 - Theme (6) Challenges and hurdles associated with human-LLMs collaboration

Comprehensive Codes/Subthemes	Key Insights
1) Data Privacy Concerns	<p>Participants express concerns about data privacy when using LLMs (P1, P4, P5, P7, P9, P10)</p> <p>Participants suggest using paid, more secure versions of LLMs to mitigate data privacy risks (P7)</p> <p>Participants emphasize the need to have clear internal policies and access controls to protect sensitive data when using LLMs (P9)</p>
2) Interpretability and Trust Issues	<p>Participants highlight the challenge of interpreting the outputs from different LLMs, as the accuracy and reliability of the information can be doubtful (P2, P6, P8, P9)</p> <p>Participants express the need to verify the sources and references provided by LLMs to build trust in the information (P2, P5, P8)</p> <p>Participants suggest that LLMs should be more transparent about the sources and reasoning behind their outputs to improve interpretability and trust (P2, P6, P8)</p>
3) Lack of Specificity and Tailored Responses	<p>Participants note that LLM outputs can be too broad or specific, lacking the specificity required for certain tasks or decision-making (P6, P8)</p> <p>Participants suggest that LLMs should be able to provide more tailored and configured responses based on the user's needs (P5, P6, P8, P9)</p> <p>Participants highlight the importance of understanding the capabilities and limitations of different LLMs to choose the most appropriate one for their needs (P2, P8)</p>
4) Overcoming Those Challenges	<p>Participants recommend a gradual approach to adopting LLMs, starting with less critical tasks and gradually increasing the importance of decisions based on LLM outputs (P11)</p> <p>Participants emphasize the benefit of developing a derivative of LLM internally (P8)</p>
5) Ethical Considerations and Responsible Development	<p>Participants suggest that LLM developments should consider the ethical implications of the systems, such as ensuring the information displayed is balanced and not biased (P2)</p>

9.8 Theme (7) Practical Outcomes of LLM Adoption

This theme focuses on the possible practical outcomes of LLM adoption. As stated before, according to Nižetić et al. (2023: 1), by improving energy system efficiency and lowering transition costs, artificial

intelligence (AI) can enhance the energy transition. Hence, as technology continues to evolve, the capability of AI to aid in energy transformation and reduce emissions keeps growing (Wang et al., 2024: 1). In this regard, this theme questions what can be the practical outcomes of LLM adoption, and whether the adoption of LLMs could provide any improvement in energy transition implementations or any reduction in energy efficiency losses.

Within this theme, a number of contributing comprehensive codes/subthemes were generated, which are potential for improved energy efficiency, potential for improved decision-making and analysis, challenges in quantifying outcomes, limitations and barriers to adoption, and importance of collaboration and stakeholder engagement.

Regarding the **potential for improved energy efficiency**, many participants anticipated a decrease in energy efficiency loss through the adoption of LLMs:

"I think energy efficiency loss is definitely a key topic. So, I think overall improved performance of energy assets is I think a key area where this could lead to an improvement. That's probably the most relevant one I see." (Participant 4)

In addition, some participants indicated that LLMs can support analysis and decision-making, which could lead to acceleration in energy transition implementation:

"I would say, yeah, it will be, we will see improvements. So, in the speed of taking decision and also of accuracy of decisions, yeah, that I definitely see, but the LLMs need to further being trained on that." (Participant 9)

A participant also pointed out that LLMs can help reduce energy costs as a practical outcome of LLM adoption:

"So, if these guys from data centers are being conscious about installing renewable power in site, they will have less operative cost in energy and they will help the planet. And being energy more effective and efficiency, the efficiency loss will be better too, right? So, and this is a practical outcome that it needs to come from every stage of like the participants of this industry." (Participant 2)

Within the context of **potential for improved decision-making and analysis**, it was mentioned by participants that LLMs can support faster and more accurate decision-making, as well as improved analysis capabilities:

“So, I would say it's not maybe directly an energy efficiency reduction, energy efficiency loss, but at least it can support with your analysis and your study prior to the implementation of the project. So, it maybe accelerates some topics, accelerates some implementations, so that would be how the adoption helps more.” (Participant 8)

A participant also stated that LLMs can help organizations overcome challenges in managing regulatory concerns across multiple markets as one of the practical outcomes:

“I think it will just help me, it will just help me because we are working in 10 countries and it's very difficult for us to have an overview of all the regulatory concerns in all markets and therefore I believe it can increase the efficiency of organizations and of our organization as such.” (Participant 11)

In the scope of **challenges in quantifying outcomes**, some participants expressed uncertainty about the actual impact and results of LLMs on energy efficiency, as the technology is still in the early stages for them:

“I cannot answer that question. It's still too much in the early stages of using those technologies. I cannot say. There is no experience yet. Let me put it this way.” (Participant 3)

One of the **limitations and barriers to adoption** for participants was the concerns about over-reliance on LLMs, which could lead to a "dumbing down" of employees:

“I mean, the efficiency is improving, but the problem now, whether employee or, let's say, co-workers are relying on this too much that even non-necessary things, they're using LLM for it, like, it makes people to be more dummy, kind of. This is what I have to watch in the future.” (Participant 7)

A participant also pointed out that the complexity of energy transition implementation may exceed the current capabilities of LLMs:

“I saw it quite difficult that this year it can have all of these data and these considerations for all of the factors. I'm not saying that it's impossible to do it, but I'm saying that like the industry itself and the installation, the physical installation itself is still maybe not ready for now to take in this.” (Participant 10)

Moreover, the need for physical interventions in a successful energy transition implementation is seen as a challenge to the direct application of LLMs for one of the participants:

“Actually, based on my work, I don't think it will work, because when you're asking for energy efficiency losses, you need to do something physically. You need to do something by your hands to get your measurements, to get your parameters, to visit the sites... I don't

think, basically, LLMs would help in real life, energy efficiency losses. The human must intervene.” (Participant 6)

Regarding the **importance of collaboration and stakeholder engagement**, the importance of a collaborative approach among all industry participants to achieve energy efficiency improvements was highlighted:

“This is not something that you can just point the finger to just one industry. I think it's something that we should come together to provide something that it will be not as energy intensive as we thought at the beginning.” (Participant 2)

Table 14 demonstrates these generated comprehensive codes/subthemes and summarizes the key insights discussed above. For a better presentation of the systematic analysis, participant numbers were also highlighted alongside the key insights.

Table 14 - Theme (7) Practical outcomes of LLM adoption

Comprehensive Codes/Subthemes	Key Insights
1) Potential for Improved Energy Efficiency	<p>Some participants anticipate a decrease in energy efficiency loss through the adoption of LLMs (P1, P4, P7, P8, P10)</p> <p>LLMs can support analysis and decision-making to accelerate energy transition implementation (P8, P9, P10)</p> <p>LLMs can help reduce energy costs (P2)</p>
2) Potential for Improved Decision-Making and Analysis	<p>LLMs can support faster and more accurate decision-making, as well as improved analysis capabilities (P8, P9, P10, P11)</p> <p>LLMs can help organizations overcome challenges in managing regulatory concerns across multiple markets (P11)</p>
3) Challenges in Quantifying Outcomes	<p>Participants express uncertainty about the actual impact of LLMs on energy efficiency, as the technology is still in the early stages (P3, P5, P7)</p>
4) Limitations and Barriers to Adoption	<p>Concerns about over-reliance on LLMs, which could lead to a "dumbing down" of employees (P7, P10)</p> <p>The complexity of energy transition implementation may exceed the current capabilities of LLMs (P10)</p> <p>The need for physical interventions in a successful energy transition implementation is seen as challenge to the direct application of LLMs (P6)</p>
5) Importance of Collaboration and Stakeholder Engagement	<p>The importance of a collaborative approach among all industry participants to achieve energy efficiency improvements (P2, P9)</p>

9.9 Theme (8) LLMs' Role in Expanding the Knowledge Base of the Firm and Decision-Makers

This theme focuses on LLMs' role in expanding the knowledge base of the firm and decision-makers. As stated before, according to Keding (2021: 93), preliminary research suggested that AI might serve as a decision support tool, gathering expert insights and guiding organizational actions, rather than acting as a sole decision-making authority, due to its limitations at the strategic level. Yet, "current research streams clarify that the real value of AI is to perform data analysis autonomously across various sorts of data, to access tacit knowledge and to create new knowledge by itself" (Keding, 2021: 93). In this regard, this study explores how LLMs could contribute to the knowledge expansion of a firm and decision-makers.

LLMs as knowledge repositories, integrating LLMs into organizational processes, potential competitive advantage, and limitations and caution were generated as the contributing comprehensive codes/sub-themes within this theme.

In the scope of **LLMs as knowledge repositories**, most of the participants pointed out that LLMs can help decision-makers and organizations acquire knowledge more efficiently and effectively:

"So enhancing the knowledge base is particularly advanced because you can like find specific information you're looking for in a summarized way that it can be processable faster than before." (Participant 2)

It was also mentioned that LLMs have a potential to serve as repositories of knowledge, allowing organizations to store and access information more efficiently:

"Yeah, it's what I've said. It was a good example with those videos. They can be stored in the data. They will be stored in the cloud. They would be accessible to all sites, to all manufacturing sites worldwide... And especially when you bring it into the context of energy transformation, where we have to deliver a lot of products, we have to cope...And we need to train a lot of people very quickly to deliver products at the right standard and in right quality. So this is where those training tools could come in quite handy, actually." (Participant 3)

Within the context of **integrating LLMs into organizational processes**, many participants indicated that by integrating LLMs into the organization's knowledge management and decision-making processes, knowledge expansion of the organization and decision-makers can be provided:

"At the moment, we have to work a lot with external consultants when we enter new topics or when we want to change our overall strategy. LLMs could simply reduce the lack of

third-party knowledge of service providers in the long run and therefore it would just change the picture of the decision making process.” (Participant 11)

Regarding the **potential competitive advantage**, a participant highlighted the potential for LLMs to provide a competitive advantage by enabling more informed decision-making and the ability to stay up-to-date with industry changes and regulations:

“So, if you know how to use efficiently the LLMs and it can really grow your knowledge again and you can, the energy market is very big and each country is different and there's always new regulations. So, to stay up to date, it's sometimes very difficult. So, using, being able to navigate the LLMs and asking the right questions would help you definitely better understand, better understand this market and different countries, different regulations and this definitely would create, increase your knowledge base and create a competitive edge.” (Participant 8)

On the other hand, another participant claimed that LLMs can provide a competitive advantage by enhancing the knowledge base, but this advantage may erode over time as the technology becomes more widely adopted:

“Yeah I think so, right. But only I think temporarily so. Because usually the competition picks up at a certain point. So, I think if you're early on in using these then you have a competitive advantage. If then obviously the industry adopts the same technology and then ultimately everybody gets the same recommendations, and if it erodes quite quickly, right...But you know over time this benefit will then erode unless you always you know stay on top of the curve and always you know adopt the next best solution while others you know what you used before.” (Participant 4)

Within the scope of **limitations and caution**, a participant stated that LLMs may not be as advanced or helpful in the energy transformation context compared to other industries:

“For energy transformation, I think, the LLMs are picking up, but still they're a bit behind. If you compare to, I don't know, other industries, maybe IT industry, for instance, software industry. So, they are actually, the LLMs are much faster, but energy transformation, they are getting it, but still, I think, I believe there is a big room for improvement to be really at that level of smartness for decision making, especially energy transition, energy transformation.” (Participant 7)

The need for caution in relying solely on LLM-generated insights for critical decision-making was also mentioned by some participants:

“So basically, it gives you some outputs that might help to understand your situation and how you could improve yourself in the future. As I said, in a nutshell, you cannot rely, yes, you cannot make a decision based on AI, but as I've said, in general, it can give you an enlightenment and a knowledge how you could start by improving your organization and decision making.” (Participant 6)

Table 15 demonstrates these generated comprehensive codes/subthemes and summarizes the key insights discussed above. For a better presentation of the systematic analysis, participant numbers were also highlighted alongside the key insights.

Table 15 - Theme (8) LLMs' role in expanding the knowledge base of the firm and decision-makers

Comprehensive Codes/Subthemes	Key Insights
1) LLMs as Knowledge Repositories	LLMs can help decision-makers and organizations acquire knowledge more efficiently and effectively (P2, P3, P8, P9, P10, P11) Potential for LLMs to serve as repositories of knowledge, allowing organizations to store and access information more efficiently (P3, P7)
2) Integrating LLMs into Organizational Processes	Integrating LLMs into the organization's knowledge management and decision-making processes (P6, P9, P10, P11)
3) Potential Competitive Advantage	The potential for LLMs to provide a competitive advantage by enabling more informed decision-making, and the ability to stay up-to-date with industry changes and regulations (P8) LLMs can provide a competitive advantage by enhancing the knowledge base, but this advantage may erode over time as the technology becomes more widely adopted (P4)
4) Limitations and Caution	LLMs may not be as advanced or helpful in the energy transformation context compared to other industries (P7) The need for caution in relying solely on LLM-generated insights for critical decision-making (P5, P6)

10 Discussion

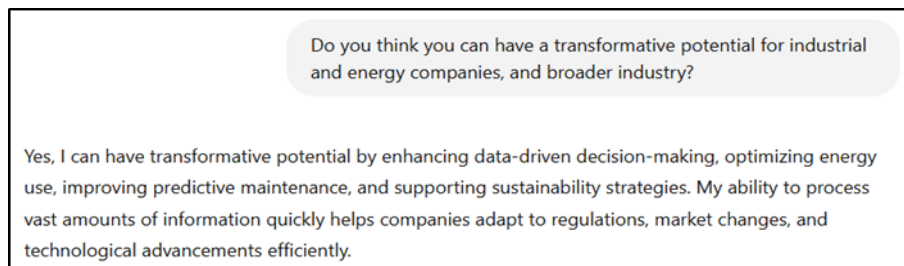
10.1 Comparison of ChatGPT Answers and Participant Responses

After the analysis of the participant insights and the presentation of the findings, the concerns and limitations expressed by the participants were tested by asking the determined questions in Table 7 to ChatGPT and comparing the participant responses with ChatGPT's answers. Hence, this comparison could demonstrate the realistic competence and potential of LLMs to support decision-makers in the energy transformation, as well as ChatGPT's ability to perceive and interpret questions and real-life

situations. By detecting and highlighting the conflicts and contradictions between those responses, the discussion progressed.

In the general scope, ChatGPT was confident about its transformative potential for industrial and energy companies. ChatGPT expressed that its abilities provide enhanced decision-making, as shown in Figure 4.

Figure 4 - ChatGPT's transformative potential



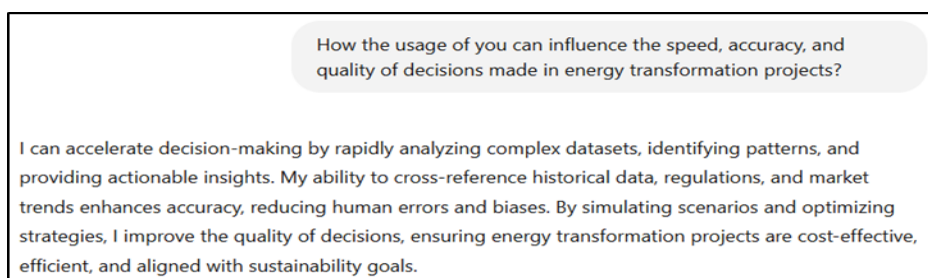
(OpenAI, 2025)

From the participants' perspective, as stated in the findings, they recognized the transformative potential of LLMs in the industrial and energy sectors. However, participants also highlighted some cautionary insights and areas where further development and integration are needed regarding the transformative potential of LLMs.

Within this context, when we consider both participants' and ChatGPT's perspectives, although they agree in general on ChatGPT's potential and abilities in energy transformation, participants had some concerns and limitations, while ChatGPT did not refer to any of them. In this regard, there were some disputes between the statements of the two sides. For instance, Participant 6 stated: "So no, no, actually, I don't think, basically, LLMs would help in real life, energy efficiency losses. The human must intervene." Hence, it can be stated that participants' cautious approach prevented a complete alignment between participant responses and ChatGPT's answer, particularly within this question.

In the scope of Theme 1, ChatGPT was confident about its ability to improve the speed, accuracy, and quality of decisions in energy transformation. The answer in Figure 5 shows how ChatGPT expresses its contribution in this regard.

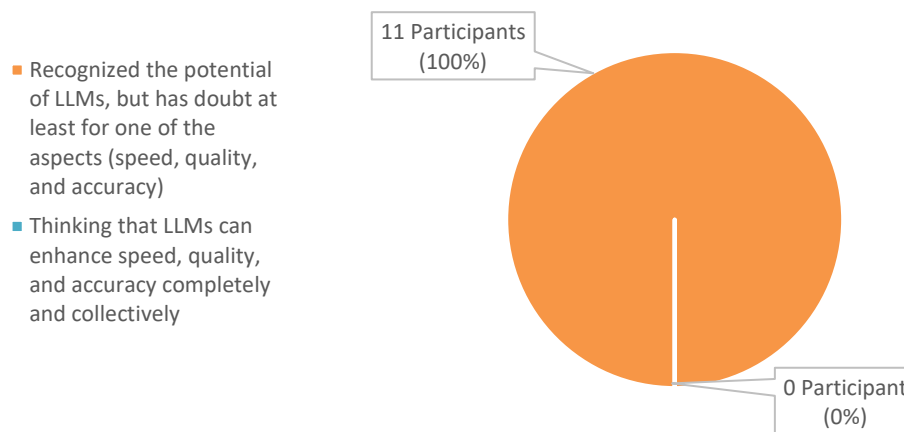
Figure 5 - ChatGPT's influence on speed, accuracy and quality of decisions



(OpenAI, 2025)

From the participants' perspective, however, there exist some apparent conflicts and contradictions. 11 out of 11 participants, as also shown in Figure 6, recognized the potential of LLMs in enhancing speed, accuracy, and quality of decisions made, but they also expressed that LLMs don't have the ability to enhance all aspects completely and collectively yet. In this regard, it was emphasized that especially the accuracy and quality of ChatGPT can be questionable, which affects its reliability in the decision-making process. In this regard, Participant 7 indicated: "Well, I would say speed, definitely, like I mentioned... Accuracy, it's really, I would say, is subjective. I cannot say in all departments; they are really accurate." Similarly, Participant 2 expressed: "So basically, so you are faster searching for like information, but then you lose a bit more time to research if that's correct or not... So, trivial task for sure, but accuracy and quality, I will say that it's not that much".

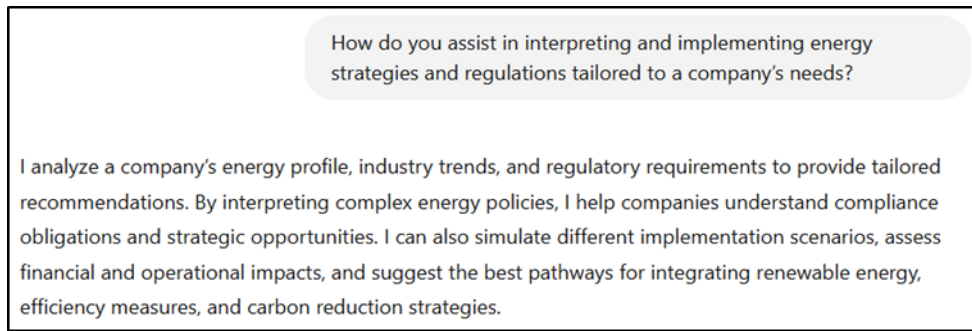
Figure 6 - Participant opinions on ChatGPT's influence on speed, accuracy, and quality of decisions



Considering the perspectives of participants and ChatGPT, it is evident that participants are still wary of trusting ChatGPT in this regard. Hence, they have some doubts about its ability to improve the accuracy and quality of decisions collectively in energy transformation. Within this context, it can be stated that participant responses did not align with ChatGPT answers, which were inconsistent with the real-life insights obtained from the semi-structured interviews.

Within the context of Theme 2, according to ChatGPT, its abilities also include making the implementation of energy strategies more efficient and providing tailored recommendations that ensure compliance. Figure 7 shows ChatGPT's statements in this regard.

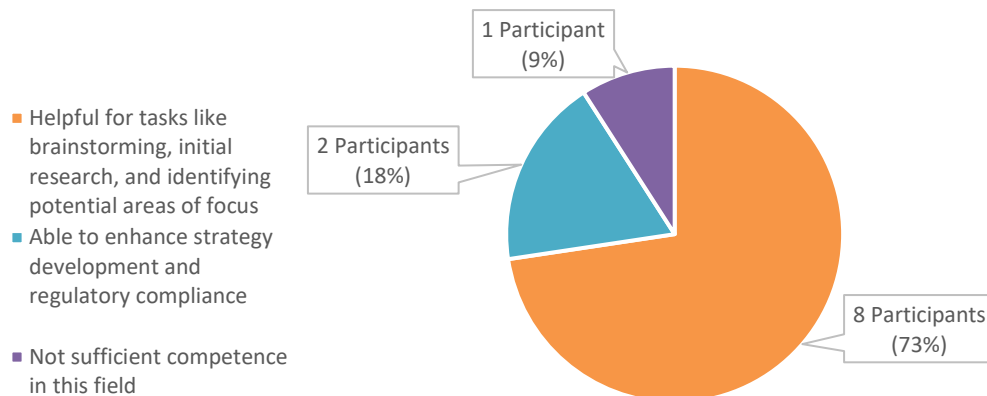
Figure 7 - ChatGPT's assistance in energy strategies and regulations



(OpenAI, 2025)

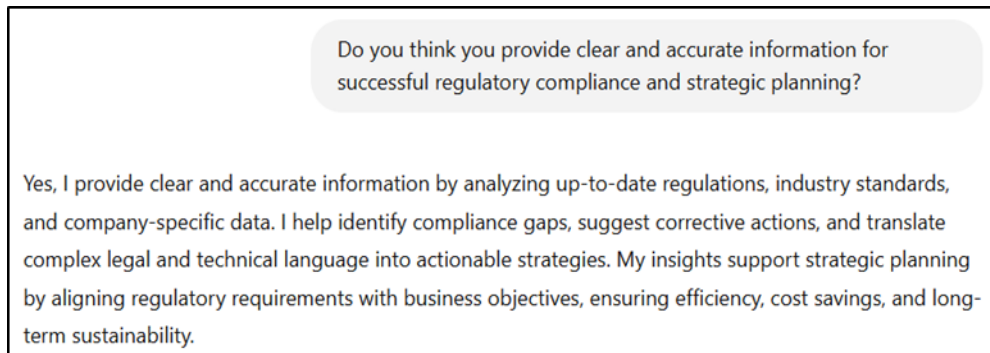
From the participants' perspective, on the other hand, a different view was expressed. While 1 participant did not answer the question as he believed that he did not have sufficient competence in this context, 8 out of 10 participants, as also shown in Figure 8, emphasized that LLMs could be useful for tasks like brainstorming, initial research, and identifying potential areas of focus, rather than being a decision-making authority for strategy development and regulatory compliance. In this regard, Participant 2 put forward a view that was opposite of ChatGPT: "As I said before, they don't assist you in this; they assist you in trivial tasks that it can be done by a machine without a human processing. So, in this one, I will say, like, the LLMs have not assisted me in interpreting or implementing energy strategies".

Figure 8 - Participant opinions on ChatGPT's assistance in energy strategies and regulations



There were also some conflicts between the participants and ChatGPT regarding the clarity and accuracy of information obtained by LLMs in strategy development and regulatory compliance. According to ChatGPT, it can provide clear, accurate, and up-to-date information, as shown in Figure 9.

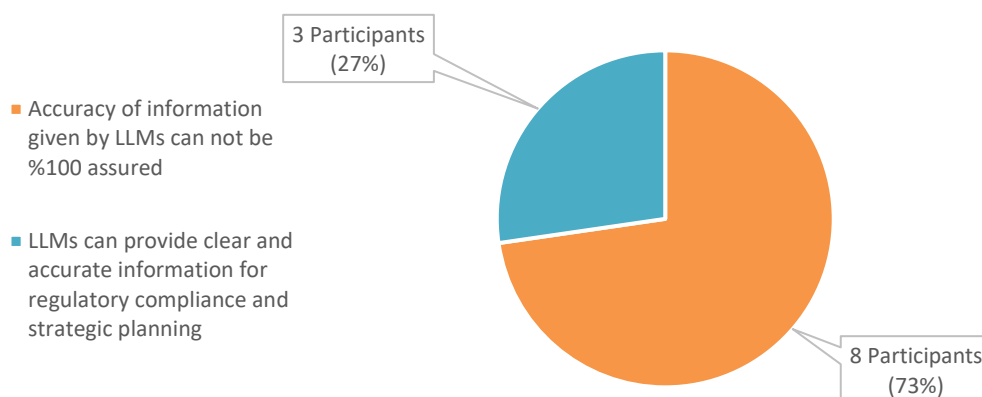
Figure 9 - ChatGPT's role in providing clear and accurate information



(OpenAI, 2025)

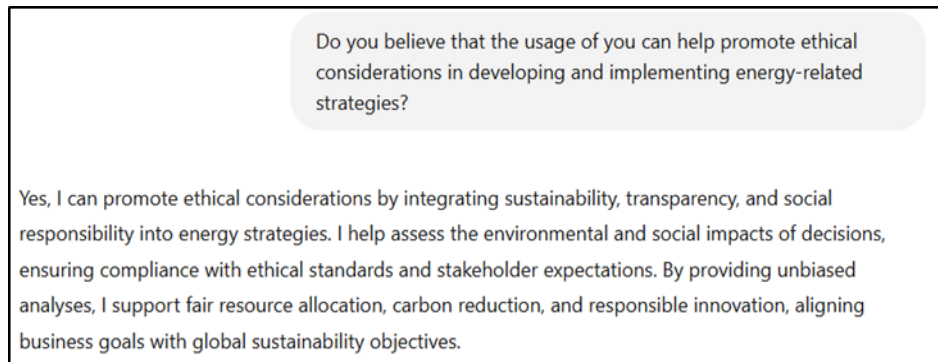
On the other hand, participants had a similar cautious approach to this aspect as well. 8 out of 11 participants, as also shown in Figure 10, expressed reservations about the accuracy of information given by LLMs. In this context, Participant 1 indicated: "I don't think so 100%. Of course, no information can be 100% accurate... I don't think it would be healthy to rely on a tool 100%". Correspondingly, Participant 3 expressed: "But would I put all my money on large language models if I had to stand up in court and defend my decision? I would rather say no". In this regard, it cannot be possible to state that there was a total agreement between the participants and ChatGPT, particularly within this theme.

Figure 10 - Participant opinions on ChatGPT's role in providing clear and accurate information



Regarding Theme 3, ChatGPT expressed a positive view about its role in fostering ethical considerations, as shown in Figure 11.

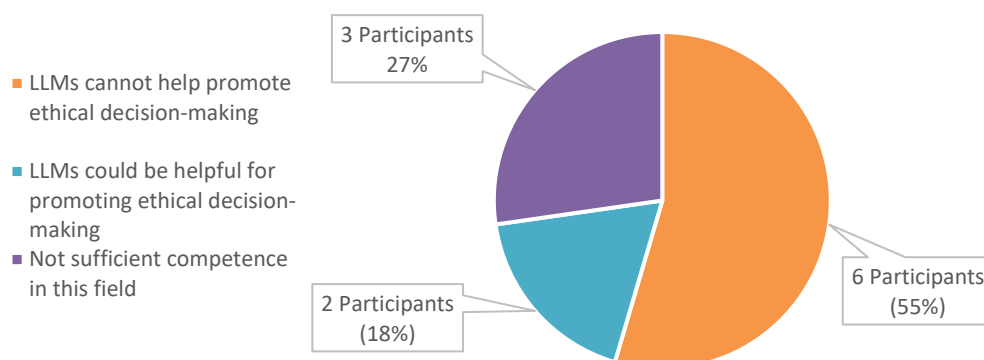
Figure 11 - ChatGPT's role in fostering ethical considerations



(OpenAI, 2025)

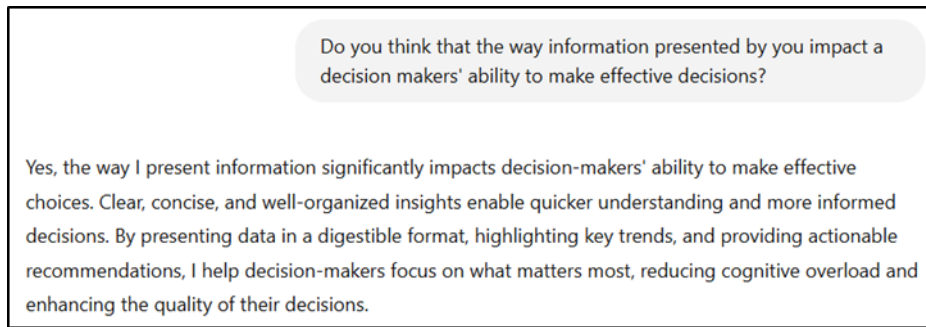
However, some participants held perspectives that conflicted with ChatGPT's view. While 3 participants did not answer the question as they believed that they did not have sufficient competence in this context, 6 out of 8 participants, as also shown in Figure 12, emphasized that LLMs cannot ensure ethical decision-making, as they are limited by the data they are trained on and may not reflect the specific ethical considerations of a given context. In this regard, Participant 3 indicated: "I would not say I believe they promote ethical considerations in any way. I do not believe, and I would be very, very careful to think those models promote ethical considerations". Similarly, Participant 6 stated: "...you cannot make a conclusion for ethical considerations based on what you have read in your answer". In this regard, it can be stated that there is a divergence between the perspectives of the participants and ChatGPT on this theme as well.

Figure 12 - Participant opinions on ChatGPT's role in fostering ethical considerations



Within the scope of Theme 5, ChatGPT agreed that the way it presents information is significantly important, and clear, concise, and well-organized insights help decision-makers, as shown in Figure 13.

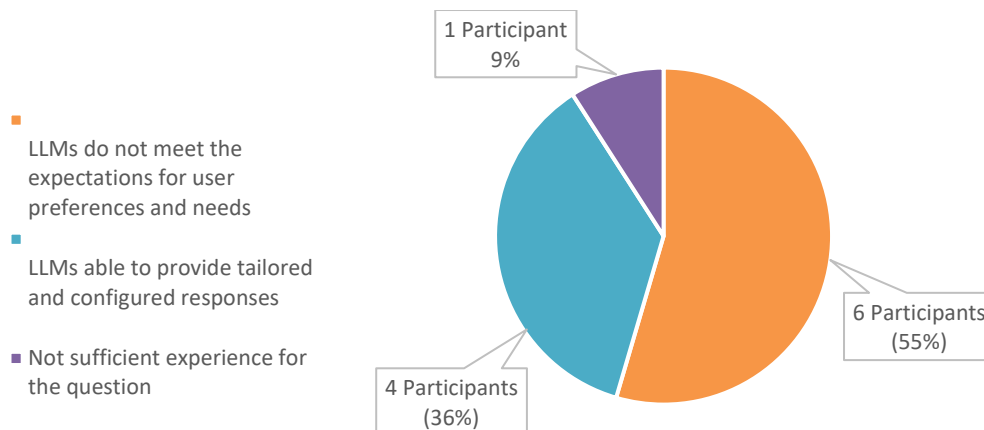
Figure 13 - ChatGPT's way of information presentation



(OpenAI, 2025)

While 1 participant did not answer the question as he stated he did not have sufficient experience for answering this question, 6 out of 10 participants, as also shown in Figure 14, had some complaints about the way information is presented by ChatGPT. In this regard, participant 8 stated: "To be honest, this is one of the struggles I have with LLMs. So, I feel it doesn't always reflect what you need. So, sometimes you want a short answer and it gives you a very broad one. And sometimes you want to dive deep into a topic, but then it decides to give you a very short answer". Similarly, Participant 6 indicated: "Another thing that I don't like in AI, you are giving me just anything, I feel this, if I can say. Just give me very general, very non-particular things that just give me hundreds, and sometimes full of paragraphs that I don't need them".

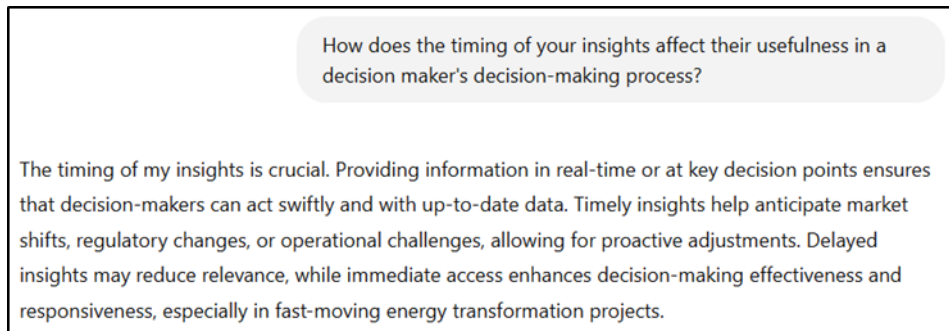
Figure 14 - Participant opinions on ChatGPT's way of information presentation



Hence, it is possible to state that the experiences participants had with ChatGPT that did not take into consideration their preferences and specific demands created an adverse judgement for the participants within the scope of this theme.

Another topic related to Theme 5 was the timing of the insights offered by ChatGPT. In its response, ChatGPT approved the importance of the timing of answers. Nevertheless, it was emphasized that decision-makers should apply ChatGPT in real-time or at key decision points, as shown in Figure 15.

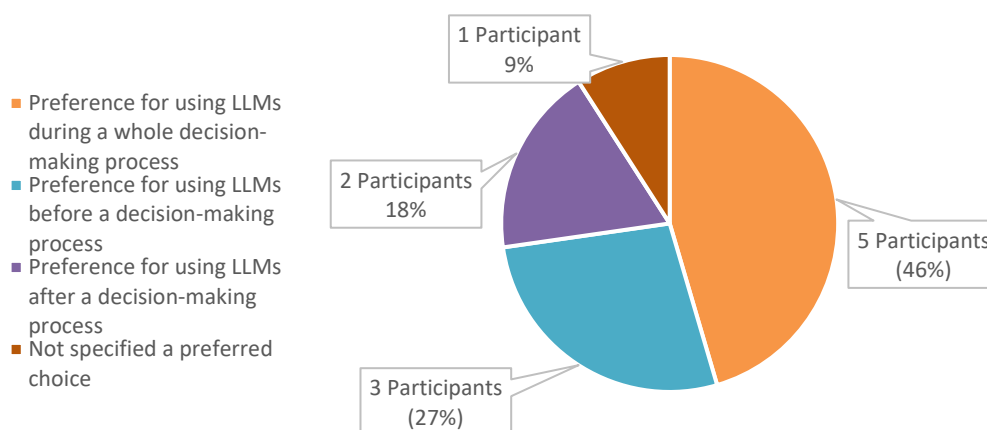
Figure 15 - ChatGPT's timing of insights



(OpenAI, 2025)

From the participants' perspective, however, various preferences were indicated, as also shown in Figure 16. In this regard, while 1 participant did not specify a preferred choice, 3 out of 10 participants emphasized that they prefer to use LLMs before a decision-making process for initial research or brainstorming. In addition to this, while 5 out of 10 participants stated that they use LLMs during a whole decision-making process, it was expressed by 2 out of 10 participants that it is a better way to use ChatGPT only after a decision-making process to double check their own decisions rather than directly using ChatGPT during a whole decision-making process. In this regard, Participant 3 indicated: "Intuitively, I would use it at the end of the process. At least where I stand right now based on what I've said before. I would definitely use it at the end to gauge the decision". Similarly, Participant 6 stated: "So, if I want to use it, I use it at the end to double-check".

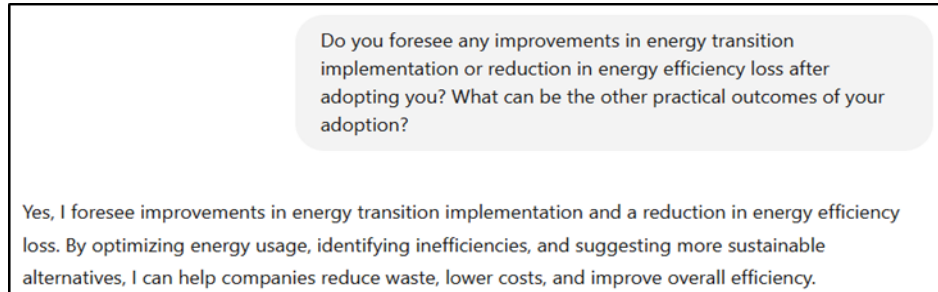
Figure 16 - Participant opinions on ChatGPT's timing of insights



Based on the perspectives of both sides, it is possible to state that participants and ChatGPT had some differences in interpretation. While some participants believe that it is better to use ChatGPT before or after a decision-making process, ChatGPT claims that the assistance should be in real-time or at key decision points. Hence, some disagreements occurred in this aspect.

Lastly, there were some conflicts and contradictions between the participants and ChatGPT in Theme 7. ChatGPT stated that it foresees improvements in energy transition implementations and a reduction in energy efficiency loss as shown in Figure 17.

Figure 17 - ChatGPT's role in energy transition



(OpenAI, 2025)

Although 4 out of 11 participants think that LLMs can support analysis and decision-making to accelerate energy transition implementations, 3 out of 11 participants, as also shown in Figure 18, expressed some cautions and opposing opinions about ChatGPT's potential in energy transition processes. Participant 8 expressed: "So, I would say it's not maybe directly an energy efficiency reduction, energy efficiency loss, but at least it can support with your analysis and your study prior to the implementation of the project". Correspondingly, Participant 6 indicated: "Actually, based on my work, I don't think it will work, because when you're asking for energy efficiency losses, you need to do something physically... and that's something you cannot deal with LLMs... So no, no, actually, I don't think, basically, LLMs would help in real life, energy efficiency losses. The human must intervene". In addition to this, 4 out of 11 participants expressed their doubts about the actual impact of LLMs on energy efficiency, as the technology is still in the early stages. Hence, it is possible to state that participants and ChatGPT had differing foresights regarding the potential of ChatGPT in energy transition and energy efficiency.

Figure 18 - Participant opinions on ChatGPT's role in energy transition

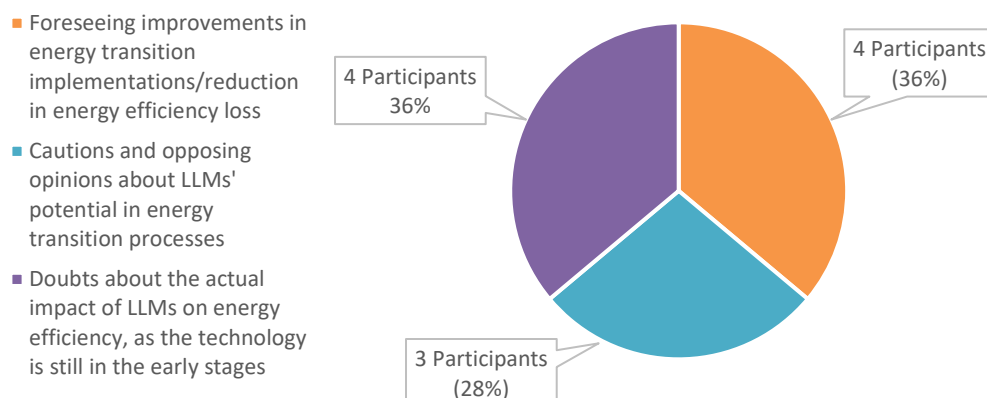


Table 16 summarizes the determined conflicts and contradictions between ChatGPT answers and participant responses in this section. In this regard, this table provides a comprehensive comparison opportunity for both perspectives.

Table 16 - Conflicts and contradictions between ChatGPT answers and participant responses

ChatGPT's Perspective	Participants' Perspective
Extremely confident about its transformative potential for industrial and energy companies and broader industry.	Some cautionary insights and highlighted areas where further development and integration are needed for ChatGPT's complete transformative potential.
Totally capable of enhancing the speed, accuracy, and quality of decisions made.	Doubts and opposing views about the improved quality and accuracy.
Making the implementation of energy strategies more efficient and providing tailored recommendations that ensure compliance.	Some insights emphasizing that it assists you in trivial tasks, not in strategy development or regulatory compliance.
Providing clear, accurate, and up-to-date information.	A cautionary approach to the 100% reliability of information provided.
Fostering ethical considerations.	Cannot ensure ethical decision-making, as they are limited by the data they are trained on and may not reflect the specific ethical considerations of a given context.
Presenting clear, concise, and well-organized insights and information.	Some complaints about the way information is presented.
Information should be provided to decision makers in real-time or at key decision points.	Some opinions emphasizing that it is a better way to use ChatGPT only before or after a decision-making process, rather than using ChatGPT during the whole decision-making process.
Foreseeing improvements in energy transition implementation and a reduction in energy efficiency loss after ChatGPT adoption.	Some cautions and question marks in the heads about ChatGPT's potential and results in energy transition processes.

In accordance with the results of the comparison between participant responses and ChatGPT answers, it is possible to state that while ChatGPT was much more confident and optimistic about its current competence and potential, decision-makers were much more reserved and cautious towards ChatGPT's role in supporting decision-makers in the energy transformation.

Participants emphasized that they would not rely solely on LLMs for critical decisions in energy transformation yet, as the information provided by LLMs may not be 100% accurate or up-to-date. It can be argued that the differences between participant responses and ChatGPT responses are a manifestation of this situation.

In this regard, the analyses throughout the study indicate that decision-makers' perception of ChatGPT's potential in energy transformation differs from ChatGPT's own perception. Hence, with the findings obtained, these interviews and analyses address the research question by indicating that the statements made by ChatGPT do not fully align with the insights and perspective of decision-makers. As a result, it can be argued that there is still a way to go to be able to obtain fully matched insights by decision-makers and ChatGPT regarding the realistic competence and potential of LLMs in real-life situations.

10.2 Hypotheses Testing Results

Based on the triangulation method, the determined hypotheses were evaluated in accordance with the obtained ChatGPT answers, participant insights, and the literature. In this regard, the study conducted the validation process by questioning whether the hypotheses were supported, partially supported, or not supported by these data sources.

The study introduced eight different hypotheses, each addressing different aspects of LLMs' role and effect on a decision-making process. Based on the Working Hypothesis and the Knowledge-Based View of the Firm as the theory and sensitizing concepts of the study, the hypotheses testing results are as follows:

H1: *Large language models (LLMs) effectively assist and guide decision-makers in a decision making process*

Although ChatGPT's responses totally aligned with H1, it is possible to state that 5 out of 11 participants had some doubts and cautions (e.g. integration issues, and legal/regulatory constraints) about a totally effective guidance and assistive role of LLMs in a decision-making process, even though LLMs' opportunities and advantages as of today. It can also be indicated that the general opinion in the literature on the subject also appears to be similar. According to Ahmad et al. (2021: 25), the use of AI presents a great chance to transform the energy sector and energy systems. Nevertheless, there still exist obstacles preventing AI from being widely used. In this regard, Ahmad et al. (2021: 26) also indicate that AI implementations and decision-making rely on vast amounts of sensitive data. These applications expose themselves to significant risks, including identity theft and data breaches. A study, which aligns with the insights of the participants, conducted by Shen et al. (2023: 2) also indicates that the precision of responses given by an AI-driven system relies on the quality and nature of data utilized to train it. Hence, although LLMs have a potential to assist and guide decision-makers, it is not always the case, especially when faced with stated factors or obstacles. In this regard, it is possible to state that the hypothesis (H1) is semi-valid as the participant insights and the literature partially supported

the hypothesis. The assessment of the hypothesis based on each data source is summarized in Table 17, along with brief descriptive "evidence highlights" for each perspective.

Table 17 - Assessment of hypothesis 1

Data Source	Hypothesis Testing Result Based on Data Source	Evidence Highlights
ChatGPT	Valid	Acknowledgment of assistance and guidance of LLMs
Participants	Semi-Valid	Some doubts and cautions
Literature	Semi-Valid	Recognized limitations

H2: *LLMs improve decision-makers' ability to interpret and implement new energy strategies and regulations tailored to specific company needs.*

Regarding H2, it can be stated that ChatGPT's perspective aligned with the hypothesis. ChatGPT claims that its abilities include making the implementation of energy strategies more efficient and providing tailored recommendations that ensure compliance. Correspondingly, Kothandapani (2025: 16) indicates that large language models provide a major advancement in companies' management of regulatory compliance. However, the incorporation of AI in regulatory compliance contains various challenges, and the difficulties associated with integrating AI systems into existing legacy infrastructures present major obstacles that demand thorough strategic planning (Kothandapani, 2025: 12). In this regard, participants had a view that supported the literature on the subject. According to 8 out of 11 participants, LLMs could be partially helpful for strategy development and regulatory compliance, but they could not be a sole decision-making authority or 100% trustworthy source in this aspect because of various issues like accuracy and reliability concerns. Hence, although LLMs may help improve decision-makers' ability to interpret and implement new energy strategies and regulations, this improvement could be restricted. In this regard, it is possible to state that the hypothesis (H2) is semi-valid as the participant insights and the literature partially supported the hypothesis. Table 18 contains the assessment of the hypothesis based on each data source, along with brief descriptive "evidence highlights" for each perspective.

Table 18 - Assessment of hypothesis 2

Data Source	Hypothesis Testing Result Based on Data Source	Evidence Highlights
ChatGPT	Valid	Alignment with the hypothesis
Participants	Semi-Valid	Highlighting the restricted ability of LLMs in this regard
Literature	Semi-Valid	Various challenges and obstacles for total integration

H3: *LLMs foster ethical decision-making and promote personal growth among decision-makers.*

ChatGPT's statements supported H3. In this regard, ChatGPT expressed a positive view about its role in fostering ethical considerations and personal growth. While 3 participants highlighted that LLMs can help foster personal growth, and ethical considerations (but only with caution and human oversight), 6 participants emphasized that LLMs cannot ensure ethical decision-making, as they are limited by the data they are trained on and may not reflect the specific ethical considerations of a given context. Correspondingly, a study conducted by Abdulhai et al. (2023: 3) indicates that LLMs could have developed a specific set of moral foundations as a result of the characteristics of the dataset used for training, which would reflect a specific cultural or political bias. Hence, although the triangulation method could approve the role of LLMs in fostering personal growth, there were contradictions with the hypothesis regarding LLMs' role in fully fostering ethical considerations. In this regard, it can be stated that the hypothesis (H3) is semi-valid as participant insights and the literature partially supported the hypothesis. The assessment of the hypothesis based on each data source is summarized in Table 19, along with brief descriptive "evidence highlights" for each perspective.

Table 19 - Assessment of hypothesis 3

Data Source	Hypothesis Testing Result Based on Data Source	Evidence Highlights
ChatGPT	Valid	Approval of the hypothesis
Participants	Semi-Valid	Mixed trust in LLMs in this aspect
Literature	Semi-Valid	Cautious approach

H4: *The adoption of LLMs among decision-makers is influenced by organizational culture, AI literacy, and complementarity of human–LLM collaboration.*

It is possible to state that the statements of both ChatGPT and participants aligned with H4. According to them, organizational culture, AI literacy, and complementarity of human–LLM collaboration are among the factors that affect the adoption of LLMs. Correspondingly, Shamim et al. (2019: 5) indicate that numerous facets of an organization are influenced by organizational culture, which can also be a major factor in the failure of new technology efforts. Thus, Bley et al. (2022: 14) consider organizational culture as “having a large (indirect) impact on the capability of an organization to apply AI; and thereby also indirectly on the performance of organizations”. In addition, a study conducted by Schiavo et al. (2024: 8) confirms a positive relationship between AI literacy and AI acceptance. In this regard, enhancing AI literacy could equip people with the essential skills and understanding needed to evaluate and interact with AI technologies thoughtfully, thus encouraging acceptance and ultimately aiding in the adoption of AI (Schiavo et al., 2024: 9). Hence, organizational culture, AI literacy, and the complementarity of human–LLM collaboration could determine the extent to which an organization could adopt LLMs. Thus, by taking into consideration the obtained data and the literature, it is possible to state that the hypothesis (H4) is valid, as the obtained data and the literature supported the hypothesis. The assessment of the hypothesis based on each data source is summarized in Table 20, along with brief descriptive "evidence highlights" for each perspective.

Table 20 - Assessment of hypothesis 4

Data Source	Hypothesis Testing Result Based on Data Source	Evidence Highlights
ChatGPT	Valid	Agreement with factors
Participants	Valid	Recognized effects of determined factors
Literature	Valid	Approval of factors in adoption

H5: *Human-LLMs collaboration is most effective when large language models provide timely assistance and present information tailored to the decision-maker’s cognitive preferences and task-specific needs.*

Within the scope of H5, ChatGPT and participants agreed that the way and time ChatGPT presents information is significantly important; and clear, concise, tailored, and in-time insights help decision-

makers improve decision-making processes. Correspondingly, as stated before, Steyvers and Kumar (2023: 728) indicate that considering the restricted cognitive resources that may be accessible for processing AI suggestions, particularly in urgent (time-constrained) scenarios, it is crucial for AI to modify its responses (e.g., by providing explanations at the right time and level of detail). Hence, by taking into consideration the time and the way of assistance (tailoring to the decision-maker's cognitive preferences and task-specific needs), LLMs could contribute to an effective human-LLMs collaboration. In this regard, it can be stated that the hypothesis (H5) is valid as the obtained data and the literature supported the hypothesis. Table 21 contains the assessment of the hypothesis based on each data source, along with brief descriptive "evidence highlights" for each perspective.

Table 21 - Assessment of hypothesis 5

Data Source	Hypothesis Testing Result Based on Data Source	Evidence Highlights
ChatGPT	Valid	Acknowledgment of factors
Participants	Valid	Consensus on importance of way and timing of assistance
Literature	Valid	Confirmatory approach

H6: *The integration of LLMs into energy transformation is negatively affected by various challenges related to AI interpretability, trust, data privacy concerns, etc.*

ChatGPT and participants also agreed regarding H6. Both sides indicate that challenges, including AI interpretability, trust, and data privacy concerns, make the integration of LLMs into energy transformation difficult. Correspondingly, Meske and Bunde (2020: 55) highlight the 'black box' problem, where the complexity of AI models often leads to a lack of transparency and trust. In this context, Reyes et al. (2020: 1) emphasize that due to the presence of numerous hidden layers in AI applications, it can be challenging to comprehend the responses, which can lead to AI interpretability issues. Besides this, Martin and Zimmermann (2024: 1) indicate that the spread of AI presents both exciting potential for innovation and new concerns and challenges, such as issues related to privacy and bias. Hence, perceived challenges like AI interpretability, trust, and data privacy concerns among the participants have a negative impact, which makes the integration of LLMs into energy transformation more challenging. In this regard, it is possible to state that the hypothesis (H6) is valid, as the obtained data and

the literature supported the hypothesis. The assessment of the hypothesis based on each data source is summarized in Table 22, along with brief descriptive "evidence highlights" for each perspective.

Table 22 - Assessment of hypothesis 6

Data Source	Hypothesis Testing Result Based on Data Source	Evidence Highlights
ChatGPT	Valid	Aligned perspective
Participants	Valid	Approval of stated challenges' negative effects
Literature	Valid	Recognized challenges

H7: *Companies that adopt LLMs in energy transformation strategies experience improved energy transition implementations and fewer energy efficiency loss issues.*

It is possible to state that ChatGPT's statements aligned with H7. ChatGPT claims that the integration of LLMs could provide enhanced energy transitions and fewer energy efficiency losses. Correspondingly, the general perspective on the subject in the literature is in line with ChatGPT. In this regard, for example, Sun et al. (2021: 9) indicate that artificial intelligence has the potential to improve technological advancements in energy-saving and greener production, as well as knowledge development and dissemination, ultimately leading to increased energy efficiency. Similarly, a study conducted by Tomazzoli et al. (2023: 4951) states that the use of AI can increase energy consumption efficiency, lower pollution emissions, and prevent energy waste. On the other hand, while 3 out of 11 participants had opposite opinions about the effectiveness of LLMs in energy transformation as of today, 4 out of 11 participants had a cautious approach. They believe that it is too early to fully understand the impact of LLMs on energy transformations as the technology is still in the early stages. Hence, although there can be some positive effects of LLMs in this aspect, it is also possible to state that there are some doubts about the total contribution of LLMs in improved energy transition implementations and energy efficiency loss issues. In this regard, it can be indicated that the hypothesis (H7) is semi-valid as the participant insights partially supported the hypothesis. Table 23 contains the assessment of the hypothesis based on each data source, along with brief descriptive "evidence highlights" for each perspective.

Table 23 - Assessment of hypothesis 7

Data Source	Hypothesis Testing Result Based on Data Source	Evidence Highlights
ChatGPT	Valid	Optimistic for enhancements
Participants	Semi-valid	Cautious approach
Literature	Valid	Positive foresights for influence of LLMs

H8: *Companies that leverage LLMs enhance the organization's and decision-makers' knowledge base, resulting in a competitive advantage.*

ChatGPT shared answers supporting the relevant hypothesis (H8). According to ChatGPT, LLM integration not only enhances the knowledge base of a firm and decision-makers but also provides a competitive advantage. Similarly, participants agreed on the role and impact of LLMs in this aspect. If we evaluate the hypothesis within the context of the Knowledge-Based View of the Firm, it can be indicated that the implementation of LLMs can be a key strategy to enhance the knowledge base of the decision-makers and the firm, thereby supporting more informed and effective decision-making processes regarding energy transformation. The literature supports ChatGPT and participants as well, within the context of KBV. According to Raghunathan (1999: 284), a more in-depth understanding of the relationships between variables improves decision quality, thus highlighting the importance of AI as a new knowledge source to minimize complexity by foreseeing changes in the organizational environment and by presenting the need for new models for managerial decision-making. Hence, by improving their own knowledge base, decision-makers could better understand the relationships between variables for enhanced decision-making, which can result in a competitive advantage in energy transformation and market position for the organization. In this regard, it is possible to state that the hypothesis (H8) is valid, as the obtained data and the literature supported the hypothesis. The assessment of the hypothesis based on each data source is summarized in Table 24, along with brief descriptive "evidence highlights" for each perspective.

Table 24 - Assessment of hypothesis 8

Data Source	Hypothesis Testing Result Based on Data Source	Evidence Highlights
ChatGPT	Valid	Approval of the hypothesis

Participants	Valid	Recognized the competence of LLMs in this aspect
Literature	Valid	Aligned perspective

Table 25 summarizes the “evidence highlights” of ChatGPT, participant insights, and literature, respectively, for each hypothesis. Correspondingly, with the applied triangulation method, the overall hypotheses testing results are indicated in the “Results” column.

Table 25 - Overall hypotheses testing results

Hypothesis	Evidence Highlights (ChatGPT; Participants; Literature)	Result
H1: Large language models (LLMs) effectively assist and guide decision-makers in a decision making process.	Acknowledgment of assistance and guidance of LLMs; Some doubts and cautions; Recognized limitations	<i>Semi-Valid</i>
H2: LLMs improve decision-makers' ability to interpret and implement new energy strategies and regulations tailored to specific company needs.	Alignment with the hypothesis; Highlighting the restricted ability of LLMs in this aspect; Various challenges and obstacles for total integration	<i>Semi-Valid</i>
H3: LLMs foster ethical decision-making and promote personal growth among decision-makers.	Approval of the hypothesis; Mixed trust in LLMs in this aspect; Cautious approach	<i>Semi-Valid</i>
H4: The adoption of LLMs among decision-makers is influenced by organizational culture, AI literacy, and complementarity of human–LLM collaboration.	Agreement with factors; Recognized effects of determined factors; Approval of factors in adoption	<i>Valid</i>
H5: Human-LLMs collaboration is most effective when LLMs provide timely assistance and present information tailored to the decision-maker's cognitive preferences and task-specific needs.	Acknowledgment of factors; Consensus on importance of way and timing of assistance; Confirmatory approach	<i>Valid</i>
H6: The integration of LLMs into energy transformation is negatively affected by various challenges related to AI interpretability, trust, data privacy concerns, etc.	Aligned perspective; Approval of stated challenges' negative effects; Recognized challenges	<i>Valid</i>
H7: Companies that adopt LLMs in energy transformation strategies experience improved energy transition implementations and fewer energy efficiency loss issues.	Optimistic for enhancements; Cautious approach; Positive foresights for influence of LLMs	<i>Semi-Valid</i>

H8: Companies that leverage LLMs enhance the organization's and decision-makers' knowledge base, resulting in a competitive advantage.

Approval of the hypothesis;
 Recognized the competence of
 LLMs in this aspect; Aligned
 perspective

Valid

Based on the obtained results, it is possible to state that four out of eight hypotheses (H4, H5, H6, and H8) were fully supported, suggesting clear conditions and circumstances under which LLMs are likely to succeed. The remaining four (H1, H2, H3 and H7) were only partially supported, indicating important challenges and limitations still perceived by the participants and the literature. In this regard, for a precisely enhanced human decision-making, these challenges and limitations need to be addressed.

11 Conclusion

This study, which was conducted as part of the “enefit” project, supporting small and medium-sized enterprises (SMEs) in Mainfranken in implementing energy efficiency and decarbonization measures, focused on the role of LLMs in decision-making process for energy transformation of industrial and energy companies by examining the collaboration between decision-makers and LLMs, as their relation may play an important role for a sound decision-making.

With the literature review and practical examples of LLM usage, first of all, a comprehensive overview of the topic was conducted. In this regard, this helped better understand the possible contributions of the study to the literature and to better comprehend how an effective collaboration between LLMs and decision-makers can be achieved in real-world situations.

Within the scope of the research question, “How can interviews show the potential of LLMs to support decision-makers in energy transformation?”, the primary data for the study were collected through semi-structured interviews with eleven key decision-makers from selected industrial and energy companies in Germany.

It is possible to state that participants shared important insights related to the main objective of the study, which was to explore how large language models (LLMs) can successfully assist and guide decision-makers for decision-making in energy transformation. In this regard, participants underscored data security and quality issues as one of the main factors driving the adoption of LLMs among decision-makers. In addition to this, curiosity and conviction in technology, efficiency and productivity gains, organizational culture and change management, cost and perceived value, AI literacy and expertise, and generational and cultural differences were other factors highlighted by the participants as influencing the adoption of LLMs among decision-makers.

Within the scope of the circumstances optimizing the most effective human-LLMs collaboration, participants indicated that the presentation way of information and the timing of LLM-generated insights play an important role in an effective human-LLMs collaboration. Moreover, complementary nature of human-LLM collaboration, which highlights the importance of the need for human oversight and verification of LLM outputs; adaptability and customization of LLM usage, which includes tailoring LLM usage to specific tasks and user preferences; and importance of user experience and familiarity, which points out the need for user training and guidance on effective LLM utilization, can be indicated as other factors and circumstances for optimizing the best practices of LLM usage.

To be able to provide a comprehensive answer to the research question, the key challenges associated with human-LLM collaboration were also tried to be understood. In this regard, trust and interpretability issues, and data privacy concerns were significantly emphasized by the participants throughout the sessions. Lack of specificity and tailored responses was another challenge associated with human-LLM collaboration for the participants. They expressed that LLM outputs can be too broad or specific, lacking the specificity required for certain tasks or decision-making. Relying solely on LLMs for critical decision-making (without additional verification and research) and a lack of integration with company-specific data and systems (limiting the usefulness of LLMs) are other underscored challenges that should be addressed for successful integration of LLMs in decision-making for energy transformation.

To be able to evaluate the overall effectiveness of LLMs in energy transformation, the practical outcomes of LLM adoption on decision-makers and energy transformation were also questioned. According to a few participants, LLMs could provide improved energy transition implementations and fewer energy efficiency loss issues. Improved decision-making and analysis was also mentioned as a practical outcome of LLM adoption. Providing different perspectives and identifying new options, and automating repetitive tasks and freeing up time for more strategic decision-making were some other highlighted practical outcomes. Other participants, however, pointed out some challenges and concerns for the practical outcomes of LLM adoption. They highlighted the uncertainty about the actual impact of LLMs on energy efficiency, as the technology is still in the early stages. Concerns about over-reliance on LLMs, which could lead to a "dumbing down" of decision-makers, and the complexity of energy transition implementations, which may exceed the current capabilities of LLMs, were also emphasized by the participants as opposite views, and limitations and challenges for improved energy transformation.

In regard to the role of LLMs in expanding the knowledge base of a company and decision-makers, within the scope of the knowledge-based view (KBV) of the firm, participants believed that LLMs could help decision-makers and organizations acquire knowledge more efficiently and effectively, which could also provide a competitive advantage. It was also expressed that LLMs have the potential to

serve as repositories of knowledge, allowing organizations to store and access information more efficiently.

Another objective of the study was to explore how LLMs can enhance human capabilities in energy transformation by supporting decision-makers in interpreting and implementing new strategies and regulations tailored to specific company needs. It is possible to state that participants had a cautious approach towards the role of LLMs in this aspect in general. Within this context, participants highlighted that LLMs can offer guidance for initial research, brainstorming, and exploring new strategies or frameworks, and they can provide a broad understanding of regulations and market conditions in different governmental bodies and regions, but they should not be trusted 100% as the information they provide may not be accurate for such an aspect.

Finally, the study also aimed to explore how LLMs can not only improve decisions but also foster ethical considerations and personal growth, as LLM integration in sustainable energy systems raises several ethical issues that must be carefully considered. In this context, participants emphasized that LLMs cannot ensure ethical decision-making, as they are limited by the data on which they are trained. Their concerns about LLMs' potential for misuse or unintended consequences in ethical decision-making were influential in their views. However, participants had a common view on the role of LLMs in fostering personal growth. They indicated that LLMs can help them explore diverse perspectives, provide efficient access to information, and expand their knowledge, facilitating personal growth.

As a comprehensive assessment of the participant insights, it is possible to state that although the participants generally recognized the transformative potential of LLMs in the decision-making of energy transformations, their perspective also suggests that the practical outcomes of LLM adoption in energy transformation are still largely uncertain. Although some potential benefits are identified, significant challenges and limitations still need to be addressed. Only then can it be possible to enhance human decision-making precisely.

It can be indicated that the findings are largely in line with existing literature on factors affecting LLM adoption and circumstances influencing effective human–LLM collaboration. While aligning on many points, it is also possible to state that the study also uncovered a gap between LLM potential as described in the literature and LLM reality as perceived by the participants. In this sense, the participant insights, which position LLMs as a supportive tool rather than a sole decision-making authority, reveal that the participants exhibited greater caution regarding the effectiveness and reliability of LLMs compared to some of the more optimistic perspectives found in the literature, which position LLMs as a decision-maker in energy transformation.

After conducting the semi-structured interviews, to be able to address the research methodology successfully, query questions were then asked to the standard version of ChatGPT-4o, as the selected LLM for the study. By taking into consideration the limitations of ChatGPT-4o and the chosen methodology, it was aimed to obtain a better determination and evaluation of the realistic potential of LLMs in supporting decision-makers. Thus, by comparing participant responses with ChatGPT's answers, it was analyzed whether decision-makers' perception of LLMs' potential in energy transition differs from ChatGPT's own perception, for a better understanding of the competence and potential of LLMs in real-world situations.

The analyses throughout the study emphasized that decision-makers' perception of LLMs' potential in energy transition differs from ChatGPT's own perception. Decision-makers were far more cautious and conservative about LLMs' role in assisting them with energy transformation, despite ChatGPT's greater confidence and optimism over its capabilities and potential. In this regard, there were various conflicts and contradictions between the responses given by the participants and ChatGPT, such as ChatGPT's influence on speed, accuracy, and quality of decisions, and ChatGPT's role in fostering ethical considerations.

Based on the determined objectives, methodology, and theory and sensitizing concepts of the study, eight different hypotheses were introduced, each addressing different aspects of LLMs' role and effect on enhancing human decision-making. These hypotheses were systematically investigated and tested throughout the research by applying the triangulation method. In this regard, H4, H5, H6, and H8 were supported by ChatGPT answers, participant insights, and literature review. Hence, these hypotheses were found to be valid. Based on the obtained results, first of all, it can be indicated that organizational culture, AI literacy, and complementarity of human–LLM collaboration play an important role in the adoption of LLMs among decision-makers. In addition to this, it is possible to state that obtaining timely assistance and information tailored to decision-makers' cognitive preferences and task-specific needs are critical factors for the most effective human-LLM collaboration. Furthermore, it can be emphasized that issues and challenges related to AI interpretability, trust, and data privacy concerns have a negative impact on the integration of LLMs into energy transformation. Lastly, companies that leverage LLMs can enhance their organization's and decision-makers' knowledge base, which can also provide a competitive advantage for their market position and energy transformation implementations.

For H1, H2, H3, and H7, it is possible to state that ChatGPT, participants, and the literature could not reach a consensus. Yet, each hypothesis was supported at least partially and, hence, they were found to be semi-valid. Based on the obtained results, first of all, it can be emphasized that large language models (LLMs) can assist and guide decision-makers in the decision-making process; however, their effectiveness is limited by potential factors or obstacles that need to be overcome. In addition to this,

it is possible to state that LLMs could be partially helpful for strategy development and regulatory compliance, but they could not be the sole decision-making authority or a 100% trustworthy source in this aspect. Furthermore, it can be indicated that LLMs may foster ethical decision-making and promote personal growth among decision-makers, but only partially, as LLMs are based on the datasets on which they are trained. Lastly, companies that adopt LLMs in energy transformation strategies can experience improved energy transition implementations and fewer energy efficiency issues, but only partially, as the technology is still in the early stages.

Based on the conclusions drawn from this study, the following direct and actionable recommendations are put forward for practitioners and policymakers, which summarize when and how LLMs should be used, under which conditions they are most effective, and what risks should be managed, for an effective human-LLM collaboration:

- (1) To be able to ensure effective decision-making processes through the complexities of energy transformation implementations, an appropriate balance between human expertise and AI-generated insights should be provided. In this regard, LLMs should be used as a supportive tool rather than a sole decision-making authority, in which LLM-generated decisions are verified and validated by human oversight.
- (2) Companies should gradually explore and experiment with LLM capabilities to identify suitable use cases in energy transformation implementations. In this regard, LLM adoption should follow a phased approach, beginning with low-risk use cases and progressing toward more strategic applications as trust and literacy for LLMs grow.
- (3) Companies should maintain the configuration and customization of LLMs and ensure the accuracy of these models through strong review, monitoring, and governance. Because LLMs are evolving rapidly, their impact should be evaluated over time. In this regard, companies should engage in longitudinal tracking of LLM usage and outcomes.
- (4) Timely and tailored LLM assistance provides an effective human-LLM collaboration. In this context, it should be ensured that LLM insights are provided at the right time and level of detail. Thus, companies should focus on enhanced prompt engineering and provide courses and training for decision-makers to acquire reasonable LLM responses.
- (5) Ethical and compliance inspections should be applied to maintain ethical considerations and regulatory compliance before integration into high-stakes decision-making processes. In addition to this, trust and data privacy should be secured through transparent use and legal data privacy protocols, ensuring robust decision-maker-LLM collaboration.
- (6) Collaborative approach of all organizational levels (e.g., decision-makers, technical teams, and executives) should be maintained, as a successful LLM adoption requires alignment across all

organizational components. In this regard, open communication between all organizational levels should be promoted to maintain successful LLM integration into human decision-making.

For a valid and proper evaluation of the applied methodology, findings, and presented recommendations, the limitations of the study must also be taken into consideration. To start with, the study had a specific industry focus. The data and findings are primarily based on the industrial and energy sectors, which may limit their generalizability to other contexts. Besides this, the research field of the study is restricted to Germany. It should be taken into account that the outcomes of research studies conducted in other regions and countries may yield different findings. Moreover, as the interview sessions were conducted with eleven participants, increasing the number of participants in further studies may yield different findings as well. The rapidly evolving LLMs landscape could also be indicated as a limitation of the study. As LLMs are evolving rapidly, with continuous improvements in their capabilities, the insights obtained in this study may become outdated as newer, more advanced models are introduced, potentially altering how decision-makers use LLMs in energy transformation.

By recognizing and addressing these limitations, further studies can be conducted within this study context. In this regard, by tracking the adoption, evolution, and impact of new LLMs in human decision-making, longitudinal studies on LLM-decision-maker collaboration can be conducted. This could help identify trends in LLM capabilities, shifts in decision-makers' reliance on LLMs, and emerging challenges that arise with new LLM developments. In addition to this, by delving deeper into the ethical side of LLMs and investigating how policymakers and regulatory bodies can ensure fair and responsible LLM usage in energy transformation, it could be more specifically focused on the ethical and regulatory aspects of LLMs with further studies. Furthermore, studying the integration of LLMs with other emerging technologies could enable an exploration of how LLMs can interact with other AI-driven technologies, such as predictive analytics or digital twins, to enhance decision-makers in energy transformation implementations. Finally, by expanding the research field and sample size, a larger and more diverse sample of decision-makers across different regions and industries can enhance the generalizability of the findings.

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Appendix A

INTERVIEW 1

Mr. P1 thank you for taking the time to participate in this interview session.

My name is Mehmet Çelik, and I am currently a master's student at the Technical University of Applied Sciences Würzburg-Schweinfurt. With my supervisor, Prof. Scheller, I am conducting a research study, which is "Enhancing Human Decision-Making in Energy Transformation of Industrial and Energy Companies by Leveraging Large Language Models".

The aim of this interview session is to explore your insights and thoughts on large language models and their role in your decision-making and strategy development processes regarding the energy transformation of your organization. Your perspective and insights will help us to better understand the interpretation and implementation of LLMs in those processes.

With your consent, I would like to record the conversation to ensure accuracy in capturing your insights. Please be assured that your and your organization's anonymity will be protected, and your and your organization's names will not be mentioned in any of the reports or presentations. All information will remain confidential and will be used strictly for academic purposes.

Please feel free to bring up anything that a question reminds you of, or anything you think is relevant. Also, you don't have to answer any question you don't want to.

P1: Okay, sure.

Interviewer: First of all, Mr. P1, can you briefly explain your role in the company and especially your involvement in the energy transformation projects?

P1: My role in the company is technical project manager. I am a technical project manager in the development of projects in the field of home and distribution, which is called for homes, buildings and factories, to implement applications there. We produce and develop energy-saving lighting elements such as Dimmer and I am in the planning and projecting of these products.

Interviewer: Okay thank you. Mr. P1 do you think artificial intelligence, particularly large language models (LLMs), have a transformative potential for your company and broader industry?

P1: Yes, definitely. With the increasing importance of AI day by day, I think they are a transformative milestone for sure.

Interviewer: Thank you. First of all, our first sub-theme is about the impact of large language models on the decision-making process. Mr. P1, are you currently using large language models to support your

decision-making process in your company's energy transformation projects? Which specific large language models do you use?

P1: If we mean language models like ChatGPT and similar ones, I, as a design and development manager, do not currently use large language models at the moment. But as far as I have observed, large language models are useful in preparing, designing and placing circuits and elements. I have learned through my own special research that LLMs can have some benefits for the information to be provided about which component will be compatible with which component visually, which component will be closest to which component in terms of heating and how far away it will be.

I plan to include these LLMs in our work over time. I can say this.

Interviewer: So, how do you think the use of large language models can affect the speed, accuracy and quality of decisions made in your energy conversion projects, if you use them?

P1: As I said, I think designs will be faster. After all, we use small equipment, small components and we work on an electronic card that is large enough to be placed in sockets. Naturally, our work space can become problematic sometimes.

Since the products we use are energy management products, it will of course be to our benefit to bring them to life more quickly, in a more time- and market-appropriate manner, at a time-to-market speed, and I think these language models will be useful at this point.

Interviewer: Thank you very much. Secondly, I have two questions about the LLMs' role in strategy development and regulatory compliance. In your experience, how do LLMs can assist in interpreting and implementing energy strategies and regulations tailored to your company's needs?

P1: From my perspective, when determining the amount of energy used and consumed during stand-by or while working, frankly, instead of scanning the resources on the internet in detail, I can find my answer when I ask a question to ChatGPT about what the energy consumption value in stand-by should be in a more practical way. This is to my benefit.

I can continue to do research at length to reach that result and answer later in the process, but I can speed up by using ChatGPT at the beginning of the design.

Interviewer: Thank you. In this regard, do you feel LLMs can provide clear and accurate information for successful regulatory compliance and strategic planning?

P1: I don't think so 100%. Of course, no information can be 100% accurate, but I think it adds speed right now. I don't think it would be healthy to rely on a tool 100%. Because the work we do ultimately affects people and if we fall outside the standards, it can cause production costs to be wasted and market losses in our products, so I don't trust it 100% and I use it as a support.

Interviewer: In the context of the effect of large language models on ethical considerations and personal development, do you believe that the use of LLMs can help promote ethical considerations in developing and implementing energy-related strategies?

P1: If you ask questions like by taking into account ethical considerations, it can also give answers according to ethical values. Therefore, I think it will be helpful. Because its infrastructure works on the input we give, I think it will be useful.

Interviewer: My second question in this sub-theme is, do you believe that the use of LLMs can help decision-makers explore diverse perspectives for their personal growth?

P1: Yes, I do. Because the inputs I give can open up more vision when I ask. In any research, the inputs I give outside of my job can also expand my thoughts.

For example, when I ask ChatGPT what to comment on the rating message that I give to my teammates while doing the year-end evaluations, the answers that it gives me broaden my horizons and allow me to write clearer, more beautiful, and more appropriate comments about them. At the same time, the answers we receive in return for the questions we will ask for design will also help develop the design vision.

Interviewer: Thank you. In the context of factors influencing the adoption of LLMs, what factors influence your decision to adopt or not adopt LLMs in the energy transformation projects?

So, what might be the reasons for your company to use these large language models in the future?

P1: Speeding up work. We are currently actively using AI Q&A on Teams. We get help from there and I think our company's managers have integrated these language models because it speeds up work.

Interviewer: In this regard, how do you think your organizational culture and AI literacy influence the adoption and use of LLMs?

P1: So if people in the management team improve their literacy, they will also affect the corporate culture. Naturally, the benefits will be positive.

Interviewer: Ok thank you. Regarding the circumstances optimizing the most effective human-LLMs collaboration, in your experience, does the way information is presented by LLMs (e.g. reports tailored to your cognitive preferences and task-specific needs.) impact your ability to make effective decisions?

P1: I think yes, and the impacts are positive. Ultimately, it presents you with conceptually processed information that you cannot think of at that moment but that needs to be considered in the database. I think this also has benefits in terms of decision making.

Interviewer: How does the timing of LLM-generated insights affect their usefulness in your decision-making processes? That is, do you want to use a language model at the beginning or end of your decision-making process, or throughout the process, or only when you need it?

P1: The times I need it are starting to increase over time. I plan to continue using it at the beginning, in the middle and at the end, as I see that my ideas mature and become more diverse when I do Q&A with ChatGPT.

Interviewer: With the focus of the challenges of human-large language model collaboration, what challenges have you encountered in collaborating with LLMs, particularly regarding interpretability, trust, or data privacy concerns? What were their impacts and what strategies or solutions have you considered to overcome those issues?

P1: I have great concerns about data privacy, but I don't have great power to prevent it. When using language models, the inputs you provide can be used for market research rather than stealing your data. Especially the fact that the phrases used in Google searches or the topics you talked about can be recorded on the phones with the voice command system and can be processed as data and then can be sold. This shows companies where you are in the market.

This risk is not in a way that will cause you trouble unless you give very confidential information, but other than that it is useful for market research and companies. I don't care much.

Interviewer: Okay, thank you very much. In the context of practical outcomes of LLM adoption on energy transformation, have you observed improvements in energy transition implementation or reduction in energy efficiency loss after adopting LLMs? What were the other practical outcomes of LLMs adoption?

P1: I haven't observed a decrease since we are just starting. But I think we will observe a decrease. In other words, I think we will observe a decrease in energy efficiency loss.

Because I believe that we can reduce energy efficiency loss more quickly as we implement faster solutions and faster products.

Interviewer: Thank you very much. Finally, LLMs' role in expanding the knowledge base of the firm and decision-makers, how do you think large language models can help your organization and decision makers enhance their knowledge base, particularly in the context of energy transformation?

P1: I don't have a very clear view on this. It's more about things that management can think about, things that they can give their heads to. I can answer that way.

Interviewer: Okay, thank you very much. Finally, as a closing question, is there anything else you want to add that my questions have not addressed?

P1: We talked about the impact of large language models or artificial intelligence solutions in business life in general. I think you asked very valid questions. Thank you.

Mr. P1 thank you for your valuable insights today. Your contributions will help shape the research in understanding how large language models are being integrated into decision-making and strategy development regarding the energy transformation of companies. If you have any additional thoughts later, please feel free to reach out. Thank you again for your time.

P1: Thank you bye-bye.

INTERVIEW 2

Mr. P2 thank you for taking the time to participate in this interview session.

My name is Mehmet Çelik, and I am currently a master's student at the Technical University of Applied Sciences Würzburg-Schweinfurt. With my supervisor, Prof. Scheller, I am conducting a research study, which is "Enhancing Human Decision-Making in Energy Transformation of Industrial and Energy Companies by Leveraging Large Language Models".

The aim of this interview session is to explore your insights and thoughts on large language models and their role in your decision-making and strategy development processes regarding the energy transformation of your organization. Your perspective and insights will help us to better understand the interpretation and implementation of LLMs in those processes.

With your consent, I would like to record the conversation to ensure accuracy in capturing your insights. Please be assured that your and your organization's anonymity will be protected, and your and your organization's names will not be mentioned in any of the reports or presentations. All information will remain confidential and will be used strictly for academic purposes.

Please feel free to bring up anything that a question reminds you of, or anything you think is relevant. Also, you don't have to answer any question you don't want to.

P2: Okay, sure. No problem

Interviewer: Thank you. So, Mr. P2, my first question will be about some introductory questions. Can you briefly describe your role in the company and particularly your involvement in energy transformation projects?

P2: Sure, so I started as a single project manager, so basically I was combining solar PV with battery storage to the grid connection. So basically it means to decide the technology to install, how to couple

the two technologies and how they're going to function together to grid signals, okay? And then I was made a team lead, so basically I have like people who are following me doing the same stuff and now I'm teaching them how to do it.

So from conception and design of the projects until connection to the grid and then the problems or liabilities that came after this position. So for example, signal interpretation, humidity on the batteries, discharge cycles, that's all of it. When you are in operation, it comes with more problems than actually just connecting projects because it's a new technology, it's a new coupling, so it's something that the industry were like getting used to it, you know?

So yeah, that's what I do now and I do it in, I started here in Germany, then I developed in Spain, Canada, Finland, Colombia and yeah, some projects that I help a bit, UK, but like they're all different, so they all depend on their like their regulation and how these concepts are going to be applied. So for example in Finland, I mean I'm developing wind plus battery because you don't have sun in Finland, right? So in Canada it's similar.

Also battery standalones and how they operate to the grid is something that I have to do a lot, basically studying the markets, right? So when are the price reductions occurring and how a future operation of a battery will happen, you know? So that's what I do.

Interviewer: Okay thank you so much for your answer. My second question do you think artificial intelligence particularly large language models have a transformative potential in the future for your company and broader industry?

P2: So it's a great question, but here I'm going to try to be cautious on my answer, right? So it has a great use useful for how to say it, to automatize some of the meaningful tasks. So like finding concepts, aligning on terms, like finding laws, etc, right?

For example, automatizing emails that you need to go for the municipality, something trivial, you know? But then out of a sudden you're just looking for sources for your own electrical design and then you have between AI different answers and then you need to research more to actually see which one is the correct one. So AI by itself by now is something useful but you still need to research a lot to them to find out if that is the correct answer or not.

Because AI can just code read it and then if someone you just like take it for granted, you could make a massive mistake. That is not what you want, you know what I mean?

Interviewer: Yes. Okay thank you so much. Regarding the session I have eight sub-themes. So for each of them I have one or two questions. My first sub-theme is LLM's impact on decision making process.

So, Mr. P2 are you currently using or strategically planning to use large language models such as chat GPT to support your decision making in your company's energy transformation processes? Which specific LLMs do you use?

P2: So right now, yeah, we're using ChatGPT. I use ChatGPT and I use Copilot a lot.

So Copilot is not my favorite, but it is the one that is granted by the company. So if they're all using like all the office products, IT just trusts Copilot more because it's less intrusive, I imagine, but I have no idea, right? So I check my data with ChatGPT perplexity, use ChatGPT 4.0, but I use it too, but in my personal phone, but in my office computer, the only one that I have access to is Copilot, you know?

So like, and you use it for finding terms, meaning or like conversion of units or analysis of prices development, for example, that's really a good one. But as I said before, we use it with caution. So, because a lot of the answers, we have found some of the answers that are like, we already know that that's not true and the engine just give it to you out of a sudden, just searching in Reddit, for example, or a nine-gag answer that you're like, this is clearly not true, you know?

So, but yeah, we have used it and particularly in the office, they just only allow you to use Copilot, but personally I use ChatGPT more.

Interviewer: Okay thank you so much. So how has the use of LLMs influenced the speed, accuracy, and quality of decisions made in your energy transformation projects?

P2: So basically, so you are faster searching for like information, but then you lose a bit more time to research if that's correct or not. So it's a mix so for example, if I have to like, just writing down like a really professional email and I write it down in English and I need to translate from Hungarian, for example, for a municipality in Hungary, yes, that's accurate to give me a head start in speed.

So trivial task for sure, but accuracy and quality, I will say that it's not that much, you know, like, so it depends on what you're searching, right? So if it's common knowledge, yes, but if it's not, it's something that it takes you an extra time to actually just research more, you know what I mean?

Interviewer: Yes definitely. Thank you for your answer. And regarding large language models' role in strategy development and regulatory compliance, my first question is in your experience how do LLMs assist in interpreting and implementing energy strategies and regulations tailored to your company's needs?

P2: As I said before, they don't assist you in this, they assist you in trivial tasks that it can be done by a machine without a human processing. So now, so if you're trying to found your technical decision on a scientific basis, you need data. So, and it depends on which artificial intelligence you are using, like which data source they're using.

So, and part of your job as an engineer is to compare different data sources and check which one has the validity for So, in this one, I will say, like, the LLMs have not assisted me in interpreting or implementing energy strategies. They just like help me out to like get out of my brain, something that like it just consumed brain power that is not necessary, you know, so it's not tailored, sorry to answer this way, but this is the truth. You cannot trust it 100%, right?

So for example, like imagine in Germany, in Germany, the majority of the municipality documents are like a JPEG, and then you need to like transform it to an OCR and then maybe translate it if you don't like understand the term. But yeah, so like an AI will not like help you with this, right? So, but if the databases are like universal and public access, I think the AIs will do better.

But until now, because you have like this, like difference in sources, the AIs are not that accurate right now, specifically for the energy strategies, right? So, the energy strategies, it depends on in what part of the chain are you? Are you a developer?

Are you an investor? Are you an NPC? So, you will have like different uses in these different components.

But I am betting that the majority of the users are like just trivial tasks for avoiding to consume brain power, to use that brain power something that you actually need to think about it. So, a strategy is more about like implementing a vision, and then using politics to it. So, you need to convince a manager that your strategy makes sense, because it will bring benefits to a company.

And that a machine cannot do it easily, if you know what I mean, right?

Interviewer: Yes exactly. so this was I think your answer for the second question so I think you don't feel exactly like they provide right now a clear and accurate information for successful regulatory compliance and strategic planning.

P2: Yes. So, do you know what? It depends on which AI are you using. You have like some of them that their engine are more appropriate to a task.

For example, you have the dvlp.de that is using an AI engine for geographical maps, right? So, and then it helps you to have a head start to just find like an injection point. And then you find it, and then you like see the surrounding area and see how you can connect a power plant, for example.

But it's not that it's accurate, the information. And it's not clear. It's just something that it just gives you a head start.

So, you can start doing your job without actually thinking about the previous step, but it's just meaningless. You know what I mean? So, before you have to like do Google Maps or like go to the municipality map that is really 2D and then imagine the topography.

So, like some of the steps, sure, you're getting ahead because of AI, but you need to be really careful in how to interpret the information.

Interviewer: Okay thank you so much and regarding the third part LLMs impact on ethical considerations and personal growth, my first question is do you believe that the use of LLMs can help promote ethical considerations in developing and implementing energy-related strategies?

P2: I understand the question. It's a complex one. So, that's why I'm taking a moment to answer you.

Mm-hmm. So, at least in Germany, you have like a really strong data privacy, right? So, the AI, they don't have access to it.

They clearly cannot access this database. It's really hard for them to do it. And the majority of the time when they attempt it, they fail.

Or they have like mixed information between pairs, so it's not accurate. So, I don't know. I'm having trouble to find an ethical compromise that will have to do with AI, to be honest, because it's available for everyone.

So, the only one that I will do is like, okay, so I'm taking advantage of a system who my competitors don't have access to it, but they have access to it too. So, I'm just like being prevented into trying to learn in advance so I can advance my efficiency, you know? So, but in this regard, I have troubles to find an example that this question can be applicable, to be honest.

Interviewer: Okay then thank you so much. My second question is, do you believe that Mr. P2 the use of LLMs can help decision-makers explore diverse perspectives for their personal growth?

P2: Well, this is clearly a yes for me, at least. I have so much access to summary of the information, for example. I have a really long, I don't know, TED talk, and then it's an hour and a half, and I don't have the time for it, right?

So, and then you just put it in scholar.io, and then it just gives you a 10-point summary, and you're like, oh, I get it. I agree or disagree, you know? So, this one, it shoots your personal growth massively because you can learn something that you didn't know before in a way faster manner.

So, imagine that I don't want to become an expert in a particular topic. I just want to have a notion of how this research is going because it could be helping me for making an argument. So, I don't need to see like an hour and a half TED talk.

I just need a bullet point of like two slides, and oh, yeah, now I get it, you know? So, in personal growth, at least me, it has helped me a lot. So, I just, before I was always like the senior technical guy who was

like making the drawings, making the projects, and then going and fixing the problems and whatever, and I was doing that, right?

So, until at some point, I was requested to become a team lead and trying to guide others to do what I do, right? So, like age comes to you, to all of us. So, at some point, you're getting a little older, and then your managers are telling you, hey, now it's time that you start teaching.

So, we like secure the level of engineers for the next generation, you know? So, and that's a personal challenge that at least me using AI, it was really helpful to try to read through a massive amount of information about the topic. So, I can interiorize it faster.

So, I can like actually like use techniques of team leading that are effective, or what works and what doesn't, or actually setting my own goals of what kind of leader I wanted to become. So, I wanted to become someone who actually is helping the new engineers or the young engineers to advance in their careers. I didn't want to be this kind of like the bossy type, but I was always like micromanaging.

And using AI to research about the topic, it helped me a lot to understand and read it through so how to achieve those goals, you know? So, in terms of personal growth, I totally agree. I think the use of AI have helped me to become a better team lead.

Interviewer: Yes. Okay. Thank you for sharing your answer. And the fourth sub-theme is factors influencing the adoption of LLMs. Mr. P2 what factors influenced your decision to adopt or not adopt LLMs in your energy transformation projects?

P2: Look, in every company, you have like young, mid-age, and really old guys, you know? So, the guys who are young, they adopt something super fast. And it happened to me when I started my career.

So, I adapted to like codes or like coding really fast because I can read it. But the older guys did not have any idea about this. And now, I'm reaching kind of like the middle age in my career.

And now, I'm feeling that like the young guys can see Python and for them, it's just kind of like, sure, yeah, I can do this and blah, blah. And I'm like, that's impressive. And then, imagine how is it for the old guys?

So, like you always have to have this consciousness of like which generation you're working on. So, for a guy who is like 57 right now, they're not thinking about learning new things. They're just thinking about retirement.

And they rely on the younger ones to explain to them the results, you know? So, which factors? Age, for sure.

And the second one, I think, is attitude. Like a lot of engineers are really close to new things, especially the German ones. The Germans are really tough and change, you know what I mean?

So, if you want to explain like, I don't know, a 50-year-old, 55-year-old engineer, German engineer, that now we're improving the process because of X result that we have in AI that is showing us that it's better, it's going to take you a while, for sure. So, I think it's about attitude of how to acquire knowledge.

That's the second factor, if you know what I mean.

Interviewer: Okay, thanks so much. Second one, so do you think also the organizational culture and AI liter is other factors maybe that influence the adoption and use of LLMs?

P2: Yes. So in a smaller company, if you work for a 200 employees company, changes are faster. IT is not that, like, pendant of these little issues or little programs that you're using in day-to-day life.

But once you become like a mid-range organization, IT is way more pendant for cyber attacks, you know? So they are more protective about what are you installing in your computer. So when you're doing this, like, okay, I found this magnificent AI that is doing specifically what I want to do at this specific moment.

And then you click download, and then it says, like, blocked, blah, blah, firewall doesn't allow it. And then you need to talk to IT, and then your manager needs to approve it. And then they say, no, you need to fight it.

It's a long process, you know? But if you're in a 250 employee company, you have one IT guy that you go to his desk and say, like, hey, dude, please tell me this, it's like, sure. So the organizational culture, that's why I mentioned it, because it changed between how big your company is.

And then the second one is, yeah, so a lot of companies have, like, these data protection issues in their mind. So they're saying, oh, there's no way that it's going to be for free. So I'm giving them something because I'm pressing this button, you know?

And then they're afraid that big brother is watching, and then they can steal their information and whatever. But, like, I understand the feelings, but it's kind of, like, slowing the progress for sure. Like, especially in engineering design, because if you have a lot of AIs right now in electrical design, that makes your life easier.

And then you can review the result and just adapt a bit at the end, right? But the majority of the old school guys who are approving the design are like, oh, but it's so much change. So the old guys will say they want to be involved in the decision making of the design because of ego, you know what I mean?

Like, so, oh, I also designed this, it was not you, young one. I am not that way. I'm not that way.

Like, if a junior engineer just came with a magnificent design, I give him credits, like, yeah, and I didn't have to do it. So good. So, but I've seen all the engineers being a little cranky about this and just ego driven by their involvement on the projects.

Interviewer: Yes, ok thank you so much. Regarding the fifth sub-theme, in in terms of circumstances optimizing the most effective human-LLM collaboration, Mr. P2 in your experience, does the way information is presented by LLMs (e.g. reports tailored to your cognitive preferences and task-specific needs.) impact your ability to make effective decisions?

P2: For sure. Yes. So, do you remember that I talked to you about one that is using an AI engine to analyze the geography of a location, for example?

Like, if you present that in words, I will not be able to see it. But since that GUI is presented to me in a visual way, I can actually see, oh, this is correct or this is not. Yeah.

So, that's one example I can give to you.

The other one is, like, design, right? So, it depends on the user you're going to use. So, you're saying reports tailored to cognitive preferences, right?

So, like, I will use a different AI engine for the task that I have during the day. So, if I have to write an email, I will just put in copilot, man. So, like, hey, answer this email with these three brackets.

Oh, perfect. Yeah. And then I fix it, right?

Yeah. But if I have to do something more meaningful and it will have more impact, I will choose wisely which one I'm using, depending on how the information is presented to me in that engine specifically.

Interviewer: Yes. So, that's an interesting answer. Thank you so much.

So, how does the timing of LLM-generated insights affect their usefulness in your decision-making process? So, maybe do you prefer to use while making a decision at the start of the process or maybe at the end of the process or during the whole process. So, how does the timing of LLM maybe affect your decision and decision quality?

P2: I use it as a tool. So, it depends on the situation that I'm against it. I will use it or not.

So, I told you, like, land is really at the beginning. And an email that is really tailored to a client is at the end of the project. So, like, which one and at what point, it depends on the application and the problem that I'm trying to solve.

So, I'm an engineer. So, I'm just trying to use the tools that I have at my disposal in the most efficient way possible, right? So, I just wanted to work less and go home as fast as possible, you know?

So, like, whatever I can do to make it faster and make my day go less stressful, I will use it at any point of my projects.

Interviewer: Yes. Okay. So, regarding the challenges of human-LLM collaboration, what challenges have you encountered in collaborating with LLMs, particularly regarding interpretability, trust, or data privacy concerns? So, What were the impacts and what strategies or solutions have you considered to overcome those issues?

P2: Yeah. It's a long question. Okay.

So, challenges, I explained it to you. It's, like, accuracy and reality of the answer that you need to be careful with.

Interpretability. Imagine you're asking an AI to interpret a law, and it depends which one you ask. If you ask Gemini, it will be completely wrong. If you ask Copilot, it will be kind of, like, center, like, a really soft answer, whatever.

If you ask Leo from Brave, it will just search the web for it. If you ask Perplexity, I think it could be more tailored, but it could also be wrong, too. So, accuracy or trust in that is something that I would like to see an AI who is quoting.

That's why I like the one in Brave, because Brave is actually giving you a summarized answer, and then at the end, it's saying, like, yeah, my answer is based on, like, these three articles. And then you can ask it to actually direct it to a scientific article, a peer-reviewed article, who is pointing out to your answer. And then you can read that article directly and say, like, okay, this guy is right, this guy is wrong, and you can debate with your own ideas, you know?

So, the trust, I think, is depending on how you're quoting your answer is important. Data privacy concerns, I'm not concerned about this, because, at least in Germany, because the AIs don't have access to it. Yeah, and as I said, I think knowledge should be shared, so that's why we advance faster.

The same way I'm asking, like, Leo, the Brave AI, Leo, and it's quoting me some answers from other scientists who are, like, thinking differently or like me, and I can read that answer and brought my own conclusions. That's science, right? So, like, hypothesis, we test it, and then we, like, see if it works or not, you know what I mean?

Like, so, I think, like, sharing information is something that we should do as much as possible, and more data that we have publicly, it will make us better to advance in the energy transition faster, right? So, and I think AI is helping through it, so that's why, for me, the data privacy concerns are not an issue, because I think we should, like, share all of this data that we have about the energy platform that we're using, right?

Interviewer: So, what were their impacts, and what strategies or solutions have you considered to overcome those issues?

P2: I, well, okay, so, the impact is, like, yeah, you have, depending on the AI that you use, you have, like, a different answer, and then you will need to have the mental capacity to process that and actually just compile all of the quotes that you're getting and decide by yourself if this is scientific-based or not, if it's logical or not, right? So, you have some interpretation or some additional research after your AI answer about a topic, right?

I think it would be great that AI's engines are also conscious about which information is being displayed. So, for example, if I search, okay, so, it's the same when we have Google, or you use .go, for example. If you're searching Google, like, a medical thing, right?

So, that has an implication, and then it's telling you, I don't know, like, vaccine are bad, and then you find, like, I don't know, 15 results of it, and then you have, like, 1500 results of the opposite. Like, the AI should show you in some way, hey, okay, your question is implicit going to this answer, and you have, like, 15 sources of it, but the real answer should be this one, that you have, like, I don't know, 2000 other sources that, like, give the opposite idea, you know what I mean? So, if the AI engines have the ethic to actually show this in a proper way, not directed to the question, I think that's the way that we should advance in these engines.

That's my opinion, at least.

Interviewer: Thanks so much. In the context of the practical outcomes of adoption on energy transformation, Mr. P2, Have you observed improvements in energy transition implementation or reduction in energy efficiency loss after adopting LLMs? What were the other practical outcomes of LLMs adoption?

P2: Well, so, it's a great question. That's why I'm pausing. Just give me a minute to collect my thoughts. So, AIs, they use data centers, but they're really energy intensive. Right now, Europe is just reacting to it. We are just saying, oh, the data centers are coming, and then we need, we're going to have a surge in energy, blah, blah, blah, etc.

But I think the same guys who are hiring the data centers from the AI platform, they should be conscious about energy efficiency in their buildings, how to make them more efficient in their location, instead of trespassing that responsibility to us in the development world. Because if they're conscious about this, their building that have the data centers and all the IT infrastructure to run the AI, the owners of the building or the land, they will probably install renewable power in their buildings to make it energy efficient. And they're going to install a thicker cable that is going to have less losses, it's going to cost a little bit more.

But in the long run, you're going to have less operation costs in energy. So, if the guys who are hiring the service of the data centers are conscious of the beginning what to hire, you will create the product that is actually going to be more energy efficient. So, what is the impact of AI?

It's that you're going to consume energy. Be conscious how your source of energy is going to be. If you're conscious, I can provide the product that can solve your problem.

And we can advance together on this. This is not something that you can just point the finger to just one industry. I think it's something that we should come together to provide something that it will be not as energy intensive as we thought at the beginning.

And then, how have you seen improvements in energy transition implementation? So, basically, the improvements is that now even the guys who are offering the data center services, they're saying, oh, I'm going to pay so much for energy because I have a constant peak during the day. So, I have 50 mega straight, I'm not burying the energy during the day.

So, this is good because they're saying, oh, okay, so it makes sense to install solar plus battery in my location. And then, I will have a constant self-consumption scheme that it will reduce my energy cost. And what does it go is because if you have a self-consumption on the spot, the energy price that they are going to pay for the energy is going to be 30 euros per megawatt hour, maybe 40.

But if they go for the grid connection, they're going to pay 250 euros per megawatt hour. So, and then from the grid, this high intensive energy consumption, it costs transmission lines and infrastructure and land and et cetera, et cetera. So, you have an avalanche of effect of just getting it from the grid.

So, if these guys from data centers are being conscious about installing renewable power in site, they will have less operative cost in energy and they will help the planet. And being energy more effective and efficiency, the efficiency loss will be better too, right? So, and this is a practical outcome that it needs to come from every stage of like the participants of this industry.

So, I'm an energy provider, I can install an energy plant, but I need your money. I need the money to actually install the renewable plant. Because if I don't have it, how can I install it?

I need to buy materials, you know what I mean? So, I think it's a compromise between all the actors on the chain. You know what I mean?

Interviewer: Yes definitely. Thanks so much. Mr. P2, my last question is LLM's role in expanding the knowledge base of the firm and decision-makers. So how do you think, Mr. P2, LLMs can help your organization and decision makers enhance their knowledge base, particularly in the context of energy transformation?

P2: Yeah, I think massively. So what the AIs do really great is to scan the web for specific examples that you're looking for.

So I will put you a situation, right? So I did my thesis, my master's thesis, I did it in combining wind, PV, and battery in one injection point. I did it for self-consumption, but my conclusion was like, you should do this for the grid injection too, right? And then one part of my job when I joined Apple was to actually convince the others that we should combine technologies in one injection point, right? So and then one director just asked me, he's like, oh, but no one is doing this, blah, blah. And just on the spot, I just like went to Copilot and went like, hey, can you give me examples of like companies who have like combined PV, wind, and batteries in one single injection point? And I had five in five seconds.

And then I told him like, are you sure? Because I have like five examples in front of my computer. Oh, I don't believe you, blah, blah. And I just show it to him and just click on the example of the competitor.

And he was like, oh, wow, this is something that we should do. So enhancing the knowledge base is particularly advanced because you can like find specific information you're looking for in a summarized way that it can be processable faster than before. This research will take me, I don't know, maybe two, three hours to actually compile all of this information, but I give him five seconds.

That's why I think it was a good example, right? So enhancing the knowledge base to decision makers, I think absolutely. And then I think the energy transformation also is really good about, for example, getting public available data that is easily to like, you can check it easily. For example, give me the highest price of last day in euros per million hour in Germany.

Like it was 150 euros per million hour. What time was it? It was at six. Oh, so see, and I can show it faster, you know, like so.

The other example I told you before about like expanding your own knowledge about applicable models of leading people, how you can transfer knowledge faster to them, having which attitude, how to solve a conflict that someone doesn't like you. And then you research about like, okay, how to deal with that at work. And AI will give you like a summarized version that you can process faster.

You will need more research later, but at least you have like an initial thought that you can start on, you know? So I give you other examples too. So electrical design, geographical locations analysis. And I would love to have like more an AI that is like doing congestion analysis per station, you know, like that will be sweet.

I haven't found it yet, but I think they're going for it soon. So, you know what I mean? Like, so, but yeah, I think like knowledge, like in haste, the knowledge basis has been a ginormous help, at least for me, like that I'm adaptable to new technologies, but like, and I'm trying to like preach to the older colleagues that it takes time for them and I'm fine with it, you know?

Interviewer: Okay. I want to thank you so much. And that was it. Is there anything else maybe you want to add that my questions have not addressed or how do you want to make a conclusion?

P2: I think like some meaningful tasks are now done by AI easily. Before you need a secretary, for example, and now you can just like press two buttons and then some of that job is done, right? I would love more advance on AI, on graphical showing of data instead of just words, you know, show me the evolution of the price in Germany, lower and higher per day, for example, and then show you like a picture of the spread.

I mean, it will be fantastic. I already have my answer, right? Instead of like me thinking about the formula and doing an Excel and then like download the database and then figure it out how to show it properly, you know, like, so I think this is the direction that AI should advance more graphical interpretation. I think an image is worth more than a thousand words, you know what I mean?

I think it's been a huge help, but I still believe that the human interaction with it is quite necessary. We don't have like a futuristic, I don't have a futuristic view of like someone takeover of all the jobs because I think it's impossible, you know what I mean? that's my opinion on this.

Mr. P2 thank you for your valuable insights today. Your contributions will help shape the research in understanding how large language models are being integrated into decision-making and strategy development regarding the energy transformation of companies. If you have any additional thoughts later, please feel free to reach out. Thank you again for your time....

P2: Happy to help you. I wish you the best of luck in your defense and your writing. The thesis is a long work, but at the end, it's important. We advance a bit in discovering the world if we got it thoroughly through thesis.

So I'm glad you're pursuing this path and I'm glad to help you. No problem. That's the way we should do it.

Interviewer: Thanks so much. I appreciate once again your contribution. I wish you a nice day.

P2: Thank you so much. Merry Christmas and Happy New Year.

Interviewer: Yes, thank you. You too. Bye-bye.

P2: Bye.

INTERVIEW 3

Mr. P3 thank you for taking the time to participate in this interview session.

My name is Mehmet Çelik, and I am currently a master's student at the Technical University of Applied Sciences Würzburg-Schweinfurt. With my supervisor, Prof. Scheller, I am conducting a research study, which is "Enhancing Human Decision-Making in Energy Transformation of Industrial and Energy Companies by Leveraging Large Language Models".

The aim of this interview session is to explore your insights and thoughts on large language models and their role in your decision-making and strategy development processes regarding the energy transformation of your organization. Your perspective and insights will help us to better understand the interpretation and implementation of LLMs in those processes.

With your consent, I would like to record the conversation to ensure accuracy in capturing your insights. Please be assured that your and your organization's anonymity will be protected, and your and your organization's names will not be mentioned in any of the reports or presentations. All information will remain confidential and will be used strictly for academic purposes.

Please feel free to bring up anything that a question reminds you of, or anything you think is relevant. Also, you don't have to answer any question you don't want to.

P3: Yeah, that's fine.

Interviewer: Okay, thank you so much. So, Mr. P3 as an introductory question, can you briefly describe your role in the company and particularly your involvement in the energy transformation projects?

P3: I'm head of production or used to be head of production in large power transformers in X Company. And now I'm in expert operations.

Interviewer: As a second question, do you think artificial intelligence, particularly large language models have a transformative potential for your company and broader industry?

P3: Yeah, absolutely. Absolutely, it will have, in which context is yet to be seen, but it will have a large impact.

Interviewer: Ok, thank you for your answer. My first sub-topic is large language models' impact on decision making processes. Mr. P3, are you currently using or strategically planning to use large language models to support your decision making in your company's energy transformation processes? If yes, which specific LLM do you use or plan to use?

P3: The answer depends. If you look at the company as a whole, I cannot say. When I look at the part of the company where I work, the answer is no, we don't use it in decision making for now. But we use Microsoft Copilot.

That is our new day-to-day companion, but we just start scratching the surface by having it deployed to a certain number of, let's say, first adapters or early movers. Let's put it this way. We are really in that stage right now to explore what Copilot can do for us.

What is it good for? I would not even bring it in the context of energy transition. I would actually start much further at the beginning to explore what can it do and then eventually we will see what has it to offer for energy transition.

Interviewer: Thank you. In the future, how the use of LLMs can influence the speed, accuracy and quality of decisions made in your applications?

P3: What I can see is it helps us to become more efficient. Let's say we have a meeting and we need to summarize what has been said. You usually have to negotiate with everybody in the room what the outcome of the meeting was.

You know how that works. Somebody writes meeting minutes and says, those are the meeting minutes. Are you okay? Then people come back and say, oh no, I meant to say X, Y, Z. No, I didn't say that.

It's a negotiation. By using large language models and you use a transcript, it instantaneously summarizes for you who has said what and what's the context. It's quite clever.

By doing this straight after the meeting, five minutes later, bang, you can send it out. You don't have to send it. It's already there.

Interviewer: Thanks so much. Regarding the LLMs' role in strategy development and regulatory compliance, in your experience, Mr. P3, how do LLMs can assist in interpreting and implementing energy strategies and regulations tailored to your company's needs?

P3: I don't know.

I have no experience on this. I may have an opinion, but I do not know. I'm not a subject matter expert on this.

Interviewer: Do you feel LLMs can provide clear and accurate information for successful regulatory compliance and strategic planning, maybe?

P3: Let me put it this way. From the experience that I have, they are already quite clever. They can offer good guidance.

But would I put all my money on large language models if I had to stand up in court and defend my decision? I would rather say no. But I would still use them to get a first inclination as to what direction we want to go. Does that make sense?

Interviewer: Yes, exactly. Thanks so much. Regarding the LLMs' impact on ethical considerations and personal growth, do you believe that the use of LLMs can help promote ethical considerations in developing and implementing energy-related strategies. How do you evaluate the LLMs in terms of ethics?

P3: We all know the examples where the LLMs turned into Nazis in just a short period of time, right? Yeah.

In terms of how they operate in an ethical way, the jury is still out. But I would recommend caution. I would not say I believe they promote ethical considerations in any way.

But at the end of the day, they are models that have been trained based on the information available. And if the information in my simple brain, as I'm an engineer, the information comes from that part of society and that dominates the smaller part, where is that going to be ethical? At least there's a challenge. So I'm only giving you my opinion.

I do not believe, and I would be very, very careful to think those models promote ethical considerations. That is where human interaction will be required.

Interviewer: Thank you for your answer. Do you believe that the use of LLMs can help decision-makers to explore diverse perspectives for their personal growth?

P3: Maybe.

Maybe as long as you remain critical to what it offers and don't take everything at face value. Again, it comes back to what I've said before, to just get a first grasp of what could potential perspectives be. But then have the mental capacity to challenge what has been offered.

And just not say, well, oh, that is what the model tells me. Wait, let's go for it. I think that would be utterly stupid, so to speak.

Interviewer: Okay. And regarding the factors influencing the adoption of LLMs, Mr. P3, what factors maybe can influence your decision to adopt or not adopt to use LLMs in your energy transformation projects?

P3: First of all, it's the next new thing. I've been in business now for 30 years, and every couple of years, something big turned up.

At some point in time, it was TQM. So when I started, it was just when computers were introduced. It sounds strange.

You cannot relate to that. But believe me, there was a time there were no computers. They were already introduced when I started.

Then we started discussing how can we put models together. And it didn't work back in the days. Then topics turned up like total quality management.

Lean became a topic. Six Sigma became a topic. There was always something.

There was always the next new hype. The last conference I went to, the last manufacturing conference was all about generative AI. And there were a lot of companies that told us, you've got to do generative AI.

Nobody really knew why, but they were plugging it. So I think that is where I want to get to. I'm still sitting on the fence.

Is it the next new big thing? Or is it just a wave and something else comes? In between also, the internet became bigger and bigger. And we use all those things now. So that also happened in this time.

But I think large language models and generative AI; they are here to stay and to grow. I think they are not just a bubble.

I'm pretty sure that's going to be the case.

So first of all, curiosity is definitely one factor. The second factor is a conviction that it is going to stay.

So you've got to be part of it. So, you either help forming it, influencing it. Or you're being left with the pieces and you have to take what others have decided.

In terms of structure, information and so on, so I think eventually, those are the main influencing factors. Of course, there will also be economic factors. Because it will help increase efficiency in certain aspects.

And let's face it, jobs will get lost because of that technology in the future. That's going to happen.

But that is quite normal in such a transition. So just trying to think, to bring it into the context of energy transformation project, I think all that is true for energy transformation as well.

Because the energy transformation only works where we are now. Just because the economics stack up. We would not have an energy transformation, energy transition, energy whatever you call it, if solar would still be as expensive as it used to be 20 years ago. If wind was still as expensive as 20 years ago, we would stand here and have no solution for energy transformation.

So now the question is, how can we even speed it up? So my hope, and here I'm expressing hope not knowledge, is that clever AI can help us accelerate the energy transformation. So that would be an influencing factor, acceleration.

Interviewer: Thank you so much for your answer. So how does your organizational culture and AI literacy can influence the adoption and use LLMs? They can also be a factor?

P3: Absolutely. If you have a very conservative culture, you are a very late adopter if at all.

And in traditional engineering organizations, traditional manufacturing organizations, that is often the case. And I'm talking not about highly automated processes where you have a higher degree of automation. I'm pretty sure, and again, that is 80% knowledge and 20% guesswork.

The adoption will be quicker and more so in more traditional type of businesses that do, let's say, more engineered to order projects. Not pre, how should I say it? Pre-configured type of products. Let's say a car is pre-configured.

You would say, I want a feature. Pre-configured, much easier to apply that technology. But if every product that you offer to a customer needs a different design or needs changes, adaptations, then it's harder to introduce it.

I'm certain, but not because it's not giving a benefit, but because of the organizational inertia, I would say.

Interviewer: Thank you so much for your answer. And in the context of circumstances optimizing the most effective human-LLM collaboration, in your experience, does the information presented by LLMs, for example, reports tailored to your cognitive preferences or task-specific needs, can impact your ability to make effective decisions based on the way the answer by the LLM is presented?

P3: Possibly. I think the answer must be yes. Because every person has a set of preferences.

And whatever is being presented to a person is being easily acknowledged and adopted and then taken on board. There's some resistance.

I don't mind. What I've seen and experienced so far, it suits me, me personally. It might not suit everybody else.

So for me, it's okay, ability to make effective decisions. I'm still a bit old school when it comes to making decisions.

Because there are a set of criteria that need to be fulfilled to make a proper decision. Have you ever heard of a method called Kepner-Trigo for decision making? It's very simple.

In a very simple form, Kepner-Trigo subdivides decision criteria into must and want criteria. So the must criteria you have to fulfill no matter what. If you offer, let's say you have five different options and one of the options does not fulfill the must criteria.

Let's say I need to develop a device that brings me to the moon. And you know somebody offers you a tractor. You're pretty certain that doesn't bring you to the moon.

So you cross it out. And all the others are wants. Based on technological, economical, maybe legal, social, you can make a pestle analysis.

The want criteria. And then you give them weighting factors. And then you say, okay, which one fits my criteria most.

So that is a traditional decision making process. So to me, there must be clear transparency in terms of what are the criteria that the model offers that helps me to make a decision. And what I'm saying is there is a risk in my opinion that models offer something that fancies or appeals to me because I have certain preferences.

But it might not be the best solution in the greater context and for the greater good. So there must be clear transparent criteria that make it visible to everybody on which basis have I made a decision. Does that make sense?

Interviewer: Yes, exactly. Thank you so much. What about how does the timing of LLM-generated insights maybe can affect their usefulness in your decision making process? So maybe do you prefer to use LLM at the start of a decision making process or at the end of the process to check your decision making or during the whole process? How does the timing maybe affect?

P3: I have not been in such a situation, I must say. But intuitively, I would use it at the end of the process.

At least where I stand right now based on what I've said before. But this could change in the future. But right now, I'm still a bit skeptical.

But I would definitely use it at the end to gauge the decision.

Interviewer: Thank you so much. And regarding the challenges of human LLM collaboration, what challenges maybe can you have encountered in collaborating with LLMs, particularly regarding interpretability, trust or data privacy concerns? What can be their impacts and what strategies or solutions can you consider to overcome those issues?

P3: Yes, that's a very good point. I can give you an example. I've been in contact with a company that offers training videos.

And that company is called DeepHow. They're a US-based startup. What they do is they take YouTube videos.

And let's say you want to introduce a new employee to a new workplace. And that could be an effective way by showing them videos. And those videos can be translated in all sorts of languages.

You can cut them. You can do whatever you like. And they can be very efficient.

So the program is clever. Translates it itself. There is an issue, especially in Germany, with the unions.

You cannot film a person. Right? So to circumvent that topic, I would go into a country that does a similar job and would do it there. So that would be a strategy.

Interviewer: Thank you so much. And in terms of practical outcomes of LLM adoption on energy transformation, have you observed or can you observe in future improvements in energy transition implementation or maybe reduction in your project's efficiency loss after adapting LLM? What can be the other practical outcomes?

P3: I cannot answer that question. It's still too much in the early stages of using those technologies.

I cannot say. There is no experience yet.

Let me put it this way.

Interviewer: Thank you so much. And my last question is LLMs' role in expanding the knowledge base of not only decision makers, but also the firm. . How do you think LLMs can help your organization and decision-makers enhance their knowledge base, particularly in the context of energy transformation?

P3: Yeah, it's what I've said. It was a good example with those videos.

They can be stored in the data. They will be stored in the cloud. They would be accessible to all sites, to all manufacturing sites worldwide.

They can download the videos and it can be in, I don't know, Turkish and Chinese and Spanish or whatever. So that will be a huge help. And especially when you bring it into the context of energy transformation, where we have to deliver a lot of products, we have to cope. The demand is much higher than the capacity in the factories worldwide. And not only in our company, everywhere.

And we need to train a lot of people very quickly to deliver products at the right standard and in right quality. So this is where those training tools could come in quite handy, actually.

Interviewer: Thank you so much for sharing your experience and your time. Maybe is there anything else you want to add that my questions have not addressed? Otherwise, that was the end of the process.

P3: Thank you very much.

It was a pleasure. As I said, we are early adopters. But very, very early. So we still lack the experience. And I'm still critical in terms of what's being promised. We need to make our own experiences. But I'm pretty certain this is where the world is going.

I wish you good luck. All the best when you defend your study, your thesis. It's an interesting topic. It really is. All the best. Have a happy holidays.

Mr. P3 thank you for your valuable insights today. Your contributions will help shape the research in understanding how large language models are being integrated into decision-making and strategy development regarding the energy transformation of companies. If you have any additional thoughts later, please feel free to reach out. Thank you again for your time.

Interviewer: Merry Christmas. Thank you so much Mr. P3 for your time. It was a pleasure for me to interview you. Bye-bye.

P3: Take care. You too. Bye.

INTERVIEW 4

Mr. P4 thank you for taking the time to participate in this interview session.

My name is Mehmet Çelik, and I am currently a master's student at the Technical University of Applied Sciences Würzburg-Schweinfurt. With my supervisor, Prof. Scheller, I am conducting a research study, which is "Enhancing Human Decision-Making in Energy Transformation of Industrial and Energy Companies by Leveraging Large Language Models".

The aim of this interview session is to explore your insights and thoughts on large language models and their role in your decision-making and strategy development processes regarding the energy transformation of your organization. Your perspective and insights will help us to better understand the interpretation and implementation of LLMs in those processes.

With your consent, I would like to record the conversation to ensure accuracy in capturing your insights. Please be assured that your and your organization's anonymity will be protected, and your and your organization's names will not be mentioned in any of the reports or presentations. All information will remain confidential and will be used strictly for academic purposes.

Please feel free to bring up anything that a question reminds you of, or anything you think is relevant. Also, you don't have to answer any question you don't want to.

P4: Okay.

Interviewer: So, as an introductory question, my first question would be "Can you briefly describe your role in the company and particularly your involvement in the energy transformation projects?"

P4: Sure. So, I'm head of M&A at Company X in Germany. I'm responsible for transactions that take place.

So, basically the acquisition of corporations and also projects that we add to our portfolio. So we're talking portable tides, onshore wind, battery storage and hydrogen projects in selected cases.

And I'm basically responsible for identifying opportunities, doing the valuation work, negotiating and basically executing transactions and then also basically supervising post-merger integration and making sure that the projects that we acquire actually go ahead and become valuable projects that you know deliver basically returns to us and our shareholders essentially.

Interviewer: Thank you for your answer. Mr. P4 do you think artificial intelligence, particularly large language models can have a transformative potential for your company and for the broader industry?

P4: Yes I definitely think so. So particularly when it comes to, you know, basically measuring and analyzing and evaluating the performance of plants, right, which can deviate quite substantially due to various reasons and applying you know artificial intelligence to really identify basically errors or root causes essentially. You know basically automatically suggesting where certain or how certain issues can be remedied and basically ultimately you know leading to improved performance of the portfolio which then translates into you know basically euros that you know we can distribute to our shareholders.

I think particularly in that field they can have a huge you know benefit and also probably in the development and improvement of technology that we use so basically modules inverters so basically you know solving let's say certain technical issues or performance issues.

I think that is also probably a field where it would make a lot of sense or where you know artificial intelligence could add a lot of value.

Interviewer: Thank you for your answer. And regarding my first subtopic, LLMs' impact on decision-making process, Mr. P4 are you currently using or strategically planning to use large language models to support your decision-making in your company's energy transformation processes? Which specific LLMs do you use?

P4: I think, for now, we don't use large language models at least not in the fields that I work in.

Interviewer: Personally do you use large language models in your, maybe, daily basis tasks?

P4: To be frank, very rarely. A lot of the things we do is sort of is still interpersonal. So, basically well I mean we've actually we've worked with sort of AI-based search machines basically, I guess. That help us identify targets so also that's actually one application that's but that's very specific to let's say M&A rather than in the energy industry itself.

But that actually helps right so basically telling an AI software what we are looking for and then it helps us screen opportunities by various factors and then improving those search fields when we for example apply certain reference companies that are relevant and these kind of things.

So that's a particular field that where I use sort AI power tools in M&A but I think in a broader sense I would have to say that I cannot say for certain so I'm not aware that we're using it at least not in the development field that we do so we develop projects but it could be that we use it in operations but I'm unfortunately not close enough to say for sure.

Interviewer: Okay thanks for your answer. So you mentioned you don't particularly use, but in the future if you use the LLMs how do you think that they can influence the speed, accuracy and quality of decisions made in your projects?

P4: Well I mean you know we try to remain let's say relatively lean organization right so we don't want to you know hire a lot of additional people because we will have we are quite limited in Germany when it comes to you know basically I mean let's put it in a nice way getting rid of people when the market has a downturn and therefore you know we like to have a lean organization but nevertheless we you know we're facing sort of more and more data from a growing portfolio which we have to stay on top of and I think in that particular case basically keeping a lean staff but then being able still to process

more and more data and review the portfolio performance in that particular case I think it's very valuable.

Interviewer: Okay thanks so much for your answer. So my second subtopic is in the context of LLMs' role in strategy development and regulatory compliance. In your experience do you think that maybe LLMs can assist in interpreting and implementing energy strategies and regulations tailored to your company needs if you would use it?

P4: I think they could but actually practically have no experience but I would be surprised because I mean the area is changing quite rapidly especially regulation in energy. It's very difficult to stay on top of that but then obviously on the internet for example a lot of that information is available and basically using AI to basically keep stock of all the changes anticipated changes where they are in the process what they mean for the energy markets and how that could be sort of translated into sort of strategic or tactical moves, I think for that it could be extremely valuable.

Because obviously you know such tools are much more capable of you know structuring and analyzing huge amounts of data in a much more efficient way than people are.

Interviewer: In this regard, do you feel LLMs can provide clear and accurate information for successful regulatory compliance and strategic planning?

P4: Exactly.

Interviewer: Okay thank you and regarding the third subtopic, LLMs' impact on ethical considerations and personal growth, Mr. P4 do you believe that the use of LLMs can help promote ethical considerations in developing and implementing energy-related strategies?

P4: Yeah possibly, possibly. No I mean most likely yeah it's obviously but I mean there are also it needs to let's let's put it this way it needs to be sure that whatever I mean let's put it this way you know using online tools or software is also obviously prone to potential you know intervention or mingling by external forces right yeah so in a sense it also creates a risk when relying too much on let's say these kind of tools.

I think they always need let's say at least a proper review and also the results need to be carefully sort of not only analyzed but sort of understood and not just be used you know go freely so but I think as long as that is ensured then yes I think they can promote ethical considerations.

Interviewer: Okay thanks so much. So, in terms of personal growth do you believe that the use of LLMs can help decision makers explore diverse perspectives for their personal growth?

P4: I think so yeah because I mean usually people have certain mindsets which they have developed over several years right and you typically still move in a certain circle whether that is at work or in your

private life and I think using tools that basically take into account information and perspectives that reflect sort of other let's say cultural perspectives or other geographical perspectives which I guess in a sense equates to culture in a sense I think that could be extremely valuable because it may allow you to look at different things from different perspectives and rethink your own beliefs and views on certain matters right so in the particular sense if you are I mean you need to be open for personal growth and to you know willing to rethink certain perspectives that you have but as long as you're open to that I think it definitely you know has the ability to open up a certain window yeah to you if you're willing to look into it basically.

Interviewer: Okay thank you. In context of factors influencing the adoption of LLMs, what factors can influence your decision to adopt or not adopt LLMs in the future in your energy transformation projects?

P4: Yeah I mean again I think data security is always a key topic so that would be one thing and then ultimately I guess it's also if we look at let's say specific products it's really just the quality of the product right I mean yeah certain tools promise to do something and then you and it maybe works in certain applications but then in your particular for your particular use case it doesn't provide the desired quality and in these cases then you would probably not adopt and then probably stick to I don't know maybe not necessarily manual work but other alternatives that are out there.

Interviewer: So, Mr. P4 do you think maybe organizational culture and AI literacy can be other factors? How does your organizational culture and AI literacy influence the adoption and use of LLMs?

P4: Yeah for sure I mean obviously if you if you don't know what's out there and you don't really understand how things work and you don't have let's say dedicated resources that look into alternatives to doing things the way they are currently being done right in the sense that what AI solutions can I use to actually improve my day-to-day work and energy sector if you don't have anybody dealing with that then obviously at least the time until you adopt something will be much much longer than compared to other companies which are very open and very actively following the space. So in that sense for sure so I think you need an organizational culture that is very open to change and is very let's say has the organization itself and the entire culture is about growth and then having the having this particular mindset and constantly reviews the things that are how the things are done right and whether they can be improved by using different tools and methods.

Interviewer: Mr. P4 regarding the circumstances optimizing the most effective human-LLM collaboration, in your experience, does the way information is presented by LLMs (e.g. reports tailored to your cognitive preferences and task-specific needs.) impact your ability to make effective decisions?

P4: Yeah I mean again like you know based on my initial comments that I'm not a like let's say super active user of AI I've at the moment I guess my response has some limitations but I mean generally speaking yes I mean I guess any tool you use whether it's a language model or any other software if the information that you're being provided is not sort of let's say it doesn't have the right level of detail whether it be too high or being too low or is not presented in the right way that it's difficult to interpret then of course it has a huge effect on whether you are able to make the right decisions or not.

Interviewer: So my second question Mr. P4, how does the timing of LLM generated insights can affect their usefulness in your decision making processes?

P4: I mean similar to one right given my lack of usage it's I would say that my response is limited but just basically based on sort of my perspective I would say using it early on is I think a good way to start right because it allows you to quickly gain a perspective and you know analyze a lot of data in a short amount of time and that is a good basis to start on and then consider how to move forward instead of spending a lot of time doing it in a different way and then adding it at the end.

I mean I think it's a possible possibility to use it as a cross check at the end but I think that's not really what we want to use it for right we want to use it as a tool initially already to help us develop the strategies and not just at the end to verify you know our perspectives so yeah okay I think timing should be important.

Interviewer: My sixth sub-topic is challenges of human-LLM collaboration. Mr. P4 what challenges maybe in the future can you have encounter in collaborating with LLMs particularly regarding interpretability, trust or data privacy concerns? What can be their impacts and what strategies or solutions can you consider overcoming those issues?

P4: So data privacy obviously is always a key concern I mean there's also depending on where you are in the world quite strict regulation on this topic and then also obviously there are security concerns around you know obviously working with companies from certain countries obviously sort of Chinese technology is always a bit looked up on with a lot of let's say care I think you could say the same for anything that comes from the sort of what countries like Russia and so on right although they have pretty good data scientists and software developers but that is always critical these days and yeah I think that would be sort of my main concern when looking at this interoperability which is talked about a little bit right so I mean always assuming that you have the right user in front of the tool then it should never be a problem if you have let's say a less experienced user that is still looking for meaningful results then obviously framing the results in the right ways is quite key to really making it useful

Interviewer: Thank you so much. In terms of practical outcomes of LLM adoption on energy transformation, in the future if you use them daily or basically, what kind of improvements can you imagine in

your energy transformation implementation or maybe can you provide a reduction in your energy efficiency loss after adapting LLMs? What can be the practical outcomes of the adaption of LLM?

P4: Yeah I mean I think energy efficiency loss is definitely a key topic so I think overall improved performance of energy assets is I think a key area where this could lead to an improvement that's probably the most relevant one I see because again the very technical technically complex assets that are being subject to technical issues it may be a change in variable wind resources right or solar resources and then it's very difficult for a manual user to directly spot where the issue lies I think using language models in that particular instance is probably key area where really performance improvements can be achieved and then therefore yeah also really I mean it has a meaningful monetary impact right on the performance of companies then definitely.

Interviewer: Thank you so much and my last question of the day will be in terms of LLMs role in expanding the knowledge base of the firm and decision makers. How do you think the LLMs can help your organization and decision makers to enhance their knowledge base? Can they provide a computational advantage in the industry?

P4: Yeah I think so right but only I think temporarily so because usually the competition picks up at a certain point so I think if you're early on in using these then you have a competitive advantage if then obviously the industry adopts the same technology and then ultimately everybody gets the same recommendations and if it erodes quite quickly right so I think it comes back to what you what you asked earlier so if you have the right people that identify very early on which solutions can help you gain a competitive advantage by making more effective decisions or by running your portfolio in a better way then for sure but you know over time this benefit will then erode unless you always you know stay on top of the curve and always you know adopt the next best solution while others you know what you used before.

Interviewer: Mr. P4, thank you so much for your valuable insights and answers. My last question maybe is there anything else you want to mention or that my questions have not addressed or anything else you just want to say?

P4: Not really but I wish you best of luck you know and getting this finalized.

Mr. P4 thank you for your valuable insights today. Your contributions will help shape the research in understanding how large language models are being integrated into decision-making and strategy development regarding the energy transformation of companies. If you have any additional thoughts later, please feel free to reach out. Thank you again for your time.

Interviewer: Yes, so it was a pleasure for me to interview with you, thank you so much again for your time and your contribution, thank you.

P4: Yeah my pleasure, best of luck. Yeah, Merry Christmas and I wish you a good day, thank you so much.

INTERVIEW 5

Mrs. P5 thank you for taking the time to participate in this interview session.

My name is Mehmet Çelik, and I am currently a master's student at the Technical University of Applied Sciences Würzburg-Schweinfurt. With my supervisor, Prof. Scheller, I am conducting a research study, which is "Enhancing Human Decision-Making in Energy Transformation of Industrial and Energy Companies by Leveraging Large Language Models".

The aim of this interview session is to explore your insights and thoughts on large language models and their role in your decision-making and strategy development processes regarding the energy transformation of your organization. Your perspective and insights will help us to better understand the interpretation and implementation of LLMs in those processes.

With your consent, I would like to record the conversation to ensure accuracy in capturing your insights. Please be assured that your and your organization's anonymity will be protected, and your and your organization's names will not be mentioned in any of the reports or presentations. All information will remain confidential and will be used strictly for academic purposes.

Please feel free to bring up anything that a question reminds you of, or anything you think is relevant. Also, you don't have to answer any question you don't want to.

P5: Mm-hmm. Okay.

Interviewer: Thank you. First of all, can you briefly describe your role in your company and particularly your involvement in energy transformation projects?

P5: Okay. So, I'm leading the Energy and Climate Change Competence Center. And we have more than 15 subsidiaries.

And our role is to support all the sites. We have 15 production sites to enhance the energy efficiency and also to report or to calculate the CO2 emissions. So, we are doing, for example, also Scope 1 and 2, but also Scope 3 emissions for the whole company, for the whole X Company Group.

And we also have software that we use as a standard on all subsidiaries. And we have digital meters, so we can monitor the energy consumption. But you can also data calculate, for example, the energy reductions and et cetera of actions.

So, energy transformation projects, yeah, we have very, very different kind of, you know, energy transformation projects. For example, we want... We have several self-generation projects.

Yeah, we implemented, for example, you know, CHP in Germany or PV stations, yeah, for example, on some of our sites. And, yeah, we also are eager to replace fossil fuels, for example, in new plants. So, we have new plants in Germany and we try to avoid fossil fuels.

So, we are using, for example, pellets, yeah, you know, instead of... and heat pumps. And, you know, it's like a combination between this pellet, you know, heaters and...

But we have just one gas heater as a backup, yeah, but we want to use more, yeah, biofuel if you want. So, these are... We also recuperate heat, for example, from our compressors, especially from our compressors to reduce also our heating energy.

So, these are this kind, you know, of projects that we are doing. I don't know if... Is it like this that you are talking about?

Interviewer: Yes, exactly. Thank you so much for your information.

P5: Okay. So, this is... Yeah, we have...

So, it is very different. It depends, you know, on the country. And then, for example, for warm countries, we will focus more on PV stations.

When you have colder countries, we will focus more on heating, you know, heating by using... by avoiding fossil fuels. I'm no more so much a fan of, you know, of CHPs, honestly, because we have now the, you know, to use green electricity.

And when you use the CHP, you have always, you know, due to the fossil fuel, you have always electricity that is not zero, you know, that is not carbon free. And it is very difficult, yeah, it is very difficult to compensate it. So, you know, it is very fast, you know, the transformation is very fast.

At the beginning, when I studied, you know, it was like 20 years ago. It was, yes, and the CHP and district heat and, you know, et cetera. But more and more now, what is saying is to say no fossil fuels at all.

No burning, you know, no combustion. Yeah, more electricity and then try to think about green electricity. Yeah, so like green nitrogen now or, you know, or TVs or electric cars.

Yeah, and things like this. Yeah, same thing is also we have also a lot of cars. Yeah, you know, and also we, there were a big part of our cars that we replaced by e-cars.

It's not a very good and sustainable solution, but we did it.

Interviewer: Okay, thank you so much for your answer. And secondly, Ms. P5, do you think artificial intelligence, particularly language models, have a transformative potential for your company and for broader industry?

P5: It depends. I saw that you are also interested in ChatGPT. And honestly, what I'm using is ChatGPT now because, and that's right, sometimes to use it for, you know, for a little bit more specific calculations.

Yeah, to go in calculations or to use it to solve, let us say, complex calculations or equations. Oh, you should be very, very, very, you know, you should really know or have a great idea about the things that could not be, you know, working or that are not scientifically, you know, correct. Yeah, because I don't know, but I think that ChatGPT will never say, I don't know.

There's not like, can you please explain more or can you please, you know, give more information? No, it always gives you a lot and lot of answers. And there are a lot of answers that are not true.

And when you ask again and say, hey, but you know, for example, say something, you know, that it should be like this and this, you know, the efficiency of, I don't know, is between this and this and, but you wrote this. Oh, you say, oh, yes, it was not true. So for me, till now, I know just ChatGPT, but I don't use any other, you know, artificial.

There were also other projects from Fraunhofer. It was about the intelligent loading of e-cars, you know. And also the concept was not something that can work for its own.

There were a lot of ifs there. And later I can give you an example about this. But let us say for ChatGPT, honestly, when you don't have, when you are not the expert and you are leading ChatGPT, you will have a lot of errors.

And at this stage of ChatGPT, I would not use it so much. Not an advanced research.

Interviewer: Don't you think it's not like the best tool to use?

P5: Not the best because I think that you have to give him so much information Exactly. Yeah, that you can do it for your own at the end, you know.

Interviewer: Thank you so much for your answer.

So regarding the core questions, the first one is about the LLMs' impact on decision making process. So I think you already answered this, but I would ask, are you currently or strategically planning to use large language models to support your decision-making?

P5: Yeah. For example, last time we also, a company presented us in KI, in Künstliche Intelligenz. And it was about to make your transition plan, climate neutrality transition plan.

And, but you have just to put, you know, your consumptions, etc. And then it will say, okay, you have to put, I don't know, in your subsidies, so much PVs and so much, I don't know, so much. But no, because for example, Mexico, you have a limit of 500 kilowatt peak.

And it is something that it's not considered, you know. For example, you have also, there are a lot of things that even the, you know, even the software is not asking. And even it's very, very complicated.

And they say, oh, in five minutes, you will have your transition plan. I, yeah. So, this was also an example where I was like, decision-making with the, hmm, difficult.

Interviewer: Yes. So, if you, like, chat with other LLMs, how the use of LLMs can influence the speed, accuracy, and quality of decisions made in your energy transformation projects? You mentioned that the quality and accuracy is a bit, like, questionable, but can it help you for speed?

P5: Yeah, what I think perhaps is that this artificial intelligence, the software should be linked to, you know, to internal or specific information. For example, if there's, I would say something where you have all the laws, you know, energy laws, for example, of all countries. You are linked to the SAP of the company.

Yeah, you should, I think in the first place, you should identify all the information or all the systems that should be linked as an input to this software or to this, yeah.

Interviewer: So, they should be linked together to work. Yeah.

P5: Yeah, I think that you should do, like, a configuration that is personal, you know, something very...

I think that if you want to use later artificial intelligence for your company, you should really do a configuration. I think even the configuration would take a lot of time or should be done by experts. And then perhaps, yes, later.

Interviewer: Yes. Thanks so much. And regarding the second one, LLMs' role in strategy development and regulatory compliance, in your experience, how do LLMs may assist in interpreting and implementing energy strategies and regulations tailored to your company's needs?

P5: I would say the same thing. Perhaps you should also link it to internal information. Yeah.

And it should be very precise. You should really, yeah, recognize or take into account all the information that are necessary. And later, yes, perhaps you can then, yeah, save time with this and do really strategic planning.

Interviewer: Thanks so much. I think you already also answered my second question. Do you feel that LLMs may provide clear and accurate information for successful regulatory compliance and strategic

planning? But you said that, there's still some way more to go to get definitely clear and accurate information. Maybe after the configurations, as you said, is it maybe possible?

P5: Yeah. At the end, later, yeah, it would be possible. But it should be something that should be also updated very frequently.

Interviewer: Yes thanks so much. And regarding ethical considerations and personal growth, do you believe that the use of LLMs can help promote ethical considerations in developing and implementing energy-related strategies?

P5: I think the first thing, you know, to implement or develop ethical consideration is the will of the company to do it. Later, you can use a tool. For me, you know, LLM or something like this is a tool that you use if you have the will to go toward, you know, an ethical, you know, development of energy-related strategies.

And it will help you perhaps to find the right path. But I think it's more a tool than something that will... Because for me, ethical, you know, it's for me a will.

It's for me a mentality. Yeah.

Interviewer: So in terms of personal growth, maybe do you believe that they can help decision makers and to you to explore diverse perspectives for your personal growth?

P5: It will save a lot of time. Yeah. For example, there are a lot of things.

Honestly, sometimes when you want to do a presentation, it will help you, you know, to directly... You can put what you want. For example, I am just...

And it will give you how you have the structures, things. But you have always to do then your own work. But it will help you to save time, to clarify, you know, your ideas with things, with information that you have to search somewhere else.

So it can help, yeah, in the personal growth. But I don't think so much in knowledge. Because I think knowledge, you have to take a book.

You have to take, you know, and to read it, okay? Yeah. To not be just an empty shell.

Yeah, you have really to take. I don't know. I'm old school, you know.

But, yes, you can be much more efficient and much more clear with this kind of tools. For me, it's a tool.

Interviewer: Thank you so much. And regarding the factors influencing the adoption, what factors do you think influence your decision to adopt or not adopt LLMs in the future? Do you think it will be necessary to adopt LLMs for everyone in the future or it will be just an option for everyone?

P5: I think that it depends on a lot of things. First, also the price, you know, that you will have to pay to have it. Because a lot of people in the industry, you know, always there's a price and they will think, oh, do I need an expert, you know, and I have to pay him a salary?

Or just I need, you know, a five-year expert or do I need a 20-year expert? Perhaps I can, you know, use this artificial intelligence to use just a five-year expert or to need just a five-year expert. But I don't think that when you have a real expert in the field that it will be like exactly the same.

I don't think so. Not yet. Not yet, yeah.

Interviewer: So, do you think maybe the organizational culture and AI literacy is another factor that can influence adoption?

P5: I think it's a helpful tool that should be used to be more efficient, more clear, to be sure that you have quickly all the information that you need. But you should never, I think, that you need the persons because, yeah, and you need also expertised persons for a company. I don't think that you can completely, you know, substitute this.

Interviewer: Okay. Thank you so much. The fifth sub-theme, circumstances optimizing the most effective human-LLM collaboration, in your experience, does the way information is presented by LLMs (e.g. reports tailored to your cognitive preferences and task-specific needs.) impact your ability to make effective decisions?

P5: From what I saw, you need always to adjust again. You will have perhaps a structure, but it is always very superficial, you know. Superficial, don't go too much.

It's always general speaking. And if you want more, you have to adjust it. It will be like a base, you know.

You have a base, and then you need to put more information. But like in five minutes, you will have, you know, a presentation that you can go to the board, and the board will say yes, you know, like this. And I don't think so.

Not yet.

Interviewer: Okay, thanks so much. So maybe also the timing of LLM-generated insights, can the timing of LLM-generated insights affect their usefulness in your decision-making processes?

P5: It could be helpful. Yeah, it could be helpful, but you should really verify the sources, the information, but they are not always true. So, sometimes there is something that you didn't consider, and you will find it in the analysis of the LLM or something, but you should verify again and again.

Interviewer: Okay thank you. In regard of challenges of human-LLM collaboration, what challenges have you encountered in collaborating with LLMs, particularly regarding interpretability, trust, or data privacy concerns? What were their impacts and what strategies or solutions have you considered to overcome those issues?

P5: Yeah, first of all, yeah, the trust of the information. You can always ask for sources to say, okay, please put the source or please verify or please use verified sources or something like this. Data privacy is also, because nowadays, you know, everything is on internet, and yeah, you have something.

It's also very, I don't know if it should be used for very, you know, high, how to say, private or confidential things. I'm not so sure. Because somewhere you have a trace, somewhere it is...

So, how to overcome? Perhaps to have really, for example, you have now ChatGPT, something for everyone. But perhaps it should be like something configured, software, artificial intelligence, okay?

That is really just for the company, you know, and like Teams, for example, or something that you can use where you can be sure that it has...

Interviewer: Thanks so much. And in terms of the practical outcomes, so do you think that when you use LLM in your whole energy transition processes, do you think you can get some improvements and get some reduction in energy efficiency loss after adopting it? What can be the practical outcomes at the end of the day?

P5: I don't know if, you know, you have to put so much information when you want to do an energy transformation plan. You have to put so much information in this software to then have other solutions. And here is really the question.

Will it really save time or will it really be better? I'm not so sure. Not in energy transformation, perhaps in other things, you know.

But in energy transformation, you don't have thousands of solutions. You have your processes, you have your countries, you have your potentials, you have also your budget, you know. There are a lot of things.

So, we are limited. Yeah, very limited. And it's not so complicated, honestly.

Even as with 15 subsidiaries.

Interviewer: Okay. Thank you. So, the last question, LLM's role in expanding the knowledge base of the firm and decision makers, do you think that LLM's can help your organization and decision makers to enhance their knowledge base, particularly in the context of energy transformation? For a competition advantage in your market? Do you think they can provide an advantage in the future?

P5: For now, if I had to choose, I would choose a good expert. Honestly, and not a software. Why?

Because there are really a lot of things that, empirically, they are very good, you know. For example, when you say, okay, heat pump. Why?

Yes, we have to go to heat pumps. Okay, but when you have very, very low temperatures, et cetera. Okay, perhaps it can also be done by artificial intelligence.

But I would not, I don't know. Perhaps for the calculation, perhaps to calculate. For decision making, yeah.

But is it not better to use simulation software instead? I don't know.

Interviewer: So, Miss P5, that was my last question. I really appreciate your contribution and I want to thank you for your time. Maybe is there anything else you want to add or want to say lastly?

P5: No, it was very great. what also should be taken into account is the competences of what this artificial or, you know, this one solution can do. What perhaps the people want or what kind of solution or how there will be the solution?

Is it capable to do simulations? Is it capable to do calculations? Is it capable to calculate also all the financial aspects?

Because you have, you know, when you do energy transition, you have the regulation, you have the financial aspects, you have the processes, you have also the infrastructure, because, for example, do you have a place, for example, to put energy storage solutions, for example? I don't know. So, there are a lot.

Interviewer: Yes, definitely. Thank you so much.

Mrs. P5 thank you for your valuable insights today. Your contributions will help shape the research in understanding how large language models are being integrated into decision-making and strategy development regarding the energy transformation of companies. If you have any additional thoughts later, please feel free to reach out. Thank you again for your time.

Interviewer: It was a pleasure to meet you and ask you some questions. Your insights were really valuable for my thesis. I want to thank you once again for your time.

P5: Thank you very much and good luck with your master's thesis. Thank you.

Interviewer: Thank you very much. Bye-bye

P5: Thank you bye.

INTERVIEW 6

Mr. P6 thank you for taking the time to participate in this interview session.

My name is Mehmet Çelik, and I am currently a master's student at the Technical University of Applied Sciences Würzburg-Schweinfurt. With my supervisor, Prof. Scheller, I am conducting a research study, which is "Enhancing Human Decision-Making in Energy Transformation of Industrial and Energy Companies by Leveraging Large Language Models".

The aim of this interview session is to explore your insights and thoughts on large language models and their role in your decision-making and strategy development processes regarding the energy transformation of your organization. Your perspective and insights will help us to better understand the interpretation and implementation of LLMs in those processes.

With your consent, I would like to record the conversation to ensure accuracy in capturing your insights. Please be assured that your and your organization's anonymity will be protected, and your and your organization's names will not be mentioned in any of the reports or presentations. All information will remain confidential and will be used strictly for academic purposes.

Please feel free to bring up anything that a question reminds you of, or anything you think is relevant. Also, you don't have to answer any question you don't want to.

P6: Okay.

Interviewer: Mr. P6, can you briefly describe your role in the company and particularly your involvement in the energy transformation projects?

P6: All right. First of all, thank you for the invitation. Actually, I just want to enhance something about the energy field that I work in. I'm working more than six years in the field of energy engineering, not specifically related more to renewable and sustainable solutions.

So, whenever I speak about renewable solutions, I'm talking about like PV solutions, battery solutions, anything related to green energy like hydrogen and so on. I lead a team for such things that we start from scratch, from initial planning to making reports, making simulation by using softwares. And whenever we get an agreement with the customer, we start the implementation of what we have designed.

And for sure, we make a coordination with other departments, suppliers, and so on. So, we can make sure that the flow of work in each project is good. And for sure, after we finish the installation, testing and commissioning is required.

And so, we can hand over the system to the customer. This is very briefly speaking, what I do actually. Now, if you have any further questions about it, I'm glad to hear you.

Interviewer: Okay, thanks so much. I have a question specifically regarding the artificial intelligence. Mr. P6, Do you think artificial intelligence, particularly large language models (LLMs), have a transformative potential for your company and broader industry?

P6: What I can see from now that I feel that AI is having potentials in our systems, because a major part of our work, at least my work right now, is made by humans, which is I make my own calculations, I make my own design, I make my own size.

So, basically, whenever you mention human, there might be human errors. Okay, so I believe that using artificial intelligence might help, I'm not saying to make it zero, a zero percent of the errors, however, to lessen the errors that we might face during our calculations. Maybe something happens, I'll give you an example, that sometimes maybe the system we have designed is oversized or denosized.

So, maybe this type of errors that might happen might be resolved by using artificial intelligence that can understand to make it, by using facts, by using basic numbers, that gives you what you need exactly. So, in a nutshell, yes, I do believe artificial intelligence might help to accelerate and make better outcomes in our work.

Interviewer: Okay, thanks so much for your answer. Regarding my first core questions, in terms of large language models' impact on decision-making processes, Mr. P6, Are you currently using or strategically planning to use large language models (LLMs) to support your decision-making in your company's energy transformation processes? Which specific LLMs do you use?

P6: Not so often, but because, as I told you, my work is based on particular cases, so I make my own calculations, I make my own reading, but sometimes I use GPT, literally, just ask some major questions, like something I don't know, definition, or something I need to know in particular, so I ask GPT, what is this exactly, what's the definition of that thing? But in my particular work, no, I don't use it, actually, because this is very critical and very sensitive thing, so I make it by my own.

Interviewer: Okay, thanks so much. So, how can the use of LLMs influence the speed, accuracy, and quality of decisions if you use them in your decision-making for your energy transformation projects? Can they make your decisions quicker, more accurate, or more qualified?

P6: Specifically, I'm talking right now about ChatGPT, for example. Okay, it might give me answers, it's true, but I don't give 100% confidence that this is the accurate one, so I need to take a look more, I need to do more research if I want to find something new, because I'm not sure where it is right now, I know it's boosting, it's in a very different level of communication and information data center, but for me, I'm not 100% confident that this is the most accurate thing. I need to take a look in different ways, because I have my own experience.

Sometimes, it gives you answers, okay, it's true, but this is my experience, this is my knowledge, it's not 100% true. There is something missing, there is something that needs to be added more, maybe the language that we use, the sentence that we added, it's not fully complete, but it needs to be more advancement to give you what you need. Maybe it's good something, like if you want to write motivation letter, okay, it's good, maybe to help you to write your CV, it's good, but asking something related to energy, it's kind of sensitive, and I don't think it's the most accurate thing that I have.

So, for your question, to help me to make a decision, not really. I keep it as a supporting enhancement for me, I am talking about like LLMs, for example, but it's not what gives me, okay, this is my decision right now.

Interviewer: Okay, so you think they cannot provide 100% true answer at least for now, okay.

P6: No, no, no, no. I have a fear from that, because you cannot rely on ChatGPT or something, because it is giving you information based on what you have written, right? So, it's very specific in what you have put as an input.

So, the output, maybe it's true, maybe it's not. Even if ChatGPT gives you like a hidden or something note, that maybe ChatGPT makes mistakes. Yeah, that's true.

So, that's why I give it a chance to read what's available on ChatGPT, but it's not the final decision.

Interviewer: Thanks so much for your answer. Mr. P6, in terms LLMs' role in strategy development and regulatory compliance, in your experience, how can LLMs assist in interpreting and implementing energy strategies and regulations tailored to your company's needs?

P6: Yes, for that thing, I believe it might help in the sense of giving you a blink or insight how it will be the regulation.

It's like giving you the first step to know what you are looking for, to know what you need to look for. I believe this is a good point for ChatGPT, for example, that it helps you to know what you need to look after. Because maybe there's something new, I need to think about it, I need to make improvements in my department, department, sorry, to make new regulations or new policy or something.

So, I get help from ChatGPT to ask what the solution is, what could I do for that thing?

Interviewer: Okay, thank you so much. So, I think you already answered the second question as well. So, you feel LLMs can provide clear and accurate information for successful regulatory compliance and strategic planning, right?

P6: Yes, exactly, exactly.

Interviewer: Okay, thank you so much. And regarding the LLMs' impact on ethical considerations and personal growth, Mr. P6, do you believe that the use of LLMs can help promote ethical considerations in developing and implementing energy-related strategies?

P6: At some point, yes, but it can give support, if I'm assuming in percent, it looks like between 10 to 20 percent. However, the 80 percent, which is the major part, it relies on the company itself, the policy of the company, because you cannot make a conclusion for ethical considerations based on what you have read in your answer, because maybe the circumstances or the government itself, I mean, the governmental rules or the policies in that country doesn't fit what you are reading. So, it might be not accurate, it might be not helpful in that point.

So, at some point, you cannot take it as, as I said before, you cannot take it as fully blinded that this is the strategy I will follow, this is the one I will use, because maybe it will not work, it's not fitting where you are. You got me? Maybe something it works in the US, it will not work in Deutschland, in Germany, you know what I mean. So, basically, you don't know regulations, ethical considerations, I mean, might fit it or not.

As I have said, it gives you an insight, it gives you an idea, knowledge, it gives you the keywords, if I can say that. I like it in that way, it gives me, for me, it gives me a keyword, what I should look for and what I, some point I should focus on. From that thing, I can continue my work, I can continue my research, I can continue my own regulations, if I can say.

Interviewer: Okay, thank you. So, in terms of personal growth, Mr. P6, do you believe that the use of LLMs can help decision-makers explore diverse perspectives for their personal growth?

P6: Yes and no. As I have said, maybe it's the first platform, I think about it if I want to look for an information, for a definition, for like, if I want to translate something, if I want to reply for something personal, for somebody in a different language. So, I go to ChatGPT because it's now, it's the fastest and easiest way to make this work.

And as long as you are not making something that you need to repeat the procedure or to tell something, please, just one time, I tell and it will do it for me if I want to make something personal. If there is something I'm working on my files, please give me an insight, what would be the best version of CV, for example. It'll give me an insight, okay, this is the best way to make your CV, to make it in that way.

Some companies are using this software to make scanning, so you should follow these instructions. So, yes, personally and in my personal growth, it might help, but as I have said, I'm skeptical guy, so I don't make decision, okay, what it said is true, I make sure that what it said, another resource might be true or not.

Interviewer: Okay, thanks so much. So, regarding the fourth subtopic, factors influencing the adoption of LLMs, Mr. P6, what factors may influence your decision to adapt or not adapt the LLMs in the energy transformation projects?

P6: What factors? When I read it, if I find it logical, like one logic thing, if I find it makes sense to use it, then I can take it as advantage for me. But if I can see it's not working right here, or it's not 100% true what you are talking about, so I ignore it, if I can say that.

So, the factor, the first thing about, I make my own judgment about what I am reading. I make it as a scenario in my head, okay, if I use it, will it be okay? If not, so it's not fine, because you can't judge what you are reading, if it's working here or not. So, the factors are personal, the factors are your own judgment of what you are reading and if it works right here or not.

I take it also, the factor of the company, it's my manager, how he's thinking, what's the strategy of the company, does it work with the company, what is the milestone of our company? Maybe what I'm thinking about is not what the company is thinking.

So, I need, because I am part of the company, I'm not the company, so I need to make something that relies under the strategy of the company that will help and enhance the improvements and the boosting of the company. you know what I mean? So, I need to be with the same page, so my thinking could be what I'm reading is fitting what the company's insight.

Interviewer: So, I think you partially answered my second question, because my question was about the organizational culture and AI literacy. So, you mentioned that the company and the organizational culture can also be an effect for influencing your adaption to AI, right?

P6: Exactly, especially if the company that you are working with is a family business, which is kind of, you know, the structural organizational family business is different from what it is like multicultural or international. So, the decision makers will be the family.

So, they are making the strategy, they are making the mission and vision, they are making the milestone movements. So, you don't know what they are thinking about, you don't know what exactly they are looking for. So, this might be a huge block, I can say that, while you are thinking of something, but the company, the family business between the brackets in different way thinking.

Interviewer: Thank you so much for your answer. And regarding the circumstances optimizing the most effective human-LLMs collaboration, in your experience, Mr. P6, does the way information is presented by LLMs (e.g. reports tailored to your cognitive preferences and task-specific needs.) impact your ability to make effective decisions?

P6: Yeah, as I said, it has an effect in a good way, if I can say. It gives me, as I said, enlightenment to understand what I am facing. So, as a short answer, yes, it has an effect, not a huge effect, not a main effect, but yes, I would not lie about that.

Interviewer: Okay, thank you so much. So, also, maybe the timing of LLM-generated insights, can they affect their usefulness? How does the timing of LLM-generated insights affect their usefulness in your decision-making processes?

P6: I am not, as I said before, I am not a big fan of AI, not because I am anti-AI, no, no, no, because, as I said, my work is very sensitive, and very critical, and very on my shoulders.

So, if I want to use it, I use it at the end to double-check. It's not the first thing I think, no, no, no. I rely on my experience, my knowledge, and if I need help, like something I don't know, or I need support technically, or financially, I ask the people that are around me, my manager, or my head department, you know what I mean. So, the timing, yes, is at the end.

Interviewer: Okay, thanks so much. So, the six subtopic challenges of human-LLM collaboration, so, what challenges have you encountered in collaborating with LLMs, particularly regarding interpretability, trust, or data privacy concerns? What were their impacts and what strategies or solutions have you considered overcoming those issues?

P6: Yes, trust issues is a personal issue. It's not something about the data privacy concern, or something, because I believe that the users of ChatGPT, we have been using it in different platforms.

The same question that I asked for AI, I could ask it for Google, or any platform that I ask questions. So, I believe it's not about that privacy, just issues about the information, about how the AI is capable to answer you, or to help you. You know what I mean.

Another thing that I don't like in AI, it's very general, and it gives you sometimes, I'm not saying it does not make sense, or it's not that what I mean. You are giving me just anything, I feel this, if I can say. Just give me very general, very non-particular things that just give me hundreds, and sometimes full of paragraphs that I don't need them.

You know what I mean. So, basically, it's good, but for something very specific, like as I have said, please give me like a template for additional. Please give me this translation, but in decision making, in something very particular, I don't think it's a good platform to use it so far, because it's very general, as I have said.

It's very wide, and if I ask it something, it just like throws hundreds of words, and I don't order them. I just need something very specific about that.

Interviewer: Thanks so much for your answer. And regarding the practical outcomes of LLM adoption, have you observed improvements in energy transition implementation or reduction in energy efficiency loss after adopting LLMs? What were the other practical outcomes of LLMs adoption?

P6: Actually, based on my work, I don't think it will work, because when you're asking for energy efficiency losses, you need to do something physically. You need to do something by your hands to get your measurements, to get your parameters, to visit the sites.

So I cannot handle a problem in an industry, like there is an energy linkage, or there is a problem in losing temperature at some point in the oven, and that's something you cannot deal with LLMs. And it's something happening physically, in the real world. I cannot ask, please, I have this problem, so help me.

I need to make energy auditing, I need to make a risk study, and to see what is the problem by myself. So no, no, actually, I don't think, basically, LLMs would help in real life, energy efficiency losses. The human must intervene.

Interviewer: Okay, thank you for your answer. So regarding my last question, LLMs' role in expanding the knowledge base of the firm and decision makers, Mr. P6, how do you think LLMs can help your organization and decision-makers enhance their knowledge base, particularly in the context of energy transformation?

P6: I don't think it will be a disadvantage or a bad idea if we ask AI that we are looking for to improve our department, or to scale up the company, or to do something new.

So basically, it gives you some outputs that might help to understand your situation and how you could improve yourself in the future. As I said, , in a nutshell, you cannot rely, yes, you cannot make a decision based on AI, but as I've said, in general, it can give you an enlightenment and a knowledge how you could start by improving your organization and decision making. You know your situation, you know your actual life, how it is, and you can ask AI, what could I do with that? And you can judge that this is true, this is not true, I can use this point.

It gives you an idea where you should start and what you should do about that. So it could help, it could help the organization.

Interviewer: So Mr. P6, this was my last question. I want to thank you once again for your time and sharing your insights and experience. Is there anything else you want to add that my questions have not addressed?

P6: Just I want the AI to be more verbatim. Just not to throw anything on the screen, please give me something very specific and very accurate. Just don't throw anything on the screen and that's it. Ah ah.

Interviewer: Ah ah, okay, thanks so much.

Mr. P6 thank you for your valuable insights today. Your contributions will help shape the research in understanding how large language models are being integrated into decision-making and strategy development regarding the energy transformation of companies. If you have any additional thoughts later, please feel free to reach out. Thank you again for your time.

Interviewer: I thank you once again for your time.

P6: My pleasure. My pleasure. I wish you best of luck. Bye-bye.

Interviewer: Thank you so much. Bye-bye.

INTERVIEW 7

Mr. P7 thank you for taking the time to participate in this interview session.

My name is Mehmet Çelik, and I am currently a master's student at the Technical University of Applied Sciences Würzburg-Schweinfurt. With my supervisor, Prof. Scheller, I am conducting a research study, which is "Enhancing Human Decision-Making in Energy Transformation of Industrial and Energy Companies by Leveraging Large Language Models".

The aim of this interview session is to explore your insights and thoughts on large language models and their role in your decision-making and strategy development processes regarding the energy transformation of your organization. Your perspective and insights will help us to better understand the interpretation and implementation of LLMs in those processes.

With your consent, I would like to record the conversation to ensure accuracy in capturing your insights. Please be assured that your and your organization's anonymity will be protected, and your and your

organization's names will not be mentioned in any of the reports or presentations. All information will remain confidential and will be used strictly for academic purposes.

Please feel free to bring up anything that a question reminds you of, or anything you think is relevant. Also, you don't have to answer any question you don't want to.

P7: Okay.

Interviewer: Okay, thanks so much. So, as an introductory question, Mr. P7, can you briefly describe your role in the company and particularly your involvement in the energy transformation projects?

P7: Yeah, sure. I'm an expert and deputy of innovation system design. And the company, yeah, so we work on the new PV applications, like photovoltaic, like agri-PV, floating PV, or exporting PV plus battery. So, our job and our team actually tries to close the gap whenever there is new need to, let's say, new solutions, new technology, let's say, in system, like in PV modules, inverters, or small extractor to help our, let's say, downstream engineering. And we are a bridge, yes.

So, we are a bridge between, let's say, our engineering and also external universities, research institutes, startups, let's say, solution providers.

Interviewer: Okay, thank you so much. So, Mr. P7, do you think artificial intelligence, particularly LLMs, can have a transformative potential for your company and broader industry?

P7: For our company, definitely. I mean, as an EPC project developer, AI can be used across the value chain. So, the answer is yes. We see this and we are behind it.

So, we always question ourselves what we are doing, how can we improve it with artificial intelligence. Yes. So, we think definitely, yeah.

Interviewer: Okay, thanks so much. So, my first subtopic is LLMs' impact on decision-making process. I would like to ask Mr. PP7, are you currently using or strategically planning to use large language models (LLMs) to support your decision-making in your company's energy transformation processes? Which specific LLMs do you use?

P7: For strategic planning and decision-making, I would say we are using now this AI or LLMs, more for enhancing our processes and making our work more efficient. And also using it to avoid repetitive work.

So, and of course, the question is, to what extent this helps in decision-making? This is a question, right? I mean, pick up an example. I'm just thinking, like, it's more, let's call it decision-making, technical decision-making.

So, this is true. So, sometimes, yeah, we use, let's say, LLM to kind of investigate high-level pros and cons of a technology, of a product, something like this, kind of high-level. So, okay, where we should, yeah, focus more on, put more our efforts.

So, overall, I would say it is helping in decision-making, but not, I would say, with the biggest weight. So, it's kind of give us indications, it helps us, okay, we consider it, but we have other KPIs where we look for decision-making. So, it's not only that one, yeah.

But technical, solving technical problems or repetitive work, it's definitely doing, we rely a lot on it. So, that's definitely true. Yeah.

Interviewer: So, how has the use of LLMs influenced the speed, accuracy, and quality of decisions made in your energy transformation projects?

P7: Well, I would say speed, definitely, like I mentioned. Speed in, let's say, in making repetitive work faster, or technical drafting faster. So, if you look to different departments, electric and our company, I think different departments can use it in different ways to increase speed, and maybe even sometimes to improve quality.

Now, the question is, you asked about accuracy. Accuracy, it's really, I would say, is objective. So, subjective, I cannot say in all departments, they are really accurate.

So, it depends, I mean, how you measure accuracy here. But I would highlight speed, definitely, and improving the quality, yes. Maybe not giving us a decision, but giving us, let's say, the way on how should we approach the problem.

What the right question to ask, a guide, kind of. What the right question to ask, and so on. So, to enrich the topic, it's kind of making the topic richer, and so on.

Interviewer: Thank you so much for your answer. And the second subtopic, LLM's role in strategy development and regulatory compliance, in your experience, how do LLMs assist in interpreting and implementing energy strategies and regulations tailored to your company's needs?

P7: Well, I think I'm not in that topic, in terms of regulatory compliance in the company. It's maybe more legal, and yes, so it's more, I'm not that, maybe, I'm not the right answer for this question.

But if you ask my opinion, I would say energy strategies and regulations related to our company, I mean, I would see it like, from my side, it's for brainstorming.

It could be really good to say, okay, now I have a team of, let's say, a team at developing strategy and regulatory frameworks, then how to brainstorm this and explore new paradigms or new frameworks,

something like this. I would see maybe LLMs add more value here. So, for brainstorming of this strategy development.

Interviewer: Thanks so much. So, do you feel LLMs can provide clear and accurate information for successful regulatory compliance and strategic planning?

P7: I didn't try it for this special topic, let's say regulatory compliance and strategy planning. But I would say, for other topics, like technical point of view, 60-70% accurate. I wouldn't say 100%.

But still, sometimes I feel like either we are not asking the right questions or there's something wrong with LLMs. Especially if you are an expert in the topic, so you can judge on accuracy of LLMs.

Interviewer: Okay thank you. So, in terms of LLMs' impact on ethical considerations and personal growth, Mr. P7, Do you believe that the use of LLMs can help promote ethical considerations in developing and implementing energy-related strategies?

P7: Here also I can only give my opinion. Related to ethics, I think so.

They should somehow have some ethics and promote the ethics in business, something like this, ethics in business. But the question is, in the end, it's like generative models. You never know whether these ethics are sufficient in that region, in that country, in that business, in that area, in that environment.

Actually, I don't see that they have a lot of experience answering this, but I believe they should have certain ethics. The question whether it's sufficient or not, I cannot comment a lot on this.

Interviewer: Thanks so much. So, in terms of personal growth, do you believe that the use of LLMs can help decision-makers explore diverse perspectives for their personal growth?

P7: Definitely, that's true. I mean, I think it's a chart, right? You start chatting with it and asking the right questions here and there and getting feedback and chatting more and going deeper.

I feel like, yes, it provides certain career paths, personal growth possibilities. Yeah, definitely.

Interviewer: Thanks so much. So, in terms of factors influencing the adoption of LLMs, what factors do you think can influence your decision to adopt or not adopt LLMs in your energy transformation projects?

P7: I would say being actual. So, I don't like to work with LLMs, which are outdated.

So, LLMs, which really has very strong insights to the market and has the market intelligence and LLMs, which is really smart that it combines. You know, in the end, decision making, it's very complex. Sometimes you have to involve the technical side, different stakeholders, politics.

So, I would say, yes, it has to be very actual and very smart that it considers all stakeholders and all possibilities and perspectives. And this is, I think, very important to improve the accuracy.

So, I would definitely consider how mature they are and how actual the data they have. Because in the end, you know, garbage in, garbage out. So, if you train your model with shitty data, you would get very low quality, actually, let's say, recommendations or something like this.

Interviewer: Okay thank you so much for your answer. So, regarding the second question, do you also think that organizational culture and AI literacy can be the other factors that influence your adoption?

P7: Yeah, definitely, I would say. I agree with this. So, yeah.

So, let's see. I mean, like, if I pick up an example in my, in our department in innovation, like, I mean, like, not every companies, very well established companies are often, yes, less actually easy to change to new products, to new setups and innovation setups. But if, if using these LLMs actually does provide solutions, which could be, could fit only, let's say, the new agile companies, but let's say our company, it's very well established, and they don't like this destructive change, then I don't see the LLMs actually fits the company's culture.

So, I think LLMs should differentiate between different companies in terms of company's culture to provide the right answers and to help for decision making.

Interviewer: Okay, thanks so much. So, circumstances optimizing the most effective human- LLM collaboration. In your experience, Mr. P7, does the way information is presented by LLMs (e.g. reports tailored to your cognitive preferences and task-specific needs.) impact your ability to make effective decisions?

P7: Yeah, of course. Yeah. Yeah, I would say, I mean, sometimes you look to a topic, or let's say decision making in a more comprehensive manner.

You would like to have a comprehensive answer from LLMs, where all, let's say, 360 degrees view is considered, means like all, from all perspectives. And I would say, this is crucial sometimes, more often actually for decision making. So the answer, yes, the way the information presented, it does actually help me.

Interviewer: Thanks so much. So in terms of timing of LLM generated insights, Mr. P7, how does the timing of LLM-generated insights affect their usefulness in your decision-making processes?

P7: That's a good point. I mean, like how often, I think often I do it at the beginning, I would say, it's for me, it's to, to, let's say, filter out the most, let's say, noisy information out there.

So kind of, yeah, filtering out the big, let's say, the big levers, and then the fine tuning, it's more doing deeper discussion with peoples. That's what I do. So for me, it has to be at the beginning.

Interviewer: Thanks so much. Regarding the challenges of human-LLM collaboration, Mr. P7, what challenges have you encountered in collaborating with LLMs, particularly regarding interpretability, trust, or data privacy concerns? What were their impacts and what strategies or solutions have you considered overcoming those issues?

P7: Yeah, our concern is always that, I mean, we use paid versions, which they claim, actually, that they, yeah, kind of, they have more data privacy, that, because you can easily, let's say, if you develop an LLM, so you give it to me, and then you can easily understand what is my next decision or my next product, just by the fact how I communicate with LLMs, right? And this is our concern, often.

Therefore, we are actually conscious, actually, which LLM we should use, and what data privacy this LLM has, because we are in a competition. And if I am, if, let's say, I'm developing products on solar, and they're using LLMs, and by my interaction with LLMs, you can easily know, actually, what is my next product.

And if this information is sold somewhere, so I am actually working against my interest in the end. And this LLM actually does not help, actually distracts me. So, we definitely see this, yeah.

Interviewer: Okay, thanks so much. So, what strategies or solutions can you consider to overcome those issues?

P7: Yeah, I would say, we don't look to, we don't work a lot with open source LLMs. We don't work with LLMs, which they have low data protection and privacy.

And also, yeah, so, whenever we think that, or we feel that, actually, there is some information leakage from LLMs, which we are using, we actually stop using it, actually, and focus more on, let's say, traditional way of working. And using more human way of decision making. So, it's more about, yeah, using something paid, but more secure. This is the way we are doing it.

Interviewer: Thanks so much. So, in terms of practical outcomes of LLM adoption, have you observed improvements in energy transition implementation or reduction in energy efficiency loss after adopting LLMs? What were the other practical outcomes of LLMs adoption?

P7: I would say, we have not been using it for many years, honestly. So, at least my team or, so, it's something new to us. I mean, we see, and then to evaluate the outcomes, I mean, maybe someone would need time, so that it's not too early to make kind of a statement here.

So, often, we need more time to collect the, yeah, to collect more results and do more, let's say more objective judgment.

But what I can tell you here, definitely, we see that LLMs actually helps us in efficiency gain, not loss, so far. But sometimes when I see that maybe this is going to be a future thing, I mean, like, we have to watch this, that when we go fast to LLMs, like, also for small things, then it makes maybe people a bit dummy, kind of relying too much, even for, yeah, something, maybe it's kind of not time demanding or really effort demanding. So, yeah, this is the risk issue.

I mean, the efficiency is improving, but the problem now, whether employee or, let's say, co-workers are relying on this too much that even non-necessary things, they're using LLM for it, like, it makes people to be more dummy, kind of. This is what I have to watch in the future.

Interviewer: Interesting. So, the last question of the session is about LLMs' role in expanding the knowledge base of the firm and decision makers. So, Mr. P7, how do you think LLMs can help your organization and decision-makers enhance their knowledge base, particularly in the context of energy transformation?

P7: Expanding knowledge, I would say, I have to highlight this and then underscore this is 100%. I mean, often, when we start discussing topics or, let's say, decision making on some areas, I think, as I mentioned, like, from the beginning, knowledge, brainstorming, looking from different perspectives, I see LLMs, they are very strong here. So, sometimes we miss some perspective and then LLM brings this out, we say, we never thought about this.

Now, decision making, I think, exactly for energy transformation, I would say, it's ranked second. So, expanding knowledge first, they are doing it really good, but they see LLMs for energy transformation, maybe they have to improve a lot. I mean, if you compare to other industries, they are very, very, let's say, advanced.

For energy transformation, I think, the LLMs are picking up, but still they're a bit behind. If you compare to, I don't know, other industries, maybe IT industry, for instance, software industry. So, they are actually, the LLMs are much faster, but energy transformation, they are getting it, but still, I think, I believe there is a big room for improvement to be really at that level of smartness for decision making, especially energy transition, energy transformation.

Interviewer: Okay, thank you so much, once again, for your time. Maybe, Is there anything else you want to add that my questions have not addressed?

P7: I mean, what, yeah, I mean, like, what I would like to add is the, like, especially when I look to energy companies, like, what is actually, like, how fast these energy companies are adapting to LLMs compared to other industries. I have a feeling always that this energy industry, they are lagging behind in terms of AI in general.

They're still working the classical way, but other industries are much faster. But this is actually, that's my experience, but it would be nice that if you reflect this in your questionnaire to see how these LLMs are doing better or worse in energy industry, energy transformation, compared to other industries. I don't know, because of the people in this industry, or because of industry itself, why there is kind of a slow adaptance to LLMs in this industry.

Interviewer: It was an interesting perspective. Okay, thank you so much, once again, your valuable insights were really helpful for the contribution to the study.

Mr. P7 thank you for your valuable insights today. Your contributions will help shape the research in understanding how large language models are being integrated into decision-making and strategy development regarding the energy transformation of companies. If you have any additional thoughts later, please feel free to reach out. Thank you again for your time.

Interviewer: Okay, thanks so much. So, I hope you have a nice day and thank you so much once again for your time.

P7: No problem. Yeah, my pleasure. Ciao.

Interviewer: Okay, ciao, bye-bye.

INTERVIEW 8

Introduction part

Mr. P8 thank you for taking the time to participate in this interview session.

My name is Mehmet Çelik, and I am currently a master's student at the Technical University of Applied Sciences Würzburg-Schweinfurt. With my supervisor, Prof. Scheller, I am conducting a research study, which is "Enhancing Human Decision-Making in Energy Transformation of Industrial and Energy Companies by Leveraging Large Language Models".

The aim of this interview session is to explore your insights and thoughts on large language models and their role in your decision-making and strategy development processes regarding the energy transformation of your organization. Your perspective and insights will help us to better understand the interpretation and implementation of LLMs in those processes.

With your consent, I would like to record the conversation to ensure accuracy in capturing your insights. Please be assured that your and your organization's anonymity will be protected, and your and your

organization's names will not be mentioned in any of the reports or presentations. All information will remain confidential and will be used strictly for academic purposes.

Please feel free to bring up anything that a question reminds you of, or anything you think is relevant. Also, you don't have to answer any question you don't want to.

P8: All right.

Interviewer: So my first introductory question is Mr. P8, can you briefly describe your role in your company and particularly your involvement in the energy transformation projects?

P8: Sure, so my role is I'm product manager for energy mainly and I focus mainly on integration of energy services to our customers. So we have, I'm part of X Company team called ETP and we offer electrification for fleets that want to become electrical and buy electrical vehicles, electrical trucks and large fleets. And my role is mainly to find ways to integrate energy optimization and energy management within our software to support our clients to use their energy efficiently and in the best prices.

Interviewer: Okay, thanks so much. Mr. P8, do you think artificial intelligence, particularly large language models (LLMs), have a transformative potential for your company and broader industry?

P8: I think definitely, so first of all they can have a lot of, the first big impact would be on our, how we do research to in different markets, how to, how do we understand how the energy market works, so that's the first step. And then also in the future when we want to do any energy optimization, we want to also understand how the market is working and when would be the best times to use the energy, using those kind of models would be very helpful as well.

Interviewer: Okay, thanks so much for your answer. So, the first subtopic is LLM's impact on decision-making process. Mr. P8, are you currently using or strategically planning to use large language models (LLMs) to support your decision-making in your company's energy transformation processes? Which specific LLMs do you use?

P8: Yes, so we have access to a version of ChatGPT in our company, so we can use it in order to ask some questions, in order to take some information, to help us with our research and also with some of the design if needed, if we have to do, if I have to do some coding that I need some support in, I would also be use it, because I'm not a software engineer, so if I need to do some kind of basic software engineering, I would use it sometimes.

So definitely it is being used, but eventually we, personally at least, I need to learn how to integrate it more in the processes.

Interviewer: Okay, thank you so much. So my second question is how do you think the usage of LLMs can influence the speed, accuracy and quality of decisions made in your energy transformation projects? Can they be helpful for your decision-making?

P8: Maybe they can be helpful to support a decision-making, it's when you use LLMs, it's easier to find some information sometimes and maybe to automate some of your decision-making, but eventually, definitely it will help, maybe not the decisions will not made purely based on LLMs, but they can play a role in supporting the decision.

Interviewer: Okay, thanks so much. So my second subtopic is LLMs' role in strategy development and regulatory compliance. In your experience, how can the LLMs assist in interpreting and implementing energy strategies and regulations tailored to your company's needs?

P8: So again, if I use them for researching and understanding the markets, then it's good to use them to understand how the regulations in each market are working. Eventually, I need to also double-check all the information with the experts, with experienced people on regulation topics, but at least they can give me a broad image on what to expect for each market.

Interviewer: Okay, thanks so much. So regarding the second question, do you feel LLMs can provide clear and accurate information for successful regulatory compliance and strategic planning?

P8: They do actually, but sometimes it's hard to know how up-to-date it is, and you need to check the references, and you have to ask some more experienced people in regulation, so it's not purely relying on the data from there.

Interviewer: Yeah, okay, thanks so much. So the third subtopic is LLMs' impact on ethical considerations and personal growth. Do you believe that the use of LLMs can help promote ethical considerations in developing and implementing energy-related strategies?

P8: I'm not sure if I am related with this scope. I'm not sure how to answer, to be honest. They might help, again, so not sure, yeah, not sure.

Interviewer: Okay, thank you. Maybe, like, in terms of personal growth, do you believe that the use of LLMs can help decision-makers explore diverse perspectives for their personal growth?

P8: Sure, so they give broader potential to learn some new stuff and to understand different topics, so for personal growth, they are very supportive.

Interviewer: Okay, thanks so much. So, in terms of factors influencing the adoption of LLMs, Mr. P8, what factors influenced your decision to adopt or not adopt LLMs in your energy transformation projects?

P8: So, usually, if it's a very new topic where I need to get some additional information, that drives me mainly to, and I need to do, for example, some research, then I might use LLMs. If it's a typical project with previous calculations already made and the research already done, then I wouldn't really use it a lot. Sometimes, when I have extra time to update some of my calculations, my Excel sheets, then I can also rely on LLMs to make it more efficient.

Interviewer: Okay, thanks so much. So, do you think that maybe organizational culture and AI literacy is another factor that influenced the adoption?

P8: Yeah, definitely. So, we got access, again, to some sort of an instance from ChatGPT that is related to the company. So, that definitely gives us more doors to use it and in a kind of regulated way.

So, it encourages you to adopt the usage of it when it's needed to increase your efficiency.

Interviewer: Okay, thank you for your answer. So, circumstances optimizing the most effective human-LLM collaboration. In your experience, does the way information is presented by LLMs (e.g. reports tailored to your cognitive preferences and task-specific needs.) impact your ability to make effective decisions?

P8: To be honest, this is one of the struggles I have with LLMs. So, I feel it doesn't always reflect what you need. So, sometimes you want a short answer and it gives you a very broad one. And sometimes you want to dive deep into a topic, but then it decides to give you a very short answer.

So, it depends on what you need, but I feel it doesn't always really reflect what you need at each moment. And this is a bit time consuming because you have to ask again and then you have to dive deeper in your questions. But yeah, that's it.

Interviewer: Yes, okay. Thanks so much. So, you think that this is one of the problems right now with LLMs, right?

P8: Yeah, I feel it doesn't always get, which is okay, it doesn't have to do it anyway. But it doesn't always understand how deep you want to dive into something and then it can give you an answer that you would expect something different. And it takes some time and it makes it sometimes useless because if you want to ask questions for 30 minutes to get an answer, then maybe it's easier to search for it in the usual ways.

Interviewer: Thanks so much. So, how does the timing of LLM-generated insights can affect their usefulness in your decision-making? So, for example, do you prefer to use LLMs at the start of a decision-making process or do you prefer to use at the end to just double-check your own decision?

P8: No, it can go in parallel with your work. So, if I'm doing a research or if I'm developing a document, then it makes sense to start with it from the beginning. So, whether laying out how the outline would

be and then also getting a first picture on how your research would look like and then you start developing it at the same time, let's say. Okay. So, from the beginning and or from maybe after you start in a bit.

Interviewer: Okay, thanks so much. So, in regard of challenges of human-LLM collaboration, Mr. P8, what challenges have you encountered in collaborating with LLMs, particularly regarding interpretability, trust, or data privacy concerns? What were their impacts and what strategies or solutions have you considered to overcome those issues?

P8: Yeah, so regarding data privacy concerns, so since we have an instance of ChatGPT developed by the company, then we don't really have this issue, at least internally. Definitely, there's an issue of trust because, you know, sometimes some of the information you ask for a reference and then it's not really an acceptable one or it's not really understandable how the information was developed. So, I can never purely trust the data coming from ChatGPT or any other LLM.

So, sometimes you have to double check it by yourself if you already have some information in mind and then you confirm it from the LLM, it can work. Interoperability, as I said before, so sometimes you expect more data and then you get less and then sometimes you expect some short concise answers and you got a paragraph that you also need to analyze.

Interviewer: Ok thanks so much. So, in the context of practical outcomes of LLM adoption, have you observed, Mr. P8, any improvements in your energy transition implementation or any reduction in energy efficiency loss in your projects after adopting LLMs? What were the practical outcomes of LLM adoption in your company?

P8: So, I would say it's not maybe directly an energy efficiency reduction, energy efficiency loss, but at least it can support with your analysis and your study prior to the implementation of the project. So, it maybe accelerates some topics, accelerates some implementations, so that would be how the adoption helps more.

Interviewer: So, my last question of the session is LLM's role in expanding the knowledge base of the firm and decision makers. How do LLMs, Mr. P8, do you think that can help your organization and decision makers to enhance their knowledge base, particularly in terms of energy transformation projects? So, can LLMs help you to provide maybe competitive advantage in your industry?

P8: So, if you know how to use efficiently the LLMs and it can really grow your knowledge again and you can, the energy market is very big and each country is different and there's always new regulations. So, to stay up to date, it's sometimes very difficult. So, using, being able to navigate the LLMs and asking the right questions would help you definitely better understand, better understand this market

and different countries, different regulations and this definitely would create, increase your knowledge base and create a competitive edge.

Interviewer: Okay, thank you so much. So, Mr. P8, is there maybe anything else you want to add finally that my questions have not addressed or anything you would like to indicate?

P8: No, all is good.

Interviewer: Okay. So, thank you very much for your time Mr. P8 today.

Mr. P8 thank you for your valuable insights today. Your contributions will help shape the research in understanding how large language models are being integrated into decision-making and strategy development regarding the energy transformation of companies. If you have any additional thoughts later, please feel free to reach out. Thank you again for your time.

P8: Yeah, definitely.

Interviewer: Okay, thank you so much. I wish you a nice week. Thank you so much.

P8: All right. Good luck.

Interviewer: Thanks. Bye-bye.

INTERVIEW 9

Mr. P9 thank you for taking the time to participate in this interview session.

My name is Mehmet Çelik, and I am currently a master's student at the Technical University of Applied Sciences Würzburg-Schweinfurt. With my supervisor, Prof. Scheller, I am conducting a research study, which is "Enhancing Human Decision-Making in Energy Transformation of Industrial and Energy Companies by Leveraging Large Language Models".

The aim of this interview session is to explore your insights and thoughts on large language models and their role in your decision-making and strategy development processes regarding the energy transformation of your organization. Your perspective and insights will help us to better understand the interpretation and implementation of LLMs in those processes.

With your consent, I would like to record the conversation to ensure accuracy in capturing your insights. Please be assured that your and your organization's anonymity will be protected, and your and your organization's names will not be mentioned in any of the reports or presentations. All information will remain confidential and will be used strictly for academic purposes.

Please feel free to bring up anything that a question reminds you of, or anything you think is relevant. Also, you don't have to answer any question you don't want to.

P9: Okay sure, no problem.

Interviewer: Thank you so much. So, I have eight sub-themes today. For each of them, I have one or two questions. So, if you want, we can start with some introductory questions.

So, can you briefly describe your role in the company and particularly your involvement in the energy transformation projects?

P9: Yes. So, yeah, my name is P9, working in the field of HVDC, so high voltage direct current. And so, I'm a project certified project director.

So, that is a certification level in project management. And I'm also responsible for project management office, so the governance of projects within that area of HVDC business. So, that is my role.

And what we are doing is we're doing these HVDC converter stations. So, connecting, for instance, offshore platforms where the wind is generating electrical energy and bringing that to shore. And that you can do with this technology only as well as on these so-called highways in Germany.

But also, it's a global business. We have businesses worldwide or projects worldwide. So, in UK, US, India, China, also in Australia, and so on. Yeah, that's in brief.

Interviewer: Thanks so much for your answer. Mr. P9, do you think artificial intelligence, particularly LLMs, can have a transformative potential for your company and broader industry in the future?

P9: Yes, I think so. Because it is so that we're getting more and more data in or collecting more and more data. And so, that requires some kind of artificial intelligence or currently, we call it large language models as you do that as well. I don't know if it's really AI already, let's say, to digest all the numbers and all the data what we have and to get much quicker inside view of the database what we have.

So, that goes hand in hand with digitalization. So, we need to have all the information not just in, let's say, on writing, I mean, that we're not doing anymore, but also not just in Excel sheets or whatever. It needs to be much more digitalized in order to get these tools, these models as AIs to get access to this data.

Interviewer: Okay, thanks so much for your answer. So, my first sub-theme is LLMs' impact on decision-making process.

So, Mr. P9, are you currently using or maybe strategically planning to use LLMs to support your decision-making in your company's energy transformation processes or projects? If you use, which specific LLMs do you use at the moment? Maybe ChatGPT?

P9: Yeah, it's ChatGPT. I mean, the topic for us is here that, I mean, I would say we are in the beginning of it. We have it already, so rolled out and connecting more and more systems to it.

The topic is more that we need to protect our data, meaning we cannot open it up to ChatGPT as we know it from private use, let's say, where you connect to an external server and then you're sending all the data there, coming back, analyzing it. So, that is not possible for company because we need to secure our data, but as well as the data of our customers. So, we are legally bound and that's why it's a bit of limitation in it.

So, we need to build up our own database, if you want to say. So, what trains these models? So, that is what we are currently doing. So, I would say decision making is not yet done, but we are on a good way to do that really, to use it more and more now.

Interviewer: Okay, thank you. So, Mr. P9, maybe if you use it for decision making in the future, how do you think the usage of LLMs can influence the speed, accuracy and quality of decisions made in your energy transformation projects?

P9: I would say it will be much faster. So, let's say at least because for every decision what you need to take, you need to have a basis for.

So, first of all, what's the topic and then what options do you have and what are the alternatives and so on and so on. There are a lot of, let's say, indicators what you need to use in order to take a decision. So, an LLM could definitely help you to get this information much faster, but also maybe a change of the perspective because the LLM sees much more at the same time as a human being could do. So, that's how I see it.

Interviewer: So, my second sub-theme is LLMs' role in strategy development and regulatory compliance. So, maybe in your experience, Mr. P9, how do you think that LLMs can assist in interpreting and implementing new energy strategies and regulations, maybe tailored to your company needs?

P9: I mean, as I said earlier, so it's getting much more information at the same time. What might be helpful is to connect these LLMs also to regulatory bodies. So, like governmental bodies or any others.

So, like what is it also, whatever we have for in UK, we have different, let's say, setups. Other topic is for me also requirement management. So, that your requirements are in the same form that are transferred from, let's say, from governments or from our customers to us, so that we can implement it in our LLM and by that using that much faster and analyzing it.

Because the requirements is a huge topic and it's hard to overview that. So, I think, yes, that is one field where we need to focus on.

Interviewer: Okay, thanks so much. So, do you feel LLMs provide clear and accurate information for successful regulatory compliance and strategic planning?

P9: Yeah, for me, in that field, it is also important and that is what we are doing when we are using AI internally, that the source is also given. So, it's highlighted then, so where it is from.

Interviewer: Thank you. So, in regard of LLM's impact on ethical considerations and personal growth, Mr. P9, do you believe that the use of LLMs can help promote ethical considerations in developing and implementing your energy-related strategies?

P9: Yes, for sure. I mean, an LLM is, I would say, the quality of it depends on how you program it or how you would train it. And by that, if you put ethical aspects in it, for sure, then you can use it also.

But that requires a strong governance also from the company. So, as we are doing it, for instance, putting it in, but it is also depending on where you use it. If you use it, for instance, in HR sector, then you need to make sure that you don't disqualify certain people from certain nationalities or backgrounds or whatever.

So, by that, you could abuse an LLM, for instance. So, that would require strong governance and also monitoring it internally. So, you have these ethical considerations in it.

It's less an aspect for us than the transformation, energy transformation currently. So, it's more people-related, I would say.

Interviewer: Okay. Thanks so much. So, in terms of personal growth, do you believe that the use of LLMs can help decision-makers explore diverse perspectives for their personal growth?

P9: I think so. Yeah. Again, if you train the LLM like that, then you can have a much wider picture. So, what we're using, for instance, is also a cultural wizard.

So, to see what kind of different cultures do we have and to map it and so on, and that helps. So, I'm in a project area, and then it's important because currently we are collecting, let's say, if you have a new project in Germany, then it does not mean that we have only Germans there. So, we have an INOPC, we have an engineering set up in India.

We have a lot of good engineers there. But that requires a much stronger or a different way of cooperation and listening to each other. And then we are getting people from US, from UK, from Sweden.

So, it's a bunch of different cultures, but also different other backgrounds, religion-wise. I mean, that has not a real aspect, but it's swings in the background, for example. But also, if it's man, female or male.

So, it's different aspects here. That can definitely be do. And also, when you are, let's say, introvert, then an LLM could help, for instance, introverts to speak up.

Interviewer: Thanks so much. So, regarding the factors influencing the adoption of LLMs, Mr. P9, what factors influenced your decision to adopt or not adopt LLMs in your projects?

P9: I mean, what drives us is also to be, let's say, market leader. And by that, you need to go, let's say, you need to go with the latest technology.

So, to speed up and to keep on the same level as others are, or even being ahead of them. And so, that is a clear message. But I mean, we will take it also on the constantly check it as other processes or other things as well, other tools and so on.

Is it needed? Yes or no? Is it bringing any value added to what we are doing or not? So, that is always, let's say, on the discussion board. I mean, not every month or so, but it's a general discussion. Is there value added for us and for our customers and for the society, maybe even yes or no? And I would say, yes, it is.

But that is what drives it. And it's also interesting.

Interviewer: Thanks so much. So, Mr. P9, maybe do you think that organizational culture and AI literacy is another factor that influenced the adoption?

P9: Yeah, absolutely. I mean, it's an LLM to implement an LLM or set it up and really using is two different things. So, it's a cultural topic or it's a change topic.

So, people need to change their thinking. So, I mean, LLMs or ChatGPT is now, let's say, kind of buzzword meanwhile. But especially people that are, let's say, in an older generation, they often have a problem also to adapt and to use it.

And so, of course, they are used to do that in a different way. But then, for instance, for these AIs, what we have is that we give training, we have a support team and so on. So, that is absolutely needed in order to get a better acceptance in our organization.

Interviewer: Thanks so much. So, in terms of circumstances optimizing the most effective human-LLMs collaboration, Mr. P9, in your experience, does the way information is presented by LLMs (e.g. reports tailored to your cognitive preferences and task-specific needs.) impact your ability to make effective decisions?

P9: Yeah. So, what I see is, of course, we are at the start of that. So, we have that rolled out and I think there is still a big learning curve. How to use it? So, you need also to know how to get good information out of it. Of course, the LLM as such is not smart.

So, it's just taking the, let's say, the likelihood of an answer. How likely is it and that could give you the answer. So, you always need to cross-check the information.

And then, yes, to get reports out that we partly have already. So, it's also kind of automated. So, it's a question, is it automated or is it really an AI? So, but yes, that is definitely been on the agenda to have more automated reports.

So, I mean, we have automated reports, but then it's a question you need to ask specific different topics that is out of the normal path and then the LLM should definitely take over and not just by short answers.

Interviewer: Okay, thanks so much. So, Mr. P9, how does timing of LLM-generated insights can affect their usefulness in your decision-making process? So, for example, do you prefer to use them at the end of a process to double-check your own decision-making or do you prefer to use it at the start of the decision-making process?

P9: Well, that is a good topic that I haven't thought about yet.

So, it's also a bit, it could be a bit dangerous. So, one thing is that is, I mean, I'm just talking now without having thought of it before. So, it definitely helps also when you want to take a decision.

So, upfront, yeah, or during the process, but also having a kind of cross-check. Dangerous is what I mean is that you could cross-check people, their performance, their decision and question them. So, that is an area where it could be, where we could create conflict between an LLM or an AI and our colleagues in an organization.

So, that needs to be somehow accompanied by a kind of mentor or something. So, a human being who still can judge also and say, yes, that is right or no, or the AI had much more information on it. So, the decision would be different than a human being who cannot process that many information at the same time and so on. So, that is what I would say.

Interviewer: Thanks so much. In regard of challenges of human-LLM collaboration, Mr. P9 what challenges have you encountered in collaborating with LLMs, particularly regarding interpretability, trust, or data privacy concerns? What were their impacts and what strategies or solutions have you considered overcoming those issues?

P9: Real challenges are more what I mentioned earlier, so that we have data privacy topics.

So, it's not about me as a person or as an employee of my company, but it is more about the data, our IPP or intellectual property. So, that we will need to keep and that needs to be clear. So, where is it from? So, what we are doing is, for instance, we have clear internal instructions who has access to what data and our AI knows that and analyzing all the data where you have access to.

So, you could, when I ask an AI, I get the results and if a colleague with different access rights puts the same question to the LLM, then could get a different answer or even a different proposal for a decision. Now, so that makes it also a bit complicated, but that is one of the biggest concerns to really to keep it. So, the data privacy and also towards our customer.

So, the customer X doesn't want to make sure that information is not leaking to someone else via our company. For instance, that could easily happen. So, that why we are strictly separating the information.

Interviewer: Okay, thanks so much for your answer. So, in the regard of practical outcomes of LLM adoption, so you said that you are at still early state of using LLMs, but in the future, can you observe any improvements in your energy transition implementations and any reduction in your energy efficiency loss after adopting LLMs? So, what can be the practical outcomes of LLM adoption for your company in the future?

P9: I would say, yeah, it will be, we will see improvements. So, in the speed of taking decision and also of accuracy of decisions, yeah, that I definitely see, but the LLMs need to further being trained on that.

So, limited factor is this data privacy because the ChatGPT outside has a much wider data from around the world than what we are using. So, and that is a limiting factor and that I do not know currently how that could be, let's say, overcome now. So, there could be that we increase this improvement, but then it will be saturated at a certain level or, as I said earlier, would be partly opened up.

So, like requirements management from our customers that we have a joint database where we have access to, but it's fed into the LLM as an example that I could see just talking loud, initiatives going on and so on.

Interviewer: Thank you for your answer. So, the last question of the session is Mr. P9, in terms of LLMs role in expanding the knowledge base of the firm of decision makers, how do you think LLMs can help your organization and decision makers to enhance their knowledge base, particularly in the context of energy transformation projects? So, can they provide a competitive advantage in the industry?

P9: Yeah, definitely because we are talking about here, for example, about lessons learned.

So, we have many projects and so, projects never go 100% straight. So, we have some problems with our sub suppliers, our own problems and so on, and they are observed. And then it takes quite a while until they're really being changed so that our problem does not occur anymore.

But you need to be on top and quite fast. If you have one project, in one project or problem, you want to transfer that quite quickly. And with this one, with an LLM, that definitely could help, for instance, and that accounts for lessons learned to a knowledge base.

So, it's less knowledge in form of, let's say, our coding or whatever, but it's more on our, let's say, really our daily work where we need to act quite quickly. It could be, for instance, one of our sub suppliers is bankrupt and it's the same sub supplier somewhere else in another project. So, and because we are working across countries or even continents, so it's hard to think, whom should I contact in that case? We have some mechanism, but they are not fast enough, I would say.

That will be one of the topics here, I would say, where it definitely can enhance our speed here.

Interviewer: So, Mr. P9, this was the last question of the session. Maybe is there anything else you want to add as a conclusion that my questions have not addressed or anything else you would like to express?

P9: No, actually not.

Interviewer: Okay, no problems. Mr. P9, thank you very much again for your time and your contribution. It was really beneficial to interview with you and to be able to get your expertise in this field.

Mr. P9 thank you for your valuable insights today. Your contributions will help shape the research in understanding how large language models are being integrated into decision-making and strategy development regarding the energy transformation of companies. If you have any additional thoughts later, please feel free to reach out. Thank you again for your time.

Interviewer: Okay. Again, thank you so much for your contribution and your time. I wish you a nice day. It was nice to meet you. Yeah. Thank you.

P9: Same to you and all the best for your master's thesis. Thanks so much. Bye-bye.

Interviewer: Thank you. Bye-bye.

INTERVIEW 10

Mr. P10 thank you for taking the time to participate in this interview session.

My name is Mehmet Çelik, and I am currently a master's student at the Technical University of Applied Sciences Würzburg-Schweinfurt. With my supervisor, Prof. Scheller, I am conducting a research study, which is "Enhancing Human Decision-Making in Energy Transformation of Industrial and Energy Companies by Leveraging Large Language Models".

The aim of this interview session is to explore your insights and thoughts on large language models and their role in your decision-making and strategy development processes regarding the energy transformation of your organization. Your perspective and insights will help us to better understand the interpretation and implementation of LLMs in those processes.

With your consent, I would like to record the conversation to ensure accuracy in capturing your insights. Please be assured that your and your organization's anonymity will be protected, and your and your organization's names will not be mentioned in any of the reports or presentations. All information will remain confidential and will be used strictly for academic purposes.

Please feel free to bring up anything that a question reminds you of, or anything you think is relevant. Also, you don't have to answer any question you don't want to.

P10: Yes, ok.

Interviewer: If you want, we can start with the introductory questions. So, Mr. P10, can you briefly describe your role in the company and particularly your involvement in the energy transformation projects?

P10: Yes, I'm a project director for the European zone for a company that produces inverters and makes also transformers for the photovoltaic sector.

Interviewer: Okay, thank you. So, do you think artificial intelligence, particularly large language models, can have a transformative potential for your company and broader industry in the future?

P10: Yeah, definitely. Yes, it will be integrated.

Interviewer: Okay. Are you currently using or strategically planning to use large language models (LLMs) to support your decision-making in your company's energy transformation processes? Which specific LLMs do you use?

P10: Yes, it's like on the overview, but like for a specific part.

In this case, for example, for the inverters in the IVQ analysis of the data to take decision how the energy has been produced and like see how we can make more efficient this part. But in other parts of the process or in other part or generally in the technology is not like taken into consideration for

taking decision. It's more about the using the data and like the inverter itself can take decisions by changing the parameters from the electrical operation.

Interviewer: Okay, thanks so much. So, how has the use of LLMs influenced the speed, accuracy, and quality of decisions made in your energy transformation projects?

P10: Well, as we didn't use it directly into the projects itself yet, I think that I cannot answer this.

Interviewer: Okay, okay, thanks so much. So, in the regard of LLMs' role in strategic development and regulated compliance, like even if you didn't use LLMs or ChatGPT in this context yet, in your experience, how the LLMs can assist in interpreting and implementing new energy strategies and regulations tailored to your company needs? Can they be helpful for this field?

P10: I think that is like a potential use of this and in terms of like make more agile the analysis of the data and take decisions to take like more quickly response and also to identify risk if they are like user appropriate.

Interviewer: Okay. So, Mr. P10, do you feel LLMs can provide clear and accurate information for successful regulatory compliance and strategic planning?

P10: I think they can, but I don't know, I'm not expert on the topic, but I think that there is still like some gaps or mistakes in the interpretation for, for example, for ChatGPT or other intelligence artificial that I think that is not appropriate at the moment, but that's my feeling as I'm not expert on the topic.

Interviewer: Okay, thanks so much. So, in terms of LLMs' impact on ethical considerations and personal growth, Mr. P10, Do you believe that the use of LLMs can help promote ethical considerations in developing and implementing energy-related strategies?

P10: Yeah, I think it could help, but also it could like put at the risk like some, for example, data as like as I hear, like if you put it like some contract or some information into these learning machines, you will have to take the information and it could be vulnerable for this. So, I think that for ethical itself depends the approach or the perspective it could support, but also it could be like a potential risk.

Interviewer: Okay, thanks so much. So, in terms of personal growth, do you believe that the use of LLMs can help decision makers explore diverse perspectives for their personal growth?

P10: Yeah, definitely. I think that it can be like potential like to explore different perspectives and also like to have different results and maybe like make more agile the selection of one that is better.

Interviewer: Okay, thank you. So, factors influencing the adoption of LLMs. What factors, Mr. P10, influenced your decision to adopt or not adopt LLMs in your energy transformation projects?

P10: I think one would be the trustworthiness of the technology itself to analyze better on the human side and be no more like a programming, but like actually like take a decision based on the behalf of all of the information. And from my perspective to have all of this information as like lessons learning and stuff, like usually the companies have it in a different format, so it will have like some process to integrate this past for this system and start to implement it for the future.

I think it could be one. Another, the risk on the data internally from the company, like to be open for using this. I think that there should be like more close language into the company to don't be a risk, especially the data protection of the clients or like some information that is critical, for example, diagrams or like patents on the company and stuff that they should be inconsiderate.

And also how to adopt all of these technologies into this industry for the project itself to start to take it. I feel like the bridge between like the person that they are making the projects and the people that this technology is still a little bit like far away to start to integrate them together. And I think that could be one of the main points to bring someone on the company that can manage this information and the technology.

Interviewer: Thank you for your answer. So regarding the second question, do you think that organizational culture and AI literacy can also be other factors that influence the adoption and use of LLMs?

P10: Yeah, definitely. Especially here in Germany, I have been difficult a little bit myself to integrate new technologies into the process.

And I think that there was like something cultural in other countries as like, for example, United States, it's a little bit more open to integrate this type of technologies. But here in Germany, we still have to use the post for some information. So I think that definitely influence.

Interviewer: Okay. Thank you very much. So regarding the circumstances optimizing the most effective human LLM collaboration, in your experience, does the way information is presented by LLMs (e.g. reports tailored to your cognitive preferences and task-specific needs.) impact your ability to make effective decisions?

P10: Well, I think that it will also depends on the on the task or in the answer that we are looking for.

If we are talking about, for example, just like a consultation to look it up, like information between a project or like Q&A answer, I think that they will be short. But if we are talking tasks more complex, such as like calculations, for example, to, I don't know, get like the dimension of a transformer or archival in stuff, I think we will need a little bit more detail.

And as far as I know, one engineer was trying to do it. And the numbers at the end was like some discrepancies because of this lack of detail. So I think it will depend on the approach.

Interviewer: Okay, thank you very much. So regarding the timing of LLM, how does the timing of LLM generated insights can affect their usefulness in your decision making process? So for example, do you prefer to use maybe ChatGPT at the start of a energy project or during the whole process? Or do you prefer to use it only at the end to double check maybe your own decision?

P10: Yeah, I think that it would be better like to have the income of like several scenarios and then get back to analyze with these technologies. The best one with some considerations and have my own opinion after. But I think this will be changed in the next year when the AI gets like a little bit stronger on their answers.

Interviewer: Okay, thank you very much. So, regarding the challenges of human-LLM collaboration, what challenges have you encountered or can you encounter in the future in collaborating with LLMs? Maybe particularly regarding interpretability, trust or data privacy concerns? What can be their impacts and what strategies or solutions can you consider overcoming those issues?

P10: Well, I'm not like really involved in this, but as a contractor and like from the project side, I think that this could be like some issues regarding the information and the scopes on the contract that the company makes with this, like for example, ChatGPT companies in terms of how they are using the data and how they are exporting the data to the next person.

And there will be one of them because at the end, I believe that you cannot just tell them like, hey, don't use my data, but you want to have access to other data to get like the machine learning. I think will be one of the challenges to see how they can protect in the part. And maybe it could be like, so how like agreement between the two companies for a specific task or like even also getting involved the language and like how this strategy will get into the project itself with some limits and maybe so how get like configuration.

But I think that the most of these challenges, you can get like writing down in the contract and the configuration of the response of the information protection, I believe, but I'm not sure.

Interviewer: Okay, thank you very much for your answer. So regarding the practical outcomes of LLM adoption, maybe have you observed or can you observe in the future any improvements in energy transition implementation or reduction in energy efficiency loss after adopting LLMs? What can be the practical outcomes of LLMs adoption?

P10: Yeah, I saw that there is definitely like room for this in energy efficiency part.

But I saw it more as a like analysis and like results or like definitely some options to take rather than taking decision by itself, at least in the projects that I am, that is like the photovoltaic projects. From the energy efficiency part, I think that is easier like the context like decide if we turning on a light or

turning off for the consumer on the heater and stuff because I think that the parameters and the room from there is like more, how would say, like more close. If the room is cold, then you heat it.

And yeah, I think that can take that decision based on these parameters. But on the photovoltaic power plants installation, I saw it a little bit more complex taking this part of decision by itself because you have so many different factors. There could be the TSO, you have another park around and yeah, the decisions has to be taken like quite quickly in terms to don't saturate the grid, for example, to know if you have to turn off like one MBS or like one string fully, or like it will be different situations that I think that on this moment, as the grid is not 100% intelligence itself.

I saw it quite difficult that the year can have all of these data and these considerations for all of the factors. I'm not saying that it's impossible to do it, but I'm saying that like the industry itself and the installation, the physical installation itself is still maybe not ready for now to take in this. So I saw it more room by the maybe five or 10 years on the way that the energy transmission lines is working on it, that it will be more use it for like make a scenarios and approach to give like more close decision without less mistakes and more like chance to be successful rather than taking decisions around itself.

Interviewer: Okay, thank you very much for your answer. So the last question of the session is LLM's role in expanding the knowledge base of the firm and decision makers. So how do you think Mr. P10, LLMs can help your organization and decision makers enhance their knowledge base, particularly in the context of energy transformation projects? So can LLM's be helpful for competitive advantage in your industry?

P10: Well, I think that could be like assign some tasks and some like a specific parts of the projects.

For example, if we are modulating a PV system, like it could be interesting to have like this mapping of the system and integrating the full model to the EIA and say like, okay, what is the best place to have the solar panels, for example, and what would be the best option to have the inverter in terms of like losses by the distance, the shadow of the panels, or also like to have so how these like, okay, these are the regulations on Spain, on Italy, in Ireland, you will need like this part.

So, so how more like a, like a having like a database that it can help you to take some decision and expose you some of the risk. And then like the project manager or the, or the, or the designer of the project, it could be like taking this into consideration and to have more so how like some incomes and some outcome from the year that then like just have it all of it.

So maybe by a few parts and soft software that we integrated, they could actually start to, to have to avoid race and reduce the time zone on the design part that I think that at the moment is where we are having more, more issues.

Interviewer: Okay. So thank you very much, Mr. P10. So maybe, is there anything else as a conclusion you want to add that my questions have not addressed or anything else you would like to mention?

P10: Well, just like a comment, I think that is important, but you are doing it because it's like definitely like opening this question into the energy part, especially on the, on the project, on the, on the project design and project implementation.

Because so far now, like one of the huge part of the, of the challenge by the, by the energy transformation sector, it is the cost on the, on the projects, not itself the technology, but all the challenges around and all the timings. So I think that if we can integrate all of these into a project assistance or a project review, I'm pretty sure that we can reduce lots of timing, lots of money, lots of risk that in the beginning, maybe they are considered, but like you have so many factors that at any stage you're like going to take a quick decision. And I think that the AI can support on this by constantly learning how to do it.

So I'm pretty sure that they will in the next year will be integrated, but the challenging here will be like, so how we can integrate these into our companies without facing all of the challenging in terms of the risk, sorry, in terms of the, of the information and the protection data for the people and making like a trustee decisions by the, by the AI that I think that is one of the, of the biggest challenge now that you don't, you have a huge spread into their response, but I'm pretty sure that getting ready is, it will help lots on the, on the project and reduce the cost and timing.

Interviewer: Thank you very much, Mr. P10.

Mr. P10 thank you for your valuable insights today. Your contributions will help shape the research in understanding how large language models are being integrated into decision-making and strategy development regarding the energy transformation of companies. If you have any additional thoughts later, please feel free to reach out. Thank you again for your time.

Interviewer: So again, thank you very much for your insights today and thank you for your time and contribution. I wish you a nice day.

P10: Bye.

INTERVIEW 11

Mr. P11 thank you for taking the time to participate in this interview session.

My name is Mehmet Çelik, and I am currently a master's student at the Technical University of Applied Sciences Würzburg-Schweinfurt. With my supervisor, Prof. Scheller, I am conducting a research study, which is "Enhancing Human Decision-Making in Energy Transformation of Industrial and Energy Companies by Leveraging Large Language Models".

The aim of this interview session is to explore your insights and thoughts on large language models and their role in your decision-making and strategy development processes regarding the energy transformation of your organization. Your perspective and insights will help us to better understand the interpretation and implementation of LLMs in those processes.

With your consent, I would like to record the conversation to ensure accuracy in capturing your insights. Please be assured that your and your organization's anonymity will be protected, and your and your organization's names will not be mentioned in any of the reports or presentations. All information will remain confidential and will be used strictly for academic purposes.

Please feel free to bring up anything that a question reminds you of, or anything you think is relevant. Also, you don't have to answer any question you don't want to.

P11: Okay.

Interviewer: Thank you. So, as an introductory question, Mr. P11, can you briefly describe your role in your company and particularly your involvement in the energy transformation projects?

P11: Yes, my role in the company, our company is building solar and wind farms all over Europe and we are producing green electricity. And in my company, I've had various roles. I have been in the investment team, investing and building solar and wind farms in three markets.

And the last three years, I'm building up the sales organization where we are selling corporate PPAs and sign contracts with corporate customers that we supply with green electricity and green power. And in addition, also battery projects that help customers to reduce grid costs and energy costs.

Interviewer: Thank you very much for your answer. Do you think artificial intelligence, particularly large language models have a transformative potential for your company and broader industry in the future?

P11: Yes, of course. They can help us to automate processes and contract negotiations. And of course, also in the future, the pricing of our complex contracts.

Interviewer: Okay, thank you very much. So, Mr. P11, are you currently using or strategically planning to use LLMs to support your decision-making in your company's energy transformation processes or projects? Which specific LLMs do you use at the moment?

P11: At the moment, we are running a strategic project to go through all processes of the company and together with the consultant to understand which process steps can be improved or taken over by LLMs.

Interviewer: Okay. So, in this regard, maybe how the use of LLMs can influence the speed, accuracy, and quality of decisions which may be made in the future in energy transformation projects? Can they be helpful in terms of speed, accuracy, and quality?

P11: Yes, of course, they can if we manage that LLMs can be trained to our purposes and we also especially can somehow teach them our risk perception especially in contract negotiations and pricing because at the moment, the human has somehow an understanding of which risks can we accept in a contract and which risks we can't.

And this is, of course, something the LLMs need to learn from my organization. Otherwise, they will be limited to pure process automation and taking over administrative steps and not, let's say, decisions.

Interviewer: Thank you very much. So, in terms of LLMs' role in strategic development and regulatory compliance, in your experience, how the LLMs can assist in interpreting and implementing new energy strategies and regulations tailored to your company needs?

P11: I have to admit we are not that deep in LLMs at the moment. So, it's difficult for me to assess.

Interviewer: Okay thank you. So, you mentioned you don't have enough experience regarding this aspect of the topic yet, but maybe do you feel that LLMs can provide clear and accurate information for successful regulatory compliance and strategic planning?

P11: Yes, of course. That's true. Maybe they can summarize the regulations and the limits.

Interviewer: Yes. Okay. Thanks so much. So, regarding LLMs' impact on ethical considerations and personal growth, do you believe that the use of LLMs maybe can help promote ethical considerations in developing and implementing energy-related strategies?

P11: I think for ethical considerations, I don't see a big topic if the LLM is used within my organization and somehow controlled by my organization.

Interviewer: Okay. So, in terms of personal growth, do you believe that the use of LLMs can help decision makers explore diverse perspectives for their personal growth?

P11: Oh, yes. Definitely, it can help using them in your career for decisions and to succeed in projects that will help building up your career.

Interviewer: So, in the regard of factors influencing the adoption of LLMs, maybe what factors can influence your decision to adopt or not adopt LLMs in the energy transformation projects in your company?

P11: The reasons to use them can, of course, be that they improve my decision, my processes, and my work efficiency.

And the reason to not adopt is if I believe or if I'm afraid that it takes me more time to train the models and then to be unsure about the final output.

Interviewer: Okay. Thank you. Mr. P11 do you think maybe organizational culture and AI literacy is another factor that can influence the adoption of LLMs?

P11: Yes, of course, if you have an open organization and if the organization has a specific team that is responsible for bringing this topic into the company and showing, giving examples, I think that is of very big help. Otherwise, I don't see that this is really taken up by different departments.

So, I think you need this in the culture or more in an organizational structure.

Interviewer: Okay. Thanks so much. In terms of circumstances optimizing the most effective human-LLM collaboration, in your experience, Mr. P11, does the way information is presented by LLMs (e.g. reports tailored to your cognitive preferences and task-specific needs.) impact your ability to make effective decisions?

P11: I think we have to skip this question because I don't have, so I have yet not made the decision based on pure or based on LLM and human collaboration.

Interviewer: Okay. That's fine. So, how do you think, Mr. P11, the timing of LLM-generated insights can affect their usefulness in decision-making process? So, maybe in the future, do you prefer to use LLMs at the start of a decision-making process or at the end of the decision-making process to double-check your own decision, or do you prefer to use it during the whole process?

P11: During the whole process.

Interviewer: So, do you think it's better?

P11: Yes.

Interviewer: Okay. Thanks so much. So, challenges of human-LLM collaboration. What challenges can have you encounter in future in collaborating with LLMs, particularly regarding interpretability, trust, or data privacy concerns? What can be their impacts and what strategies or solutions can you consider overcoming those issues?

P11: It's trust and how much time does it take. To be able to overcome, I think it's just getting to used to LLMs, not directly using them maybe for core decisions you have to make, but to slowly increase the importance of decision that you base on the LLMs and then with this trust move forward in more complex topics and solutions.

Interviewer: Okay, thanks so much. Regarding the practical outcomes of LLM adoption, you mentioned that you don't have enough experience with LLMs right now, but maybe in the future, do you think that you can observe any improvements in your energy transition implementations or maybe any reduction in energy efficiency loss after adopting LLMs?

P11: I think it will just help me, it will just help me because we are working in 10 countries and it's very difficult for us to have an overview of all the regulatory concerns in all markets and therefore I believe it can increase the efficiency of organizations and of our organization as such.

Interviewer: Okay, thanks so much. So, the last question of this session is LLMs role in expanding the knowledge base of decision makers. So, how do you think Mr. P11, LLMs can help your organization and decision makers enhance their knowledge base? So, do you think these LLMs can provide a competitive advantage in your industry?

P11: I would not say specifically in our industry, it might just change the picture of the industry.

At the moment, we have to work a lot with external consultants when we enter new topics or when we want to change our overall strategy. LLMs could simply reduce the lack of third-party knowledge of service providers in the long run and therefore it would just change the picture of the decision making process. If LLMs stay cheap, then our projects get of course cheaper and we need less time for them.

Yeah, this would be my thoughts around that.

Interviewer: Okay, thanks so much. So, maybe is there anything else you want to add to my questions?

P11: All good.

Interviewer: Okay, so, thank you very much Mr. P11.

Mr. P11 thank you for your valuable insights today. Your contributions will help shape the research in understanding how large language models are being integrated into decision-making and strategy development regarding the energy transformation of companies. If you have any additional thoughts later, please feel free to reach out. Thank you again for your time.

Interviewer: So, thank you very much once again for your valuable time. It was a pleasure to meet you and make an interview session with you.

P11: I wish you a nice day. Thank you, Mehmet. Have a nice day too and a lot of success with your master thesis. Ciao, ciao.

Interviewer: Thanks so much, bye-bye.

Appendix B

ChatGPT Query Session

Interviewer: I would like to explore your competence and potential in enhancing human decision-making in energy transformations of industrial and energy companies in Germany.

Please don't answer the questions with too long texts or bullet points. Give descriptive and concise answers.

I will be asking my questions now.

ChatGPT: Sounds great! I'm ready. Go ahead with your questions.

Interviewer: Do you think you can have a transformative potential for industrial and energy companies, and broader industry?

ChatGPT: Yes, I can have transformative potential by enhancing data-driven decision-making, optimizing energy use, improving predictive maintenance, and supporting sustainability strategies. My ability to process vast amounts of information quickly helps companies adapt to regulations, market changes, and technological advancements efficiently.

Interviewer: How the usage of you can influence the speed, accuracy, and quality of decisions made in energy transformation projects?

ChatGPT: I can accelerate decision-making by rapidly analyzing complex datasets, identifying patterns, and providing actionable insights. My ability to cross-reference historical data, regulations, and market trends enhances accuracy, reducing human errors and biases. By simulating scenarios and optimizing strategies, I improve the quality of decisions, ensuring energy transformation projects are cost-effective, efficient, and aligned with sustainability goals.

Interviewer: How do you assist in interpreting and implementing energy strategies and regulations tailored to a company's needs?

ChatGPT: I analyze a company's energy profile, industry trends, and regulatory requirements to provide tailored recommendations. By interpreting complex energy policies, I help companies understand

compliance obligations and strategic opportunities. I can also simulate different implementation scenarios, assess financial and operational impacts, and suggest the best pathways for integrating renewable energy, efficiency measures, and carbon reduction strategies.

Interviewer: Do you think you provide clear and accurate information for successful regulatory compliance and strategic planning?

ChatGPT: Yes, I provide clear and accurate information by analyzing up-to-date regulations, industry standards, and company-specific data. I help identify compliance gaps, suggest corrective actions, and translate complex legal and technical language into actionable strategies. My insights support strategic planning by aligning regulatory requirements with business objectives, ensuring efficiency, cost savings, and long-term sustainability.

Interviewer: Do you believe that the usage of you can help promote ethical considerations in developing and implementing energy-related strategies?

ChatGPT: Yes, I can promote ethical considerations by integrating sustainability, transparency, and social responsibility into energy strategies. I help assess the environmental and social impacts of decisions, ensuring compliance with ethical standards and stakeholder expectations. By providing unbiased analyses, I support fair resource allocation, carbon reduction, and responsible innovation, aligning business goals with global sustainability objectives.

Interviewer: Do you believe that the usage of you can help decision-makers explore diverse perspectives for their personal growth?

ChatGPT: Yes, I can expose decision-makers to diverse perspectives by analyzing global industry trends, stakeholder viewpoints, and multidisciplinary insights. I facilitate critical thinking by presenting alternative strategies, potential risks, and ethical considerations. By encouraging data-driven discussions, I help leaders expand their understanding, challenge biases, and refine their decision-making for more balanced and informed energy transformation strategies.

Interviewer: What factors can influence the decision to adopt or not adopt you in energy transformation projects?

ChatGPT: Several factors influence the decision to adopt me in energy transformation projects. Key considerations include data security, integration with existing systems, regulatory acceptance, and trust in AI-driven insights. The company's digital maturity, cost-benefit analysis, and willingness to embrace AI for strategic decision-making also play a role. Additionally, cultural and organizational resistance to automation may impact adoption.

Interviewer: How does organizational culture and AI literacy influence the adoption and use of you?

ChatGPT: Organizational culture shapes openness to AI-driven decision-making. Companies with a culture of innovation and data-driven strategies are more likely to adopt and integrate me effectively. AI literacy influences trust and usability—leaders and employees who understand AI’s capabilities and limitations can leverage it more effectively. Resistance to change, lack of technical skills, or fear of job displacement can slow adoption, while strong leadership support and training accelerate it.

Interviewer: Do you think that the way information presented by you impact a decision makers' ability to make effective decisions?

ChatGPT: Yes, the way I present information significantly impacts decision-makers' ability to make effective choices. Clear, concise, and well-organized insights enable quicker understanding and more informed decisions. By presenting data in a digestible format, highlighting key trends, and providing actionable recommendations, I help decision-makers focus on what matters most, reducing cognitive overload and enhancing the quality of their decisions.

Interviewer: How does the timing of your insights affect their usefulness in a decision maker's decision-making process?

ChatGPT: The timing of my insights is crucial. Providing information in real-time or at key decision points ensures that decision-makers can act swiftly and with up-to-date data. Timely insights help anticipate market shifts, regulatory changes, or operational challenges, allowing for proactive adjustments. Delayed insights may reduce relevance, while immediate access enhances decision-making effectiveness and responsiveness, especially in fast-moving energy transformation projects.

Interviewer: What challenges can you encounter in collaboration of human-LLMs, particularly regarding interpretability, trust, or data privacy concerns? What can be their impacts and what strategies or solutions can you consider overcoming those issues?

ChatGPT: Challenges in human-AI collaboration can include interpretability issues, where decision-makers may struggle to understand how I arrive at my conclusions, leading to trust concerns. Data privacy is another concern, particularly when handling sensitive company or regulatory information. These issues can lead to hesitation in adopting AI or reluctance to fully rely on it.

Interviewer: Do you foresee any improvements in energy transition implementation or reduction in energy efficiency loss after adopting you? What can be the other practical outcomes of your adoption?

ChatGPT: Yes, I foresee improvements in energy transition implementation and a reduction in energy efficiency loss. By optimizing energy usage, identifying inefficiencies, and suggesting more sustainable alternatives, I can help companies reduce waste, lower costs, and improve overall efficiency.

Interviewer: How do you think you help a company and decision-makers enhance their knowledge base, particularly in the context of energy transformation?

ChatGPT: I help companies and decision-makers enhance their knowledge base by providing continuous access to up-to-date industry insights, trends, and best practices in energy transformation. By analyzing large datasets and offering data-driven insights, I help identify emerging technologies, regulatory changes, and market opportunities. I also help synthesize complex information into actionable knowledge, enabling leaders to make informed decisions, stay ahead of trends, and foster innovation within their energy transformation initiatives. This empowers them with a deeper understanding of both the challenges and opportunities in the energy transition.

Sources of ChatGPT Query Sessions

Query Session 1: <https://chatgpt.com/share/67dad3ab-f888-8008-bc8a-a25bd1c8fdcd>

Query Session 2: <https://chatgpt.com/share/67c2fc9f-c474-8008-9f99-32ca0c8fd63a>

Query Session 3: <https://chatgpt.com/share/67dad423-a954-8008-a856-1aef1c868cb1>

Query Session 4: <https://chatgpt.com/share/67dc089a-6a3c-8008-a0d8-b6e5eeb140b6>

Query Session 5: <https://chatgpt.com/share/67dc08b2-ab90-8008-a63d-067bcd5e00eb>

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