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LLM-based Transformation of Electrical Distribution Grids: Gathering Requirements for Optimised Workforce Management in the Era of Renewable Energy Integration

Cansu Kahveci[1], Kajan Kandiah[1], Max-Ferdinand Stroh[1], Wolfgang Boos[1]
[1]*FIR - Institute for Industrial Management at RWTH Aachen University, Aachen, Germany*

Abstract

The advancing climate change and the resulting need to restructure the energy supply industry mark the beginning of an era of significant upheavals, profoundly impacting energy distribution. The ongoing integration of renewable energy sources introduces new strains on power grids, as they are now confronted with bidirectional energy flows as well as significant fluctuations in energy generation and demand. These developments pose unprecedented challenges to the physical integrity and operational efficiency of distribution networks. Therefore, electrical distribution grid operators (DGOs) must balance these new challenges while ensuring supply security and sustainability, as well as considering economic efficiency. To meet these new challenges, the development of innovative maintenance strategies is essential. In this context, the digitalisation of power grids emerges as a key technology, offering solutions through the introduction of holistic assistance and prognosis systems (APS). This paper focuses on the collection and analysis of requirements leading to the development of an assistance system for maintenance workers in distribution networks based on Large Language Models (LLM). The LLM aims to support workforce management by providing maintenance workers with targeted information and real-time recommendations. The methodology involves conducting expert interviews to gather essential requirements, followed by a thorough analysis of the collected data. Based on this, the foundation for developing the LLM-based assistance system is established. The results demonstrate how LLMs can enhance the efficiency and effectiveness of maintenance management by optimising workflows and supporting personnel in decision-making processes.

Keywords

Electrical Distribution Grids, Maintenance Management, Workforce-Management, Requirements Analysis, Lange Language Models (LLM)

1. Introduction

Germany's climate and energy policy aims to extensively integrate renewable energy sources and promote the transition to electric mobility by supporting the integration of wind, water and solar power, as well as charging stations for electric vehicles, into the existing power grid [1,2]. This leads to significant fluctuations in load, caused by decentralised solar and wind installations, and the constantly changing energy demand of the charging infrastructure for electromobility, resulting in considerable strains [3]. These strains can lead to the overload of electrical facilities and their components, especially within switchgears. According to the DGOs these electrical facilities traditionally had a life cycle of more than 30 years, which is now in some cases drastically shortened, as a result of the newly integrated energy sources and consumption. This situation carries immediate risks, especially since operators often lack relevant information on the current condition of the facilities and their components [4,5]. To implement the ambitions of the energy and mobility

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transition while ensuring electricity supply security, it is essential for the DGOs to develop a deeper understanding of the current state and potential failure of components. This knowledge is also beneficial for managing the rising cost pressure and to make educated investment decisions. The use of new sensor technologies combined with advanced LLM methods now allows condition-based monitoring of assets for these purposes [6]. This commitment is part of the research project named "AProSys - AI-driven assistance and prognosis systems for the sustainable deployment in the intelligent distribution grid", which builds on the results of the completed FLEMING project that dealt with a technical solution consisting of cost-effective sensors and machine learning algorithms to classify conditions and predict the future state of switchgear components. The proposed initiative aims to achieve the transformation of condition analysis into a cognitive assistance system with a resource-efficient use of sensors and extended monitoring of connected energy technology installations.

This paper presents the initial set of requirements gathered from a variety of DGOs and offers an analysis and classification of these requirements in the form of a large language model. The objective is to subsequently develop use cases for an LLM-based APS aligned with the requirements. Initially, the paper highlights the current challenges and requirements faced by DGOs, according to expert interviews. Finally, the derived use cases are presented, and the opportunities of optimised workforce management for DGOs are singled out.

2. Methodology and focus of this paper

2.1 Related work

The integration of Large Language Models (LLMs) into workforce management and maintenance processes represents a relatively new field of research. However, several related studies have already examined similar methodological approaches and application areas.

First, research has investigated the use of AI-driven systems for predictive maintenance and asset management in energy distribution. Zhou et al. (2023) provide a comprehensive analysis of switchgear asset management, focusing on condition monitoring and predictive analytics for grid operators [5]. The findings of this paper align with the approach taken here, which aims to use AI to optimize workforce management. Second, studies on knowledge-based expert systems in maintenance highlight the potential of AI-powered assistance systems. Sharma et al. (2020) explore the application of AI-based fault diagnosis in condition monitoring of electric motors [6]. Methodologically, this paper shares similarities with the present work, particularly in utilizing AI models to process sensor data and support maintenance personnel. Additionally, existing methodological approaches for requirements gathering in AI-driven workforce management systems have been explored. Grande (2014) describes structured methods for requirements engineering [13]. This paper extends these frameworks by applying a semi-structured expert interview approach to identify specific requirements for workforce management.

Although research on LLMs in the context of distribution grid maintenance is limited, this paper builds on findings from related fields, such as condition monitoring, predictive maintenance, and AI-assisted workforce support. By integrating these insights, this paper contributes to a better understanding of LLM applications in energy distribution.

2.2 Methodological approach

The research findings presented in this paper are based on semi-structured expert interviews and are therefore defined as empirical research [7,8]. The semi-structured expert interviews were specifically chosen to provide a guideline and common theme for the interviews, while allowing the experts to share their own narratives and perspectives beyond the predetermined framework [7]. This approach provided a comprehensive insight and understanding of the operation of the German medium voltage networks and their

components. Based on this understanding, the functional and non-functional requirements for an APS, as well as a prioritisation based on the identified needs and wants, were systematically determined. Based on this data analysis, use cases will be developed to support the DGOs staff in the best possible way according to the collected data from the expert interviews. The underlaying methodology followed a three-step approach of data collection, analysis, and the development of use cases for an LLM-based APS [9].

2.3 Conducting the expert interviews

The semi-structured interviews were conducted online with selected users of a possible LLM-based assistance system. The maximum number of participants per interview was three. The interviewees included employees who either work directly on switchgear (assemblers) or are responsible for planning and managing these systems (asset managers). These individuals represent the primary stakeholders who would interact with the APS in their daily operations.

The interview guide focused on five key areas to stimulate discussion. First, a stakeholder analysis was conducted to identify relevant actors and their roles. Second, regulatory requirements and industry standards were examined. Third, the current state of technical systems and operational processes was analysed. This was divided into two parts: an assessment of the existing technical infrastructure and an evaluation of the workflow processes. Following this, an in-depth analysis of pains and gains was carried out to identify challenges and potential benefits. Finally, requirements were systematically captured and documented in the form of user stories (epics), using formulations such as "As an assembler/asset manager, I need/want [requirement]." The identification of pains and gains allowed for the prioritization of problem areas and the categorisation of requirements.

To provide further context, Table 1 presents an overview of the distribution grid operators interviewed during the paper, including the number of employees, the size of their electrical distribution grid, and their area of supply.

Table 1: Interviewed DGOs

DGO	Number of employees	Length of electrical distribution grid	Area of supply
1	2000	Rd. 30.000 km	Regions in Lower Saxony and North Rhine-Westphalia
2	600	Rd. 2.200 km	Regions in North Rhine-Westphalia and neighbouring municipalities
3	5800	Rd. 175.000 km	Regions in North Rhine-Westphalia
4	1830	More than 5.000 km	Regions in Rhineland-Palatinate and neighbouring regions

This paper presents the interim results of the first stage of the project. A requirement analysis is presented which includes the development and utilisation of use cases for the validation of LLM application.

3. Gathering and analysing requirements for the development of an LLM-based assistance system in distribution grids

As outlined above, DGOs are faced with the increasing challenge of managing the growing complexity of their grids. To meet these challenges, the introduction of a cognitive assistance system is a strategic necessity. Such a system aims to simplify and support the identification, prioritisation and execution of maintenance and servicing tasks. This will reduce the workload of maintenance personnel, increase the efficiency of work processes and minimise the risk of knowledge loss. It is also worth noting that without a structured approach to capturing and managing knowledge, there is a risk of significant loss of expertise, exacerbated by demographic changes and the resulting staff turnover, particularly in maintenance [10].

The complexity associated with workforce management in the age of digital transformation and the integration of renewable energies into existing structures require a targeted approach. For this reason, this paper focuses on the workforce management to guide the requirement analysis and subsequent development of the LLM-based assistance system. This ensures the fulfilment of the specific requirements of DGOs and enhances the capabilities of maintenance teams in this evolving area of the digital landscape.

In the following, the results of the requirement analysis are explained. These are the foundation for the development of an LLM-based assistance system for DGOs, which will be integrated into existing switchgear maintenance.

3.1 Data collection

The interviews were conducted in two stages, with the number of participants ranging from three to six individuals per DGO. The interviewees included both senior executives and employees from the respective organisations, typically with representatives from the same organisation participating in an interview. This led to multiple interviews being conducted with the intent to elaborate a representative objective, exploring how an APS can support all employees in their maintenance and servicing related tasks [7,11].

In the first step, the selected DGOs were surveyed regarding relevant stakeholders within their organisation [12]. It was found that a significant portion of the identified stakeholders were potential users of the APS, that is currently under development.

As a second step in the data collection process, semi-structured expert interviews were conducted with the primary aim of gaining a comprehensive understanding of the interviewees' workflows and their specific needs [12]. To ensure consistency and depth in the discussions, a questionnaire with pre-defined questions was developed as a foundational tool. These pre-defined questions served as a framework, allowing interviewees to share anecdotal knowledge while simultaneously enabling discussions within their respective organisations. This approach provided the interviewer with a holistic perspective on the requirements for an Assistance and Prognosis System (APS). The structure of the interviews balanced the need for comparability with the flexibility to explore emerging themes. While the pre-defined questions guided the conversation, the open-ended nature of the interview allowed for spontaneous follow-up questions based on the context, ensuring a dynamic exchange that captured both anticipated and unforeseen insights. Key areas of inquiry included the challenges and best practices associated with existing information systems, the envisioned role of future assistance and prognosis systems, and the current processes of maintenance and servicing. Interviewees were specifically asked to describe in detail their existing maintenance and servicing workflows, highlighting pain points and inefficiencies. They were also encouraged to articulate their expectations and aspirations for potential simplifications or improvements that new systems could offer. Additional questions targeted knowledge management practices and resource planning strategies, both critical for effective system integration. Through this iterative process, a total of 163 requirements were identified, categorised, and systematically classified, providing a robust basis for further analysis and system design.

The requirement analysis is a crucial part of the research as it determines the conditions that the LLM-based APS under development must fulfil.

3.2 Analysis and classification

The systematic analysis and classification of the requirements identified in the expert interviews was a crucial step in gaining precise insights into the complex use case structures of the DGOs [8]. While clustering the requirements, the focus was not exclusively laid on technical aspects but also on organisational and human factors that are critical for the successful implementation and acceptance of the system. Taking these dimensions into account, ensures that the emerging system not just meets the functional requirements but is

also capable of enhancing the efficiency of workflows and improving work conditions among maintenance personnel.

To further facilitate a structured analysis and implementation of these requirements, a classification into functional and non-functional requirements was performed. Functional requirements specify what the system must do, defining its behaviours, functions and operations to meet user needs. For maintenance and service personnel, this includes tasks such as processing and visualisation of operational data, automated generation of maintenance schedules, and the ability to perform real-time diagnostics of equipment failures. In addition, functional requirements include seamless interaction with existing asset management systems and tools, as well as user interfaces that support on-site and remote operations. These requirements are directly related to the core activities of maintenance personnel and provide the basis for the development of system functionalities that improve the efficiency and accuracy of their daily work. Functional requirements are typically concrete and measurable and serve as a blueprint for the design, development and testing phases of the system [13]. Non-functional requirements, on the other hand, define the criteria that govern how the system works, rather than what it does. For maintenance personnel, these may include performance attributes such as the ability to quickly process large amounts of data to enable rapid decision making in critical situations. Reliability and system uptime are also critical, ensuring that tools are consistently available during maintenance operations. Other non-functional considerations include usability—ensuring the system is intuitive and minimises training requirements for field personnel—and compatibility with a wide range of hardware and software environments commonly used by DGOs. Security is also critical, protecting sensitive infrastructure data and ensuring compliance with regulatory standards. Non-functional requirements set the quality benchmarks for the system, directly impacting the user experience and the overall effectiveness of maintenance and repair operations. Although these requirements are often more difficult to quantify and verify, they are essential to ensure the robustness and usefulness of the system in practical applications [13].

To systematically derive these requirements, a structured analytical approach was applied. The method followed a multi-stage process based on qualitative content analysis [14] and thematic coding [15]. First, the data collected from expert interviews was segmented into discrete requirement units through an open coding process. These individual requirements were then categorised inductively based on thematic similarities. The categories were subsequently refined using axial coding, where overarching thematic patterns were extracted and systematically structured. This iterative process ensured a clear alignment between the collected requirements and the emerging thematic fields, providing a structured foundation for the subsequent development of system functionalities.

Within the analysed requirements, five relevant thematic areas were identified: User Experience, Maintenance and Service, Workforce Management, Knowledge Management and Condition Monitoring (see Figure 1). Each of these thematic areas plays a crucial role in the overall functionality and effectiveness of the system and were defined as use cases.

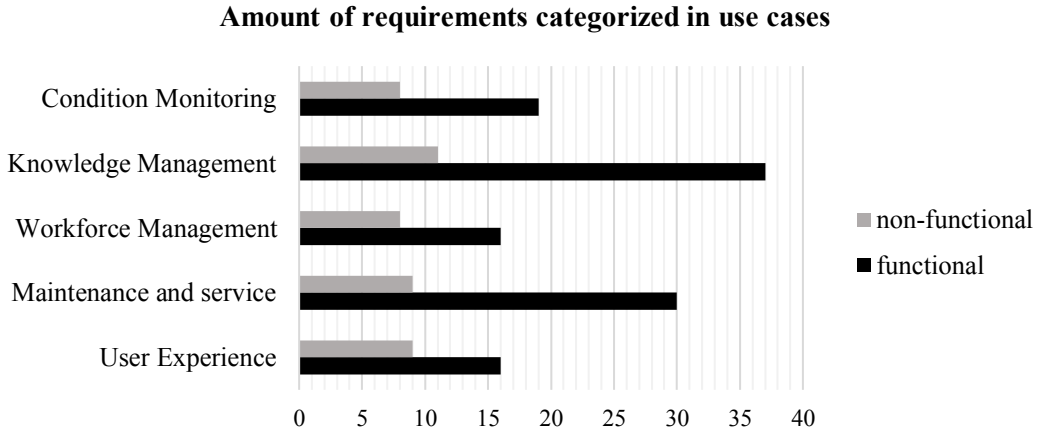

Figure 1: Distribution of requirements for LLM-driven APSs among the defined use cases

This graphic should not be interpreted as a scoreboard that indicates which use cases are the most important, because the requirements are not weighted in any way. However, it gives an impression in which areas the most potential for an improvement through the introduction of an APS lies, according to the employees and managers of the DGOs.

In detail the five defined use cases can be described as follows:

User Experience (UX) focuses on the overall experience of a person using the system, especially in terms of how easy and pleasant it is to use [16]. It includes the design of systems that offer intuitive navigation, meaningful feedback, and satisfying interactions, aiming to enhance user satisfaction and engagement.

Maintenance and Service (MS) embraces the routine actions necessary to keep machinery, systems, and structures functioning efficiently [17]. This includes preventive maintenance to avoid potential failures and corrective maintenance to repair issues that have already arisen, ensuring the system operates smoothly and reliably.

Workforce Management (WFM) encompasses the range of activities required to maintain a productive workforce. This includes scheduling, forecasting demand, managing staff assignments and ensuring the right resources are available at the right time to meet the system's needs [18].

Knowledge Management (KM) refers to the systematic approach of creating, sharing, using and managing the knowledge and information of an organisation [19]. It encompasses the strategies and practices used to identify, create, represent, and distribute knowledge to ensure its availability for future usage and learning.

Condition Monitoring (CM) is the process of monitoring the condition of machinery or systems through various indicators to identify early signs of deterioration or failure. It allows for timely intervention to prevent unplanned downtime and extend the lifespan of the equipment [20].

Each of these use cases contributes to the holistic design and functionality of the APS, ensuring it not only meets the technical requirements but also addresses the needs of users and the operational demands of the organisation.

3.3 The importance of workforce management

In the contemporary landscape of electrical grid management, particularly within the AProSys Project, the optimisation of the WFM did establish as a critical factor for operational efficiency. Table 2Table 2 presents an excerpt of the requirements and their respective use cases, that have been gathered from Asset Managers and Assemblers, who were defined as the key roles to use the APS within the DGOs. For Asset Managers, the provision of a well-maintained ERP system is pivotal. It is not merely a database but the digital synapse connecting human resources with physical assets [21]. The requirement for real-time data emphasises the

necessity for a dynamic APS, capable of not just reactive but proactive measures. It is intended to minimise downtime by allowing foresight and immediate response. The need for precise information, before deployment to the switchgears, accentuates the strategic alignment between resources and operational demands.

From a strategic perspective, WFM ensures that skilled personnel are available at the right time and in the right place, minimising downtime and maximising the efficiency of maintenance processes. In an environment where system failures can result in significant costs, proactive resource management is essential. APS supports this by enabling predictive planning and allocation of personnel, matching workforce skills with operational requirements. Meanwhile the emphasis on maintenance cycles in accordance with imposed guidelines, calls for compliance in and standardisation of these procedures. For Assemblers on the other hand, the table shows a call for tangible, user-centric interfaces, and data access, naming the APS's role in facilitating ground-level tasks with clear, actionable checklists and preparatory information. The system's capacity to facilitate the efficient completion of core tasks by assemblers, without the encumbrance of administrative responsibilities, serves to enhance both productivity and job satisfaction. Additionally, WFM enables a systematic approach to managing workforce qualifications, ensuring that current needs are met while identifying future skill gaps. By capturing and planning for qualifications within the APS, organisations can adopt a proactive approach to addressing training needs, thereby fostering a skilled and adaptable workforce. This structure enables personnel to be prepared for current requirements while also positioning them to meet future demands, thereby supporting continuous workforce development.

Table 2: Requirements regarding the use cases

DGO	Position	Requirement	Use Case
1	Asset Manager	A well-maintained SAP system to manage assets efficiently and reliably	KM
		Real-time data that provides information on equipment defects to proactively respond to maintenance needs and minimise downtime	CM
	Assembler	Before departing to work on a switchgear, adequate information about the type of system needs to be provided to ensure that suitable equipment is taken, so that the efficiency of the maintenance work increases	KM
		Information on specific maintenance cycles in accordance with the guidelines for the maintenance of electrical systems needs to be provided	KM
2	Asset Manager	Provide the possibility to prioritise maintenance work economically	KM
		Identification of bottlenecks	KM
		Documentation of necessary maintenance worker qualifications for upcoming work and proactive proposition of training measures	WFM
	Assembler	Access to utilised technology for training purposes	KM
3	Asset Manager	Support with the different processes in regional system technology	MS
		Support for route optimisation	WFM
		Digital training option for maintenance workers	WFM
	Assembler	Compatibility with maintenance worker's tablets	UX
		Option for pre-scheduling of materials at least one day in advance	MS
4	Asset Manager	Insights in the availability of necessary resources for fault clearance personnel	MS
		Predictive prognosis from the system to utilise for personnel resources	CM
	Assembler	Easy-to-use checklists	UX

It has been found that WMF can improve efficiency and accuracy when carrying out maintenance work. The APS's ability to identify bottlenecks and propose training measures, directly relates to workforce development and creates a system that not only identifies gaps but actively seeks to fill them. It ensures a continuously evolving and competent workforce. By reducing the administrative burden associated with scheduling and resource planning, the APS enables maintenance personnel to dedicate a greater proportion of their time to their primary tasks, thereby enhancing the overall efficiency of the workflow. Moreover, WFM plays a pivotal role in enhancing operational safety and regulatory compliance, particularly critical for distribution grid operators. By ensuring that maintenance and servicing tasks are performed on time and in accordance with established guidelines, WFM not only promotes safe and reliable operations but also mitigates the risk of regulatory non-compliance, thereby protecting the organisation from potential penalties and reinforcing stakeholder trust.

The requirements identified through the project's methodological approach underscore the necessity for a workforce management system that is cognisant of both the technical and non-technical nuances of the energy sector's workforce. By identifying functional and non-functional requirements, the AProSys project aims to develop a system that not only addresses the technical aspects of workforce management but also the human factors, thereby ensuring user satisfaction and the overall effectiveness of the APS.

4. Summary and Outlook

The transformative potential of Large-Language-Modells within the realm of electrical distribution grids has been elaborated throughout this paper, underscoring its pivotal role in optimising workforce management against the backdrop of renewable energy integration. The research presented herein has illuminated the multifaceted challenges faced by DGOs and proposed a robust methodology for eliciting and analysing requirements critical for the development of an AI-based APS. The convergence of technological innovation and human-centric approaches in workforce management has been identified as the essential aspect for maintaining the integrity and operational efficiency of distribution networks. Through a comprehensive empirical study, informed by semi-structured interviews, this paper has delineated the requirements of DGOs, facilitating the conceptualisation of a system that not only meets the functional and non-functional needs but also enhances the overall user experience.

The research presented in this paper is an integral part of the AProSys project, which aims to address the challenges faced by DGOs in the context of the energy transition towards renewable sources and the integration of electric mobility into the German electrical grid. This transition has highlighted the need for advanced maintenance strategies and the digitalisation of power grids to ensure supply security, economic efficiency, and sustainability. The paper has outlined the development of initial requirements from various DGOs, which then got systematically processed to derive and classify use cases. These use cases will get developed further for the implementation into an AI-based APS, utilising large language models.

Moving forward, the next phase of this research endeavours to elevate the conceptual framework established by developing the use cases into use case diagrams using the Unified Modelling Language (UML) methodology. In this process each of the requirements will be described in detail within the context of its use case, so that complete coverage of the DGOs needs is guaranteed. This progression will allow for a granular and visual representation of the system's functionalities, providing stakeholders with a clearer and more comprehensive understanding of the APS. By harnessing the analytical strengths of UML, the project anticipates uncovering deeper insights into the behavioural patterns of system interaction, thus facilitating a user-centric design approach. The visual articulation of use cases will serve as an invaluable tool for developers, users, and stakeholders alike, fostering an environment conducive to collaborative development and iterative refinement.

In essence, the creation of use case diagrams represents a strategic milestone in translating the theoretical framework of workforce management but also the other use cases, into a tangible and operational LLM system. This initiative is poised to significantly contribute to the AProSys project's goal of revolutionising workforce management within the electrical distribution sector, thereby reinforcing the resilience and adaptability of the grid infrastructure amid the march towards a sustainable energy future.

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References

[1] Rechsteiner, R., 2021. German energy transition (Energiewende) and what politicians can learn for environmental and climate policy. Clean technologies and environmental policy 23 (2), 305–342.

[2] Skjærseth, J.B., 2021. Towards a European Green Deal: The evolution of EU climate and energy policy mixes. Int Environ Agreements 21 (1), 25–41.

[3] Wang, W., Yuan, B., Sun, Q., Wennersten, R., 2022. Application of energy storage in integrated energy systems — A solution to fluctuation and uncertainty of renewable energy. Journal of Energy Storage 52, 104812.

[4] Subramaniam, A., Sahoo, A., Manohar, S.S., Raman, S.J., Panda, S.K., 2021. Switchgear Condition Assessment and Lifecycle Management: Standards, Failure Statistics, Condition Assessment, Partial Discharge Analysis, Maintenance Approaches, and Future Trends. IEEE Electr. Insul. Mag. 37 (3), 27–41.

[5] Zhou, N., Xu, Y., Cho, S., Wee, C.T., 2023. A Systematic Review for Switchgear Asset Management in Power Grids: Condition Monitoring, Health Assessment, and Maintenance Strategy. IEEE Trans. Power Delivery 38 (5), 3296–3311.

[6] Sharma, A., Mathew, L., Chatterji, S., Goyal, D., 2020. Artificial Intelligence-Based Fault Diagnosis for Condition Monitoring of Electric Motors. Int. J. Patt. Recogn. Artif. Intell. 34 (13), 2059043.

[7] Bogner, A., Littig, B., Menz, W. (Eds.), 2009. Interviewing Experts. Palgrave Macmillan, Basingstoke, London, 281 pp.

[8] Haberfellner, R., Weck, O.L. de, Fricke, E., Vössner, S. (Eds.), 2018. Systems Engineering: Grundlagen und Anwendung, 14., überarbeitete Auflage ed. Orell Füssli Verlag, Zürich, 487 pp.

[9] Jain, N., 2021. Survey Versus Interviews: Comparing Data Collection Tools for Exploratory Research. TQR (26).

[10] Albinowski, M., Lewandowski, P., 2024. The impact of ICT and robots on labour market outcomes of demographic groups in Europe. Labour Economics 87, 102481.

[11] Dorussen, H., Lenz, H., Blavoukos, S., 2005. Assessing the Reliability and Validity of Expert Interviews. European Union Politics 6 (3), 315–337.

[12] Hildebrandt, A., Jäckle, S., Wolf, F., Heindl, A., 2015. Methodologie, Methoden, Forschungsdesign: Ein Lehrbuch für fortgeschrittene Studierende der Politikwissenschaft. Springer VS, Wiesbaden, 387 pp.

[13] Grande, M., 2014. 100 Minuten für Anforderungsmanagement. Kompaktes Wissen nicht nur für Projektleiter und Entwickler, 2nd ed. Wiesbaden: Vieweg+Teubner.

[14] Mayring, P., 2015. Qualitative Inhaltsanalyse: Grundlagen und Techniken. 12. Auflage. Weinheim: Beltz.

[15] Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. Qualitative Research in Psychology 3 (2), 77–101.

[16] Hussain, J., Ul Hassan, A., Muhammad Bilal, H.S., Ali, R., Afzal, M., Hussain, S., Bang, J., Banos, O., Lee, S., 2018. Model-based adaptive user interface based on context and user experience evaluation. J Multimodal User Interfaces 12 (1), 1–16.

[17] Stenström, C., Norrbin, P., Parida, A., Kumar, U., 2016. Preventive and corrective maintenance – cost comparison and cost–benefit analysis. Structure and Infrastructure Engineering 12 (5), 603–617.

[18] Safarishahrbijari, A., 2018. Workforce forecasting models: A systematic review. Journal of Forecasting 37 (7), 739–753.

[19] Omotayo, F., 2015. Knowledge Management as an important tool in Organisational Management: A Review of Literature. Library of Philosophy and Practice (e-journal) 10 (4).

[20] Nithin, S.K., Hemanth, K., Shamanth, V., Shrinivas Mahale, R., Sharath, P.C., Patil, A., 2022. Importance of condition monitoring in mechanical domain. Materials Today: Proceedings 54, 234–239.

[21] Putra, D.G., Rahayu, R., Putri, A., 2021. The Influence of Enterprise Resource Planning (ERP) Implementation System on Company Performance Mediated by Organizational Capabilities. JAI 22 (2), 221–241.

Biography

Cansu Kahveci (1992*) has been a scientific researcher and project manager of the Institute for Industrial management (FIR) at the RWTH Aachen University since 2023. As a member of the Information Technology Management group, she focuses on the intersection of information technology and its effective use in organisational processes.

Kajan Kandiah (*1994) has been working at the Institute for Industrial Management (FIR) at the RWTH Aachen University since 2020. In his current position as part of the Information Management he works in the technical group IT-complexity management. He specialises in IT-Architecture management, Smart Grid and transformation strategies.

Max-Ferdinand Stroh (*1991) is a researcher at FIR at RWTH Aachen University since 2017 in the department Information Management. He is head of the department Information Management. His scientific work is focused on the practical application of AI, smart products, and IT-OT-Integration.

Prof. Dr.-Ing. Wolfgang Boos (*1975) is the head of the Institute for Industrial Management (FIR) at the RWTH Aachen University since 2023. In addition to his current role as CEO he is involved in managing other entities of the RWTH Aachen Campus. His research focuses on sustainable production and circular economy.