

Contributions to Decision Support for Wind Energy, Literature Research Processes and Towards a Better World through Information Systems

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This thesis is dedicated to those
who inspired and supported me,
especially my family.

I. Abstract

Decision making is an important and complex challenge for companies, organizations and individuals. Making the right operational and strategic decisions at the right time has a big influence on a successful development and the survival in competition. To make the best possible decisions it is essential to have access to aggregated and processed information which are accurate, reliable and consistent. Decision support contributes to the decision-making process by preparing and providing relevant information. Decision support systems (DSS) further contribute to decision-making processes as they embed approaches into integrated systems which aim to provide fast and easy access to decision-relevant information. This cumulative dissertation is divided into three thematic chapters according to different research areas which are presented and discussed in the context of quantitative and qualitative decision support. The first thematic chapter focuses on decision support for the wind energy sector based on quantitative financial approaches. A DSS is constructed that addresses the needs of all project stakeholders for the assessment of corresponding projects. The system integration of renewable energies (RE) in general and of wind energy represents a fundamental challenge as the unsteady electricity generation introduces variability in the electrical system. Decision support is provided by introducing a modeling approach that can help to design support schemes which promote a spatially-diversified deployment through location-based investment incentives. The second thematic chapter revolves around the enhancement of the literature research processes which is an important sub-step of a complete literature review and part of many other scientific research methods. Decision support is provided by our Tool for Semantic Indexing and Similarity Queries (TSISQ) that allows a fast and simple identification of semantically similar research articles. The third thematic chapter deals with survey-based decision support. Qualitative and quantitative data was gathered with an explorative survey among leading IS researchers. The findings can contribute to decisions regarding the future alignment of the IS research domain. In summary, it is shown that decision support based on qualitative and quantitative data contributes to decision making by providing decision-relevant information. As data amounts will continue to grow in the future, the relevance of decision support will further increase.

Keywords: Decision Support, Decision Support System (DSS), Renewable Energies, Wind Energy, Literature Research Process, Design Science, Survey Research

Zusammenfassung

Entscheidungsprozesse stellen komplexe und bedeutende Herausforderungen für Unternehmen, Organisationen und Individuen dar. Die richtigen operativen und strategischen Entscheidungen zum richtigen Zeitpunkt zu treffen hat großen Einfluss auf den eigenen Erfolg und das Bestehen im Wettbewerb. Entscheidungsunterstützung trägt zu Entscheidungsprozessen durch das Bereitstellen entscheidungsrelevanter Informationen bei, da bestmögliche Entscheidungen den Zugriff auf aufbereitete Informationen verlangen, die zuverlässig und konsistent sind. Entscheidungsunterstützungssysteme (EÜS) können einen zusätzlichen Beitrag leisten, indem sie Methoden in einem Gesamtsystem vereinen, das einen schnellen und einfachen Zugriff auf entscheidungsrelevante Informationen ermöglicht. Diese kumulative Dissertation ist in drei thematische Kapitel unterteilt, die sich mit qualitativer und quantitativer Entscheidungsunterstützung befassen. Das erste thematische Kapitel behandelt Entscheidungsunterstützung im Bereich der Windenergie basierend auf quantitativen, finanziellen Methoden. Das erstellte EÜS deckt die Anforderungen aller Stakeholder eines Windenergieprojektes hinsichtlich der finanziellen Bewertung ab. Die Integration erneuerbarer Energien (EE) in die Stromnetze stellt durch die schwankende Stromerzeugung eine zentrale Herausforderung dar. Entscheidungsunterstützung wird hierzu durch einen Ansatz geboten, der die Gestaltung von Einspeisevergütungssystemen adressiert. Dazu wird eine räumliche Verteilung von EE Anlagen durch standortbezogene, finanzielle Vergütungsanreize gefördert. Im zweiten thematischen Kapitel geht es um die Erweiterung von Literaturrechercheprozessen, die ein wichtiger Bestandteil eines Literaturüberblicks und darüber hinaus Teil weiterer wissenschaftlicher Forschungsmethoden sind. Entscheidungsunterstützung wird mit Hilfe von TSISQ (*Tool for Semantic Indexing and Similarity Queries*) gegeben. Es ermöglicht die schnelle und einfache Identifizierung semantisch ähnlicher Forschungsartikel. Das dritte thematische Kapitel beschäftigt sich mit umfragebasierter Entscheidungsunterstützung. Die Ergebnisse einer explorativen Befragung führender IS Forscher können zu Entscheidungen bezüglich der zukünftigen Ausrichtung der IS Forschungsdomäne beitragen. Insgesamt wird deutlich, dass Entscheidungsunterstützung basierend auf qualitativen und quantitativen Daten zum Entscheidungsprozess durch das Bereitstellen entscheidungsrelevanter Informationen beiträgt. Durch künftig zunehmende Datenmengen wird die Bedeutung von Entscheidungsunterstützung zudem weiter steigen.

Schlagnworte: Entscheidungsunterstützung, Entscheidungsunterstützungssystem, Erneuerbare Energien, Windenergie, Literaturrecherche Prozess, Design Science, Umfrageforschung

II. Management Summary

Making the right decisions at the right time is an important challenge for companies, organizations and individuals. A successful development and the survival in competition strongly depends on the quality of operational and strategic decisions. In order to make the best possible decisions it is essential to have access to aggregated and processed information which are accurate, reliable and consistent. For the preparation of relevant information, all kinds of qualitative and quantitative data that can contribute to an issue should be considered. The complexity of decision making based on diverse information and increasing amounts of data highlight the importance of approaches, models, and tools for decision support.

Decision support contributes to the decision-making process by providing relevant information based on quantitative as well as qualitative data which is collected and extracted from various data sources. Continuously increasing amounts of data e.g. through different kinds of sensors, the connection of devices or digitalization (Power, 2014) demand for the use of information systems (IS) for automatic data processing, preparation and supply. The ability to consider and use the huge amounts of publicly or internally available data for decision making can have a significant influence on how companies or organizations effectively compete in the market. Embedding decision-supporting approaches and models into decision support systems (DSS) can further contribute to corresponding decision-making processes as they aim to provide fast and easy access to aggregated, decision-relevant information in integrated systems.

In this cumulative dissertation, three major research areas are presented and discussed in the context of quantitative and qualitative decision support based on corresponding research papers. The dissertation is divided into three thematic chapters according to these research areas. Chapter 2 is the first thematic chapter and deals with decision support for the wind energy sector based on quantitative financial approaches. Chapter 3 focusses on decision support for the enhancement of literature research processes by employing quantitative approaches. Chapter 4 revolves around survey-based decision support. Figure I illustrates the research streams with corresponding conference and journal publications. Each of the three research streams finally resulted in an “A” publication according to the VHB JOURQUAL 3 ranking.

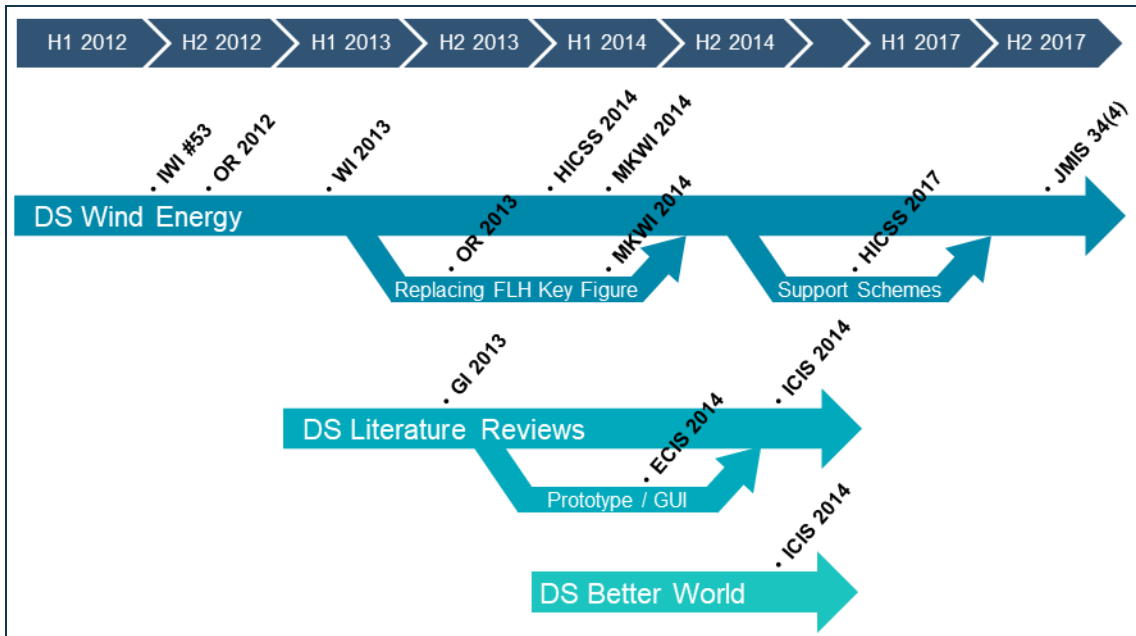


Figure I: Research Streams with related Journal and Conference Publications.

Decision Support for the Wind Energy Sector:

Considering that the energy demand is constantly increasing all over the world and climate change effects from greenhouse gas emissions are becoming more and more evident, an intensive expansion of renewable energies (RE) seems not only necessary, but mandatory. To facilitate this expansion decision support is provided for the assessment of wind energy projects. The constructed decision support system (DSS) utilizes probability distributions and a Monte Carlo simulation (MCS) to consider project risks on top of a discounted cash-flow model. The DSS addresses the needs of all project stakeholders and thus can contribute to an expansion of RE as well as environmental and economic sustainability. Figure II shows simulation results of relevant key figures for investors (project value) and lenders (DSCR, LLCR, PLCR). The applicability of the DSS and the underlying models are evaluated in two exemplary wind energy projects in Germany and Brazil.

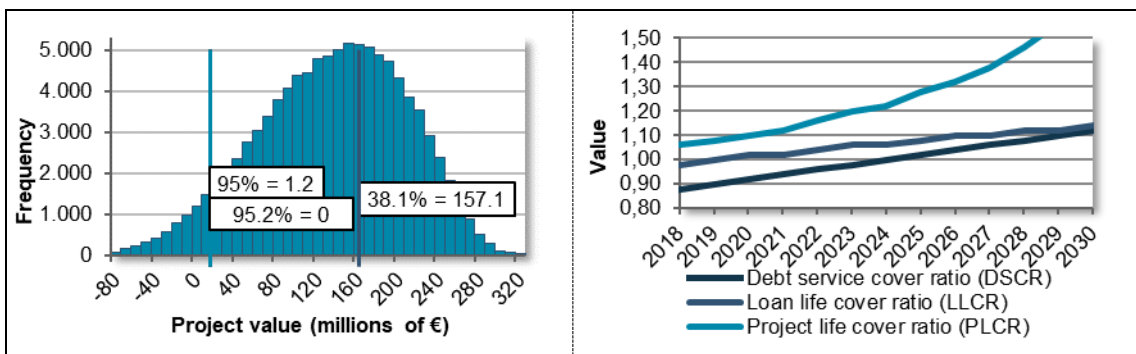
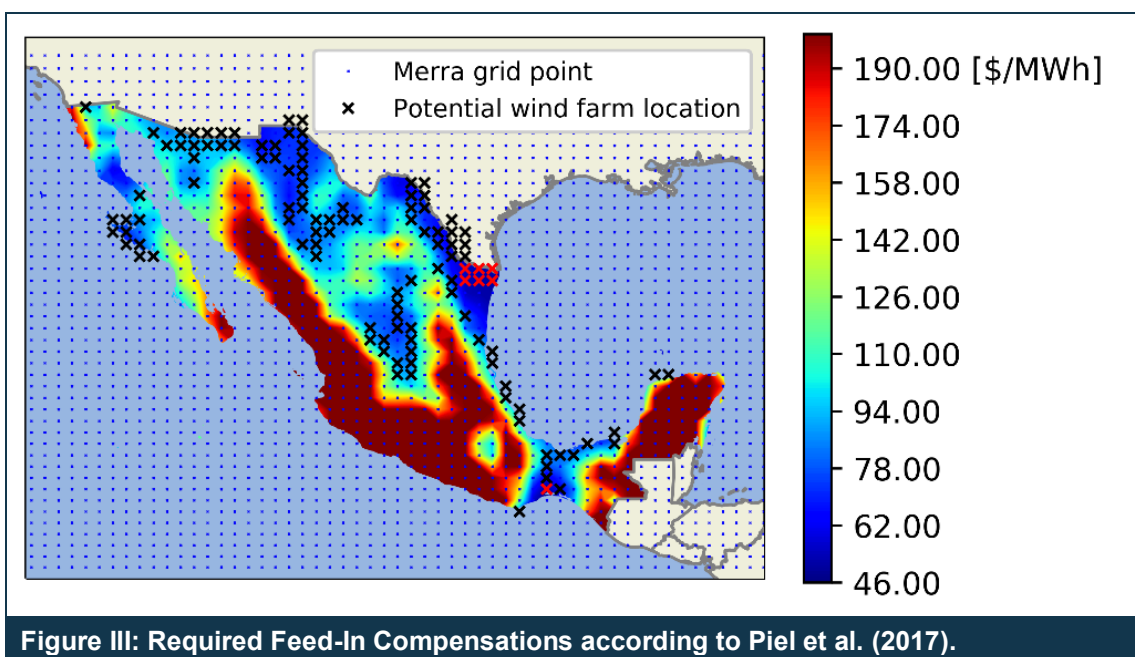


Figure II: Distribution of the Project Value and Key Figures at 95% Confidence Level based on Koukal and Breitner (2014).

Next to the assessment of individual RE projects from the perspective of investors or lenders, the system integration of RE represents an important challenge in the transition towards sustainable energy systems. Their unsteady electricity generation introduces variability in the electrical system and leads to high ancillary services costs and technical issues regarding grid stability and supply reliability. These issues can be significantly mitigated through a spatially diversified deployment of RE which smooths the variability in the electrical system over sufficiently large regions. By introducing a modeling approach that can help to design support schemes to promote a spatially-diversified deployment for RE through location-based investment incentives, decision support is provided. The modelling approach combines a consideration of favorable spatial distributions of RE capacity with current policy designs that aim at an active capacity expansion management. It is evaluated in a simulation study with focus on diversifying wind energy deployment in Mexico under an idealized auction-based support scheme. Figure III shows required feed-in compensations and potential wind farm locations in Mexico.



The study demonstrates how location-based investment incentives reduce resource-dependent competition among projects and shift the competition towards the economic efficiency of projects. The underlying approach and application results provide guidance and support policy-makers to quantify and evaluate location-based incentives for RE support schemes. Design elements of the created models and artifacts offer prescriptive knowledge that can help policy-makers to assess current approaches for quantifying location-based incentives. They can further be used as a benchmark model for comparisons of different concepts for support schemes or location-based investment incentives.

Decision Support for the Enhancement of Literature Research Processes:

Literature search is an important sub-step of a complete literature review and a part of many other established scientific research methods. By addressing and enhancing this fundamental and time-consuming step in every literature research process, decision support is provided with the Tool for Semantic Indexing and Similarity Queries (TSISQ). The simplified access to a huge amount of scientific resources requires an increasing effort to conduct comprehensive literature reviews. To address this issue, TSISQ is designed to use unstructured texts, e.g. either complete scientific research papers or any kind of natural language, as query input to identify semantically similar texts. It makes use of a technique called latent semantic indexing (LSI) which belongs to the field of natural language processing and provides a web-frontend to allow a simple use and fast identification of semantically similar research articles. The components of TSISQ, their functions, and the respective data flows are presented in Figure IV.

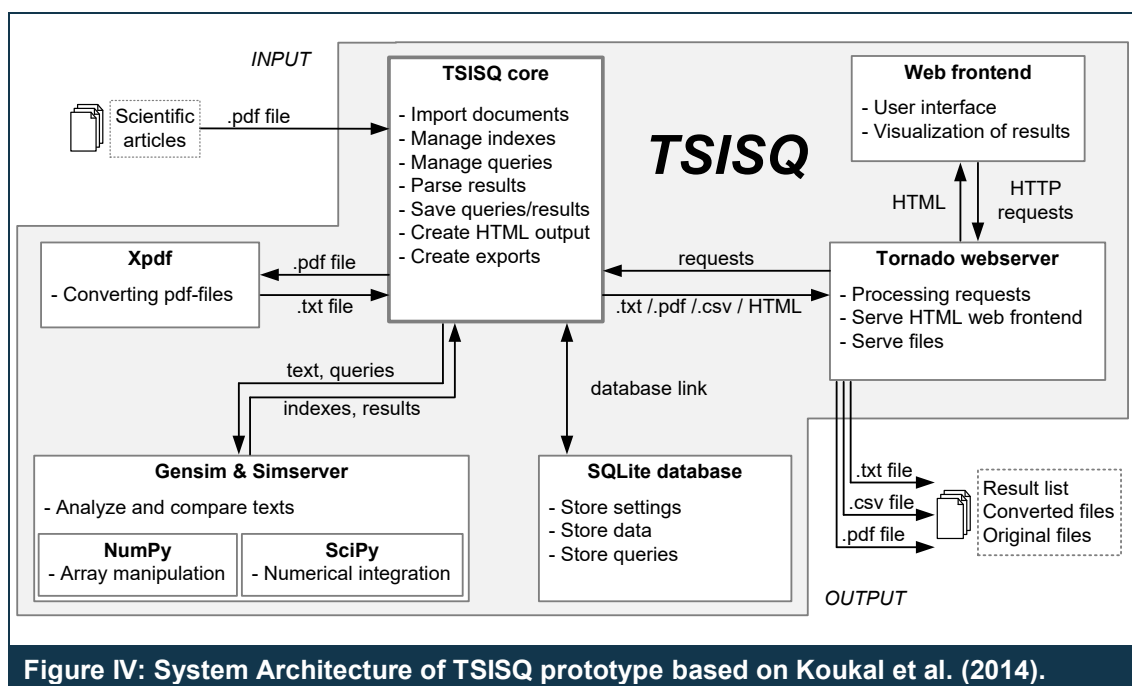


Figure IV: System Architecture of TSISQ prototype based on Koukal et al. (2014).

The applicability of TSISQ is evaluated in different environments and search cases covering realistic applications that aim at the identification of semantically similar literature. Results indicate that TSISQ can increase the efficiency of a literature search by saving valuable time in finding relevant literature in a desired research field. Additionally, it can improve the quality of search results and enhance the comprehensiveness of a review by identifying sources that otherwise would not have been considered. In summary, TSISQ can contribute to decision support and represents a useful complement to the established search engines used in scientific literature research processes. The target audience includes all researchers who need to efficiently gain an overview of a specific research field and refine the theoretical foundations of their research.

Decision Support towards a Better World through IS:

Behind the background of the Millennium Development Goals (MDGs) decision support is provided on top of survey research methodology and a questionnaire (Chapter 4). To answer the high-level and abstract question of how IS can contribute to build a better world, an explorative survey among leading IS researchers on a global scale was conducted and qualitative and quantitative data was gathered. The results show that the impact of IS is largely perceived as indirect and that the perceived contribution of different IS research streams varies considerably. The biggest contribution is seen regarding the goals universal education, environmental sustainability, and a global partnership for development. A selection of quantitative results derived from the survey data concerning the MDGs is presented in Figure V.

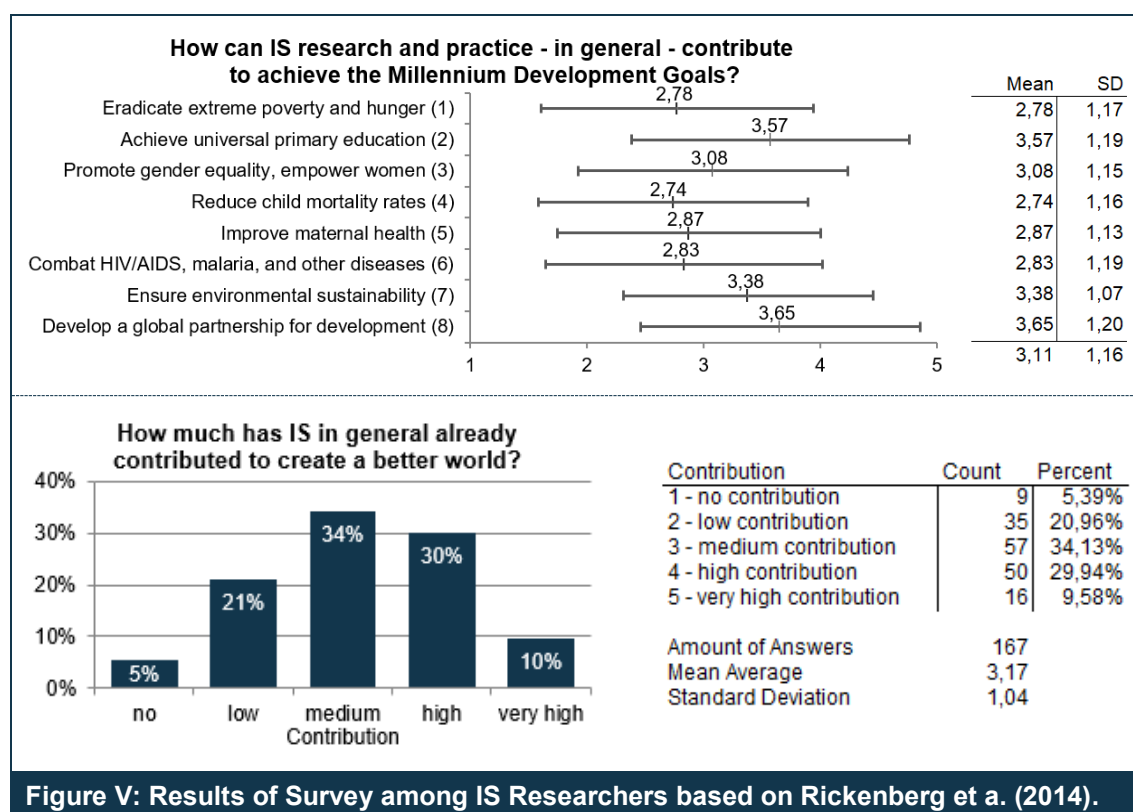


Figure V: Results of Survey among IS Researchers based on Rickenberg et al. (2014).

Besides positive aspects, the survey also reveals challenges and critique concerning IS research. It can serve as a starting point, create awareness, and stimulate further discussions and research. With the right focus and alignment, IS practice and research have the potential to take on the big questions and can help to build a better world. Significant improvements regarding high level goals like the MDGs can only be reached within an incremental progress. Structural changes to the IS research domain and involved institutions can facilitate IS researchers to really take on the big questions and build a better world. In summary, it is shown that qualitative and quantitative data gathered with surveys can contribute to decision support and improve decision making.

In this cumulative dissertation, several topics of three different research streams and corresponding research publications are investigated. The results address two objectives. On the one hand, they contribute to IS research in the area of qualitative and quantitative decision support regarding the application and enhancement of different research methods as well as the alignment of the IS research community concerning important global challenges. On the other hand, the presented findings address practical problems of investors, lenders and other stakeholders of specific wind energy projects, policy makers that are faced with issues concerning the variability in the electrical system due to renewable energies and related grid stability as well as the process to find relevant literature in a specific research field.

Different research methods were employed for the presented research. Design-orientated approaches according to Peffers et al. (2008) as well as Hevner et al. (2004, 2007) were followed for the research regarding wind energy and literature research processes by identifying domain-specific problems, specifying research objectives and formulating research question. Formal models and instantiations were designed, constructed and refined in a loop of iterations and finally demonstrated and evaluated. Survey-based approaches found application for the research concerning questions about how IS can contribute to a better world. After the research objectives have been set and a research question was posed, an explorative online survey among leading IS researchers was conducted to gather qualitative as well as quantitative data. With the help of open coding techniques and descriptive statistics, the given answers were classified and visualized to enable interpretations and the formulization of findings.

Even though the research processes presented in the thematic chapters of this dissertation mainly focused on practical problems in different IS research areas or in the IS research discipline in general, they all considered both main principles of IS research: rigor and relevance. Methodological rigor is ensured by employing research approaches that are well established in the IS research domain and by following specific guidelines in the research processes. Relevance is also addressed as the conducted research is focused on practical problems and contributions are provided that enhance existing solutions or establish new approaches.

In summary, it is shown that decision support based on qualitative and quantitative data contributes to decision makers' needs by processing and preparing data and providing aggregated information. It can lead to better decision making and aims at the goal of long-term corporate and organizational success. As data amounts will continue to grow in the future, the relevance of decision support will further increase.

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