Association for Information Systems
AIS Electronic Library (AISeL)

PACIS 2016 Proceedings

Pacific Asia Conference on Information Systems (PACIS)

Summer 6-27-2016

UNDERSTANDING THE ROLE OF DECISION SUPPORT SYSTEMS IN GREEN IS RESEARCH: LITERATURE REVIEW AND RESEARCH AGENDA

Benjamin Klör
European Research Center for Information Systems, benjamin.kloer@ercis.uni-muenster.de

Follow this and additional works at: http://aisel.aisnet.org/pacis2016

Recommended Citation
Klör, Benjamin, "UNDERSTANDING THE ROLE OF DECISION SUPPORT SYSTEMS IN GREEN IS RESEARCH: LITERATURE REVIEW AND RESEARCH AGENDA" (2016). *PACIS 2016 Proceedings*. 378.
http://aisel.aisnet.org/pacis2016/378

This material is brought to you by the Pacific Asia Conference on Information Systems (PACIS) at AIS Electronic Library (AISeL). It has been accepted for inclusion in PACIS 2016 Proceedings by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.

UNDERSTANDING THE ROLE OF DECISION SUPPORT SYSTEMS IN GREEN IS RESEARCH: LITERATURE REVIEW AND RESEARCH AGENDA

Benjamin Klör, European Research Center for Information Systems, University of Münster, Münster, Germany, benjamin.kloer@ercis.uni-muenster.de

Abstract

Green information systems (IS) can contribute to more sustainable actions in a globalized and complex business environment. Since sustainable actions can only result from a pluralistic decision-making process, researchers agree that decision support systems (DSSs) in particular are important for green IS research. Because this research field has grown during the last decade, we set out to identify the contribution of DSS research conducted in green IS research. We conducted a structured literature review to reveal currently available DSSs contributions, their structure, and impact. The applied literature search and selection process identified 23 papers to be relevant to the review. A concept-centric literature analysis revealed that many DSS contributions conduct design research and demonstrate the addressed research problems' feasibility by implemented DSS prototypes. However, the literature review identifies a lack of subscription to green IS research. Despite numerous "green" DSSs are available in the literature, their subscription to the field of green IS research is missing. Finally, a research agenda is conceptualized for systematizing future DSS research in the domain of green IS research. Further research should increase the number of contributions conducting design-oriented research that should mainly result in software implementations to demonstrate the solutions' feasibility and "green" utility.

Keywords: Structured Literature Review, Organizing Framework, Green IS Research, Decision Support Systems, Research Agenda.

1 INTRODUCTION

At the end of the year 2015, representatives of 195 nations, who participated in the United Nations Climate Change Conference in Paris, France, unconditionally agreed on the goal to limit global warming by 1.5°C during the next decades (United Nations, 2015). According to leading politicians, experts, and journalists, the Paris agreement is considered as a landmark to sustainably fight the antecedents of global warming (Doyle and Lewis, 2015; Sutter et al., 2015) and therefore extends the scope of, e.g., the Kyoto protocol adopted in 1997. The pervasive and recurrent calls for taking more environmental care require individuals, organizations, and entire societies to change their lines of action to become more sustainable for protecting the natural environment and its scarce resources. While the basic constraints for regulating this change are set by legislative forces, the implementation of change must occur on the individual and organizational level, e.g., through the design of adequate organizational action systems.

Researchers from the information systems (IS) discipline agree that substantial environmental changes can be achieved by the design and support of IS (Melville, 2010; Watson et al., 2010). Green information systems (green IS hereafter) are considered to transform organizations by implementing sustainable business processes (Seidel et al., 2012) and, thus, sustainable actions (Melville, 2010; Watson et al., 2010) on macroscopic and microscopic levels (Melville, 2010). Research on green IS can be distinguished by two fundamental paradigms. While "green by IS" represents a paradigm where the application domains (non-IT domains) improve as their supported activities become sustainable, "green in IS" can be understood as the adoption of ecological improvements to the IS/IT landscapes, products, and services of organizations (Kossahl et al., 2012).

As a matter of fact, decisions are the source to actions and are prerequisites to the implementation of sustainable actions. While IS in general support diverse operational and analytical organizational tasks, the more specific IS class of decision support systems (DSSs) is known to solve semi-structured to unstructured decision problems by, e.g., utilizing sophisticated (mathematical) models and methods (Turban et al., 2007). Because identifying and implementing a sustainable course of action can shape such semi-structured or unstructured decision problems, especially DSSs are considered to have an impact on the emergence of the green IS research field (Hasan et al., 2014). Furthermore, DSSs are likely to make achievements to the field of green IS research as they are known to support decision-makers in finding effective and efficient solutions, which are deeply required for greening several business contexts. Since this research paper strives for revealing the role of DSSs in the context of green IS research, we ask the following two research questions (RQs):

RQ 1: What are the current contributions of decision support systems to green IS research?

RQ 2: What are possible future DSS research directions for contributing to the field of green IS?

To answer the RQs a structured literature review of 23 identified research papers is conducted, which finally results in a research agenda to propose further research directions for DSS contributions in the field of green IS research. The literature review has several key results. One of the most important and promising findings is that design-oriented research is mainly addressed within the identified DSS contributions. In addition, many DSS researchers contribute to the field of green IS research by instantiating a software prototype to demonstrate the feasibility of the addressed research problems. However, the review identifies a lack of subscription to green IS research. Although numerous "green" DSS contributions can be identified in the broad scientific literature, their proactive subscription to the field of green IS research is missing.

The remainder of the paper is structured as follows. Section 2 introduces DSSs as an important IS class to green IS research and, hence, creates a link between both concepts. Section 3 outlines the structured literature review method as the applied research method, which follows a concept-oriented approach. The required theoretical concepts are defined in Section 4 that also constitutes the organizing framework for the literature review. Then, the literature configuration, search, and analysis processes are conducted and documented in Section 5. Based on the findings, which are derived in Section 6, the paper concludes with the conceptualization of a research agenda in Section 7.

2 DECISION SUPPORT SYSTEMS IN GREEN IS RESEARCH

From a theoretical perspective, decision processes comprise four abstract phases, the intelligence phase (e.g., identify the decision problem), design phase (generate decision alternatives), choice phase (pick one decision alternative), and implementation phase (realize decision alternative) (Simon, 1977). Since decision processes can address structured, semi-structured, or unstructured decision problems (Turban et al., 2007), various specialized types of DSSs (Alter, 1977; Arnott and Pervan, 2008; Holsapple, 2008; Power, 2000, 2004) are in place to support decision-makers in solving their diverse decision problems adequately. DSSs enable decision-makers to easily collect, manage, analyze, and retrieve relevant data to support decision-making in each of the specific phases of decision processes (Turban et al., 2007).

Green information systems are intended to sustain companies' activities, contributions, and success in more than an economic dimension over the long run (Melville, 2010; Watson et al., 2010). Building on the wide and rather undefined notion of sustainability, green IS research—a stream in IS research—deals with achievements to the three dimensions of sustainability (Melville, 2010), the economic, the ecological, and the social dimension (e.g., Dalal-Clayton, 1993; Elkington, 1994). Up to now, IS research and development mainly addressed the economic dimension (vom Brocke and Seidel, 2012) and often neglected the ecological and social dimensions. To overcome this problem substantially, green IS are supposed to make an impact on all three dimensions of sustainability (Melville, 2010).

In his comprehensive literature review, Loeser (2013) reveals that many IS researchers define and understand green IS to *support business practices* "[…] which determine the […] use and management of information systems […] to minimize the negative environmental impacts of IS, business operations, and IS-enabled products and services." (p. 6) To make achievements to these goals of green IS, business stakeholders must be able to find adequate solutions for adopting or changing (existing) business practices according to the pluralistic properties of sustainability. As indicated, DSSs provide assistance with such structured to unstructured decision problems and provide problem solutions, which are usually targeted to be optimal (e.g., identifying effective and efficient lines of action). Since such optimal solutions perfectly contribute to the goals of green IS, DSSs are an important topic to green IS research.

Other researchers agree and explicitly refer to DSSs or related concepts in their definitions. According to Loock et al. (2011), "[…] the Green IS movement encompasses improvements in the eco-efficiency of business processes […] [and] the development of more sustainable strategies with the help of decision support systems […]" (p. 2). Researchers, who position their DSS as green IS, consider green IS to improve resource efficiency of businesses by optimizing their processes and products (Rickenberg et al., 2013) and to enable transparent decision-making for transforming business practices to become more sustainable (Stindt et al., 2014 citing Loeser, 2013). Hence, DSSs are important to the field of green IS research since they are eligible for analyzing, indicating, and choosing sustainable business practices. In addition, the responsible AIS special group of interest (SIGGreen) considers specifically designed DSSs and related functionalities as crucial contributions for leveraging green IS research (Hasan, 2016).

3 RESEARCH METHOD

A structured literature review identifies previous research activities in a specific domain of interest (Cooper and Hedges, 2009) and reveals under-researched and yet unattended research fields (blind spots) within this domain (vom Brocke et al., 2009; Webster and Watson, 2002). Reversely, it identifies (descriptively) and defines (prescriptively) possible research areas for future scientific and practical contributions. According to Webster and Watson (2002), a literature review—as conducted in this paper—is "concept-centric" (p. xvi), which means that theoretical concepts "determine the organizing framework of a review" (p. xvi). Theoretical concepts are "topic-related" (vom Brocke et al., 2009, p. 10) and can be differentiated by further units of analysis (Webster and Watson, 2002).

As an implication to the present research paper and its addressed research problem, this review intends to identify blind spots in the field of green IS research with a strict focus on DSS contributions. In the

following, the theoretical concepts including their units of analysis—constituting the analysis' organizing framework and the concept matrix—are derived from the surrounding topics of the three fields "green IS research", "DSS research", and "IS research", alongside which the structured literature review (classification, analysis, and research agenda) is then conducted (Figure 1).

For the sake of reproducibility and research rigor, a structured literature review must be thoroughly conducted and documented (vom Brocke et al., 2009). Commonly, the documentation of a literature review comprises the applied search strings, date of query, names of the queried databases, number of hits retrieved from each database, and the criteria and results of the literature selection process (rough and detailed literature analysis). This literature review's search and selection process is documented in Section 5. In addition, forward and backward searches should also be conducted (Webster and Watson, 2002), which, however, are not considered for this literature review as papers strictly focusing on green IS and DSSs are already included in the databases' retrieval sets.

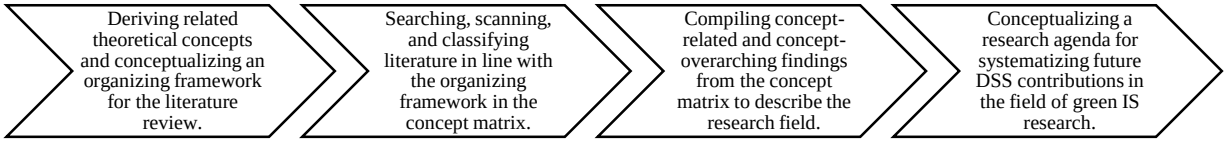

Figure 1: Research process for the literature review conducted in this paper

4 THEORETICAL CONCEPTS AND ORGANIZING FRAMEWORK

4.1 Theoretical Concept 1: Type of DSS

As yet, several frameworks for classifying decision support systems have been proposed (Alter, 1977; Arnott and Pervan, 2008; Holsapple, 2008; Power, 2000, 2004). For this work, the classification of Power (2000, 2004) is adapted in order to analyze the "green" decision support of the revealed papers regarding their functional scope, which is provided by the DSS's "dominant component driver" (Power, 2004, p. 161). Power (2000, 2004) differentiates the DSS types by five component drivers.

Model-driven DSSs focus on, e.g., mathematical models for solving simulation and optimization problems and utilize advanced mathematical methods such as the Monte Carlo method or (non-)linear programming (Power and Sharda, 2007). This type is used when decision support is required for mostly (semi-)structured decision problems that can only be solved by (mathematical) decision models.

Data-driven DSSs integrate internal and external data sources for efficient data accessing and manipulation purposes, e.g., by management information systems, data warehouse systems, or online analytical processing (OLAP) systems (Power, 2004). The rationale behind this type of DSSs is the sophisticated analysis of large data sets to detect hidden patterns and structures and to generate knowledge from the data discovery by adequate data presentation techniques (e.g., OLAP, management reporting, and dashboards).

Knowledge-driven DSSs store domain expertise by "[…] facts, rules, and procedures or in similar structures […]" (Power, 2000, p. 353) to provide specialized, domain-specific problem-solving capabilities. Systems of this type "[…] suggest or recommend actions to decision makers […]" (Power, 2004, p. 162) by using an inference engine that generates knowledge from the integrated knowledge base and by logical rules and logical inference (e.g., logic programming, case-based reasoning).

Document-driven DSSs manage and retrieve information from highly unstructured data sources, such as websites and other digital document types (Power, 2000) like image and audio files (Power, 2004). The main component of this DSS type is a search engine comprising of comprehensive data storing and data processing capabilities in order to retrieve and analyze such information (Power, 2004).

Communication-driven DSSs comprise functionalities that foster group decision-making processes, e.g., by web and video chats (Power, 2000). Thus, this DSS type's dominant component driver contains extensive "[…] communication and collaboration […] technologies […]" (Power, 2004, p. 162), which allow for "[…] multi-participant decision support […]" (Power, 2004, p. 162).

However, many DSSs that are developed in a scientific or practical context cannot always be distinctly classified to be exactly one of the proposed types, as they comprise several component drivers and, hence, interface several DSS types. To classify such systems, for instance, Holsapple (2008) introduces the type of "compound DSS" (p. 181), whereas Power (2000) calls such systems "hybrid DSS" (p. 352). In this literature review, papers that comprise more than one dominant component driver are not explicitly classified as a *compound DSS*, but can be identified by a multiple classification of several component drivers.

4.2 Theoretical Concept 2: IT Artifact

To characterize the specific DSS contributions in green IS research it is important to identify the types of IT artifact, which are addressed and created within the papers under study. Consequently, this concept aims at revealing how DSSs are presented and created in the scientific community. Following March and Smith (1995), IS research is basically focused on creating four types of IT artifacts.

Constructs, i.e., languages shape "[…] the vocabulary of a domain […]" (March and Smith, 1995, p. 256) and are the basis for creating all other artifacts. To classify a paper focusing on constructs requires the creation of language instances such as a (domain-specific) modeling language or a programming language within that paper.

Models serve as purposeful abstractions of real world entities to reduce their complexity by making "[…] propositions or statements expressing the relationships among constructs […]" (March and Smith, 1995, p. 256). Papers with a focus on models comprise model instances such as software architectures, enterprise models, reference models, business process models, and mathematical decision models.

Methods comprise "[…] a set of steps […] used to perform a task […]" (March and Smith, 1995, p. 257) and are defined by "[…] a set of underlying constructs (language) and a representation (model) […]" (March and Smith, 1995, p. 257). In the spirit of an IT artifact, methods can be found in algorithms, decision processes, or procedures, e.g., providing a description on the structured development of routines and information systems.

Instantiations, i.e., software implementations "[…] operationalize constructs, models, and methods […]" (March and Smith, 1995, p. 258) to realize and demonstrate the contained models and methods (March and Smith, 1995). A paper is classified to develop a software implementation if a software prototype is clearly perceivable by a thorough prototype description and/or demonstration (e.g., screenshots, link to running prototype).

4.3 Theoretical Concept 3: IS Research Method

In science, research methods are used to rigorously create research results that can be reproduced by independent third parties. According to Oates (2006) and on a high level of abstraction, four streams of research methods can be distinguished that are used to conduct research in the IS domain.

Design research is conducted in order to systematically build and evaluate IT artifacts (Hevner et al., 2004; Peffers et al., 2007), i.e., constructs, models, methods, and instantiations (March and Smith, 1995) as introduced before. *Conceptual research* is used to create mostly theory-driven research results without collecting and analyzing empirical field data (Mora et al., 2008). *Literature reviews* reconstruct research domains by studying and classifying their past contributions and deriving research agendas for future research contributions (Cooper and Hedges, 2009). *Empirical research* compiles research results by conducting quantitative (e.g., (field) experiments) and qualitative (e.g., interviews) research in order to collect, analyze, and evaluate empirical field data (Oates, 2006).

4.4 Theoretical Concept 4: Supported Lifecycle

In general, DSSs are used in the context of organizational decision-making (Turban et al., 2007) and support in specific problem situations. In the context of green IS research, such problem situations mainly arise, e.g., in the planning, development, production and manufacturing, reusing, or disposal of products or other entities, such as energy, waste, and water (Melville, 2010). Hence, this concept reflects on the supported lifecycle of the application context, which is supported by a DSS.

DSSs that are used for the *first-life* are considered to support decision-making in application contexts such as the planning, production, manufacturing, selling, and distribution of goods and further entities like energy and water. DSSs in *second-life* domains deal with the reusing, the repurposing, and the replenishment of goods. In our conception, goods or entities like energy cannot be reused or repurposed and, hence, cannot be transferred to a second life. DSSs in *end-of-life* domains support decisions for the termination of the goods' lifecycles in terms of their recycling and disposal, including the processing of waste of different kinds. Furthermore, papers dealing with the decision supported planning, design, and delivery of services (e.g., car sharing) or processes (e.g., manufacturing or disposal processes) can also be assigned to a distinct lifecycle.

4.5 Theoretical Concept 5: Green IS Paradigm

The field of green IS research has evolved over the last decade. Green information systems are supposed to enable a substantial change throughout the landscape of business and society due to the realization and support of sustainable actions (vom Brocke and Seidel, 2012). However, IS are currently regarded to be both problem and solution to sustainability-related issues (Corbett, 2013; Elliot and Binney, 2008). For instance, while IS may support an energy efficient behavior of the inhabitants of a smart home, the systems themselves consume a considerable amount of energy. To make a clear distinction between these two addressed issues, Kossahl et al. (2012) recommends the subdivision of the green IS field into the two paradigms "green by IS" and "green in IS".

Information systems that can be assigned to the concept of g*reen by IS* improve the application domains (excluding IT), since their supported activities become (more) sustainable through the introduction of (green) IS. Kossahl et al. (2012) understand contributions addressing the "green by IS" paradigm when they support non-IT "[…] industries and their efforts to pursue the new IS enabled opportunities to achieve their economical and ecological goals."

In turn, systems that follow the *green in IS* paradigm can be perceived as improvements in terms of sustainability-related issues to the IS/IT-related landscapes, products, services, and processes of enterprises and organizations. For instance, contributions to "green in IS" address algorithms for better IT resource efficiency or decision support (processes) for the production of "[…] more products and services with using less resources […]" (Kossahl et al., 2012).

4.6 Constituting the Organizing Framework

In the following, an organizing framework is constituted to inform other IS researchers about structuring their literature reviews on this article's subject-matter. Hence, the organizing framework is supposed to guide and simplify further literature reviews in this domain. By analyzing new and relevant research papers accordingly, future research might add new perspectives and insights to the already known research results such that the addressed research field can further emerge.

The organizing framework for systematically studying DSS research contributions in the field of green IS research is defined as a 5-tuple comprising the theoretical concepts "type of DSS", "IT artifact", "IS research methods", "supported lifecycle", and "green IS paradigm", which were introduced before. Consequently, the organizing framework aims at investigating the structure and characteristics of DSS research contributions in the field of green IS research and allows for investigating new developments in this research field accordingly. Despite the consensus that theoretical concepts for shaping the

organizing framework should not overlap and should be defined independently from each other (Webster and Watson, 2002), there is an obvious relationship between both concepts "IS research method" and "IT artifact", since IT artifacts are straight research results from *conceptual research* and especially *design research* activities. The reason for introducing the dependent concept "IT artifact" results from the constant appeals of renowned DSS researchers (e.g., Arnott and Pervan, 2012, 2014) to position DSS research endeavors in line with design science research (DSR) (Gregor and Hevner, 2013; Hevner et al., 2004; Peffers et al., 2007). Consequently, the organizing framework allows for classifications that do not address each theoretical concept in the concept matrix.

5 LITERATURE ANALYSIS ON DSS IN GREEN IS

5.1 Literature Search and Selection Process

The literature review was conducted as follows. To reveal contributions in the intersection of decision support systems and green IS research, a search term comprising both abstract domains was defined. To retrieve as many hits as possible, the domains' respective synonyms were also considered:

(("decision support system" OR "decision support systems" OR "dss") AND ("green information system" OR "green information systems" OR "green is"))

Querying the scientific literature databases "Scopus", "AIS Electronic Library", "Web of Science", "IEEE Xplore Digital Library", and "ACM Digital Library" with the predefined search term retrieved 116 papers in total. The literature search was conducted on December, 10th 2015.

To roughly differentiate between important and unimportant hits, the following paper dropping strategy was applied. After scanning the papers' titles, abstracts, and keywords, 81 papers were removed that did not *seriously address a DSS contribution* at their core or did not *explicitly subscribe to the field of green IS research*. The remaining literature hits were merged to a set of 35 articles, which was then cleansed by six doublets to a resulting set of 29 articles. The literature search and selection process is (quantitatively) documented in Table 1.

Database	Search Configuration	Total Hits	Scanned Hits
Scopus	"Title, Abstract, Keywords"	8	6
AIS Electronic Library	"Across all repositories"	103	27
Web of Science	"Topic"	2	1
IEEE Xplore Digital Library	"Basic Search"	2	0
ACM Digital Library	Standard search	1	1
Sum (merged sets)		116	35
Sum (cleansed by doublets)			**29**

Table 1: Search configuration and quantitative search results per literature database

5.2 Classification of the Relevant Literature

Based on the rough analysis of the database hits, the detailed literature analysis was conducted by reading the entire papers. As a consequence, the detailed analysis revealed that six papers from the set of 29 had to be dropped, too. The papers deal with closely related topics but do not have a direct relationship to DSS research (Golding et al., 2013; Hasan, 2012; Rush and Melville, 2012; Smith et al., 2011), green IS research (Abdelhamid, 2014), or both (Esfahani et al., 2015). Consequently, 23 papers remained for the classification, which was conducted in the concept matrix (Table 2).

	Type of DSS					IT Artifact				IS Research Method				Supported Lifecycle			Green IS	
Authors	**Model-driven**	**Data-driven**	**Communication-driven**	**Knowledge-driven**	**Document-driven**	**Instantiation**	**Model**	**Method**	**Construct**	**Design Research**	**Conceptual Research**	**Literature Review**	**Empirical Research**	**First-Life**	**Second-Life**	**End-Of-Life**	**Green by IS**	**Green in IS**
Angeles (2013)*		•	•										•	•	•	•	•	
Beverungen et al. (2015)	•						•	•		•					•		•	
Bodenstein et al. (2011)	•						•			•				•				•
Brandt et al. (2012)	•	•					•				•			•			•	
Brauer et al. (2015)												•		•		•	•	
Corbett (2011)	•	•	•				•				•			•			•	
Eickenjäger and Breitner (2013)	•					•	•			•				•			•	
Frehe et al. (2014)*		•				•				•				•			•	
Gräuler et al. (2013)*		•		•			•			•			•	•	•	•	•	•
Hasan et al. (2014)											•			•	•	•	•	•
Hasan and Smith (2012)		•	•										•	•	•	•	•	
Hilpert et al. (2011)*	•	•					•			•				•			•	
Hilpert et al. (2013)		•				•				•			•	•			•	
Koukal and Breitner (2014)	•					•	•			•				•			•	
McGrath et al. (2013)				•			•				•			•			•	
Nishant et al. (2013)													•	•			•	•
Nuss (2015)*		•				•				•				•			•	
Rickenberg et al. (2013)	•					•	•			•				•			•	
Simkin and Schrödl (2014)*		•										•		•	•	•	•	
Sodenkamp et al. (2015)		•		•				•		•				•			•	
Sonneberg et al. (2015)	•					•	•			•				•			•	
Stindt et al. (2014)*	•	•					•			•					•	•	•	
Thompson et al. (2015)		•		•		•							•	•			•	
Total	**10**	**13**	**3**	**4**	**0**	**8**	**12**	**2**	**0**	**13**	**4**	**2**	**6**	**21**	**7**	**7**	**22**	**4**

Table 2: Concept matrix for classifying DSS contributions in green IS research (contribution deals with an environmental management information system)*

6 DISCUSSION OF THE FINDINGS

"A review should identify critical knowledge gaps and thus motivate researchers to close this breach." (Webster and Watson, 2002, p. xix) To derive viable results for this literature review, the following discussion presents descriptive findings, which can be drawn from the concept matrix, in a *concept-related* and *concept-overarching* manner. While concept-related findings simply rely on vertical patterns that can be detected by counting the classification marks (frequency of units of analysis per concept), concept-overarching findings identify horizontal patterns in terms of existing relationships among the concepts. In addition, the discussion creates a link between the descriptive findings and exemplary literature contents and provides a statement that summarizes the key aspects of each finding.

6.1 Concept-Related Findings

Most of the identified papers deal with model-driven (10 instances) and data-driven (13 instances) DSSs. The overrepresentation of model-driven DSSs corresponds to the call of the green IS community (Hasan et al., 2014) stating that the "[…] modelling of past, current and future scenarios […]" (p. 100) is important for decision-making in the context of green IS research. For instance, Eickenjäger and Breitner (2013) provide a model-driven DSS, which deals with political decision support and provides scenario analyses for substituting fossil fuels with renewable fuels. Beverungen et al. (2015) deal with a model-driven DSS for repurposing used electric vehicle batteries, which is supposed to gain momentum in the near future. Furthermore, data-driven DSSs are dominantly represented in this study, since the sophisticated (data) analysis and monitoring of organizational green IS initiatives is crucial for internal and external decision-making. Frehe et al. (2014) create a data-driven DSS for assessing and benchmarking the maturity levels of companies in terms of their environmental management efforts. Hilpert et al.'s (2013) data-driven DSS comprises a carbon tracker (data collection) and a sophisticated geographical dashboard (data analysis) for determining the greenhouse gas emissions of trucks. Nuss (2015) develops a data-driven DSS, which reports energy usage data to customers and suppliers leading "[…] to an improved balancing of power supply and demand and to more sustainable energy systems." (p. 12)

Additionally, model-driven and data-driven DSS shape most of the compound DSSs (4 instances, 9 instances in total) that we could identify in green IS research. For instance, Stindt et al. (2014) create a compound DSS—comprising a model-driver and data-driver—that provides optimization and OLAP capabilities to plan "[…] product take-back and reprocessing of used IT equipment." (p. 1) In turn, knowledge-driven (4 instances, three of which are part of a compound DSS), communication-driven (3 instances, all of which are integrated into a compound DSS), and document-driven (no instance) DSSs are completely underrepresented in the literature review. McGrath et al. (2013) deal with a knowledge-driven DSS, which applies logical programming to "[…] help tourism planners mitigate against and adapt to the impacts of climate change in tourist destinations." (p. 11) Angeles (2013) presents a compound DSS with a strong emphasis on a (group) communication-driven component, which supports Nike's green initiative by enabling "[…] group-based collaborative decision making initiatives […]" of virtual teams located around the globe.

Finding 1: Model-driven and data-driven DSSs shape the dominant component drivers of present (compound) DSS instances within green IS research. Document-driven DSSs cannot be identified.

From an IT artifact's stance, DSSs are often presented by models or instantiations, whereas methods and constructs can only be rarely identified. Models are often the core artifacts of DSS papers dealing with optimization problems (e.g., Eickenjäger and Breitner, 2013; Koukal and Breitner, 2014; Rickenberg et al., 2013; Sonneberg et al., 2015) and other mathematical problems (e.g., financial models). Bodenstein et al. (2011) present several linear and non-linear optimization models to reduce energy usage in datacenters. Brandt et al. (2012) formulate a mathematical model for the regulation of energy auctions. In addition, one paper (Beverungen et al., 2015) presents a design theory (which is a model in the broadest sense) for a DSS to repurpose used electric vehicle batteries. Several papers create (conceptual) models in order to describe, e.g., their applied DSS architectures (e.g., Beverungen et al., 2015; Gräuler et al., 2013; Koukal and Breitner, 2014; Stindt et al., 2014) or required functions and capabilities to achieve (DSS) effectiveness (Corbett, 2011). Methods are only created by two papers, for instance, Sodenkamp et al. (2015) "[…] [build] a supervised classification algorithm as an IT artifact[, i.e., method] […]" (p. 6) that "[…] predicts probabilities of individual customers to sign up on an energy efficiency portal." (p. 1) Papers crafting (domain-specific modeling or programming) languages could not be identified in the literature review. In addition, six papers (Angeles, 2013; Brauer et al., 2015; Hasan and Smith, 2012; Hasan et al., 2014; Nishant et al., 2013; Simkin and Schrödl, 2014) do not provide any IT artifacts.

Finding 2: IT artifacts that are mainly used to present DSS contributions in green IS research are instantiations and models. As yet, only few methods and no constructs for describing and modeling DSSs

have been create in this research field. Especially the design of decision processes (methods) could improve the understandability of the addressed decision problems in green IS research.

In green IS, design (science) research is highly used for building DSSs. Hence, DSS researchers seem to follow the domain calls for applying design-oriented research to DSS research (e.g., Arnott and Pervan, 2012, 2014) and, thus, contribute to the field of green IS by building and evaluating IT artifacts in a practical and scientific manner. Exemplary instances for DSR research activities can be drawn from the previous finding that discussed the availability of IT artifacts, which are created by design research.

The other research methods are not highly used for conducting DSS research in the domain of green IS. Empirical studies are the second most common research method used for positioning DSSs. Two papers (Gräuler et al., 2013; Hilpert et al., 2013) that are presented in line with the DSR method jointly conduct an empirical study to evaluate their findings. For instance, Gräuler et al. (2013) constructed a reference architecture for environmental management, which is derived from requirements elicited and evaluated by a qualitative empirical study conducting interviews with an expert panel. Other empirical studies deal with, e.g., content analyses (Angeles, 2013; Hasan and Smith, 2012), which systematically process empirical field data from, e.g., documents and interviews. Nishant et al. (2013) apply a quantitative study to assess "[…] the relationship between sustainable IT practices and environmental performance." For instance, the DSS-related construct "[…] 'information to support decision-making' is negatively associated with direct [carbon] emissions." (Nishant et al., 2013) Hence, "[…] the adoption of [..] technologies [like business intelligence] provides transparency in the carbon emissions to the [manufacturing and service delivery] processes." (Nishant et al., 2013) Decisions on contributing processes can consequently lower the carbon footprint of organizations (Nishant et al., 2013).

Papers dealing with conceptual research and literature reviews are underrepresented. For instance, Brauer et al. (2015) conduct a comprehensive structured literature review on smart city research activities and reveal that the main focus of the identified papers "[…] primarily addresses city planners, who are […] service providers supporting municipal tasks (e.g., garbage collection or public transportation providers)." Despite their classification of 26 papers dealing with a DSS or a related IS class (geographical information systems), these papers do not directly subscribe to the streams of DSS research or green IS research and were, thus, not considered in our review. Hasan et al. (2014) conduct conceptual research in order to create a theory-driven taxonomy for green IS research, including recommendations for the design of DSSs. This taxonomy (Hasan, 2016) also shapes the basis for the AIS to scope the field of green IS by a special group of interest (SIGGreen).

Finding 3: DSS contributions to green IS research are mainly created by design-oriented research endeavors. Only few literature reviews for structuring the research field can be identified. However, this is necessary to better understand possible areas to contribute with DSSs to green IS research.

Most of the reviewed contributions provide decision support for first-life applications. Many of them deal with energy-related topics (e.g., Corbett, 2011; Gräuler et al., 2013; Koukal and Breitner, 2014; Nuss, 2015; Simkin and Schrödl, 2014; Thompson et al., 2015) providing decision support in terms of energy analytics and supporting decisions on topics such as energy production, energy demand management, energy distribution, and energy usage.

Two papers, which clearly make a distinction, deal with the second-life domain by planning and designing reverse logistics networks for used IT equipment (Stindt et al., 2014) and repurposing used traction batteries from electric vehicles (Beverungen et al., 2015). An exemplary instance for an end-of-life DSS application can also be recognized by Stindt et al. (2014), since the disposal of used IT equipment is also in the scope of their paper.

Finding 4: The reviewed contributions to green IS research highly address decision support for the first-lifecycle and often support business contexts in the energy domain. In the field of green IS, especially the second-life and end-of-life domains for reusing, repurposing, refurbishing, reprocessing, recycling, and disposing goods need further investigations and contributions by DSS research.

Regarding the paradigms of green IS research, nearly all of the papers in this literature review address the concept of "green by IS". In turn, there is only one paper that distinctly deals with a "green in IS" problem. Bodenstein et al. (2011) introduce a DSS for solving IT resource allocation problems in datacenters. The rest of "green in IS" approaches are mixed approaches, which enable the entire organization ("green by IS"), including the IT ("green in IS"), to become green.

Since the "green in IS" paradigm closely relates to the well-known stream of green IT (Kossahl et al., 2012), many DSS contributions, also those of researchers originating from the IS domain, rather address green IT than green IS research. Nevertheless, contributions from the IS domain could certainly be assigned to green (in) IS, too.

Finding 5: While the paradigm "green by IS" is highly targeted by DSS contributions in green IS research, there are only few contributions dealing with decision support for becoming "green in IS".

6.2 Concept-Overarching Findings

The review reveals an interesting relationship between the model-driven DSS type and the form of its presentation by an IT artifact. As expected, all model-driven DSSs are presented by a model artifact, such as an optimization model or another type of a (mathematical) model. However, less than half of them is implemented and demonstrated via an instantiation by a software prototype. Hence, the implementation of the intended (model-driven) solution remains questionable. Since model-driven DSSs might have a special impact on solving inefficiency problems and, hence, sustainability-related issues in an organizational context, the implementation of this DSS type is considered to be of an essential importance.

Finding 6: While most of the identified model-driven DSSs introduce a model as an IT artifact, only half of them are visibly presented as an instantiation. Hence, a practical contribution by implementing a solution to the addressed research problem remains questionable.

Around 30% of the papers (Angeles, 2013; Frehe et al., 2014; Gräuler et al., 2013; Hilpert et al., 2011; Nuss, 2015; Simkin and Schrödl, 2014; Stindt et al., 2014) present their DSSs as environmental management (information) systems (EMISs). EMISs are (analytical) information systems to measure, collect, process, analyze, monitor, and report "[…] environmental information in a company." (Loos et al., 2011, p. 247) However, a clear definition for EMISs cannot be identified in the literature (Simkin and Schrödl, 2014), especially when designed (as a DSS) in the energy sector (Nuss, 2015).

This becomes even more obvious by structurally analyzing the contributions—identified in this literature review—stating to deal with an EMIS. These papers are inconsistently presented as (compound) DSSs comprising different main component drivers. For instance, several EMISs, comprising the characteristics of a data-driven DSS, are often defined as a compound DSS with a tandem driver, such as a model-driver (Hilpert et al., 2011; Stindt et al., 2014), knowledge-driver (Gräuler et al., 2013), or communication-driver (Angeles, 2013), whereas the other three EMISs are distinctly designed as a data-driven DSS (Frehe et al., 2014; Nuss, 2015; Simkin and Schrödl, 2014). Furthermore, the identified EMISs either target the first-life domain or address all lifecycles as they are positioned and presented very generically to support decisions for, e.g., managing, reusing, and disposing products and other resources. For instance, Gräuler et al. (2013) position their corporate EMIS "[…] to address all relevant issues (e.g., air, water, and soil quality; waste management; legal requirements; auditing) in an integrated manner […]." (p. 100)

Finding 7: Many DSSs created in green IS research are inconsistently presented and positioned as environmental management information systems for which a clear definition is still missing. The relationship between DSSs and EMISs remains unclear.

In this literature review, DSS researchers, who provide contributions that address the stream of green IS research, are often affiliated at the same universities or even research groups. The geographical clusters can mainly be found in Hanover, Germany (Eickenjäger and Breitner, 2013; Koukal and Breitner, 2014; Rickenberg et al., 2013; Sonneberg et al., 2015), Göttingen, Germany (Brauer et al., 2015; Hilpert et al.,

2011, 2013), Augsburg, Germany (Nuss, 2015; Stindt et al., 2014), Freiburg, Germany (Bodenstein et al., 2011; Brandt et al., 2012), Osnabrück, Germany (Frehe et al., 2014; Gräuler et al., 2013), and Wollongong, Australia (Hasan and Smith, 2012; Hasan et al., 2014). Moreover, researchers originating from the same universities or research groups provide DSS contributions that elaborate on the same research topic, such as EMISs (Nuss, 2015; Stindt et al., 2014) and car sharing location optimization (Rickenberg et al., 2013; Sonneberg et al., 2015).

Finding 8: DSS contributions, which address the idea of green IS, are mostly written by researchers residing in Germany and are often initiated by researchers affiliated at the same universities.

The first queries we conducted on literature databases with more generic search terms retrieved a great number of research papers, which are available on the topics "green" and "DSS". For instance, searching the literature database Scopus for the search string ("dss" AND ("green" OR "sustainable" OR "environmental")) reveals more than 1,000 hits with many DSS contributions that would definitely fit into the stream of green IS research as they address its general idea. However, the majority of the papers does not proactively subscribe to this research field. Certainly, a reason is that DSSs shape a famous and wide-spread class of information systems and are well-known to researchers with various research backgrounds, such as (electrical) engineering and (reverse or supply chain) logistics. While researchers from these fields are not familiar with concepts and streams of IS research, their DSS contributions are not positioned to the field of green IS research.

Finding 9: In the broad scientific literature, many DSS contributions address the idea of green IS research but do not subscribe to this research stream.

7 CONCLUSION AND RESEARCH AGENDA

In line with Webster and Watson (2002), this paper presented a structured literature review for systematically analyzing the contributions of DSS research to the field of green IS research. The applied literature search and selection process revealed 23 paper instances, which were assessed by a concept-centric literature analysis, including the five theoretical concepts "type of DSS", "IT artifact", "IS research method", "supported lifecycle", and "green IS paradigm". A condensed overview of concept-related and concept-overarching findings that were derived from the concept matrix is presented by Table 3. Based on the most important findings we propose four future research directions for DSS contributions in green IS research.

Emphasizing further design research resulting in more (model-driven) DSSs implementations: As the findings show, several design research papers provide software implementations of DSSs to demonstrate the feasibility of the addressed challenges. Despite the fact that design research conducted in this field is already on a good way, future design research contributions should highly consider to provide models, methods, or languages in line with an implementation. This insight is especially important for model-driven DSSs, since especially this type can make a special impact on the green IS domain, e.g., by optimizing business problems in terms of efficiency- and effectivity-related issues. Moreover, the investigation of document-driven DSSs should also be in the scope of green IS research. Future document-driven DSSs could be designed for systematically acquiring and analyzing product sheets or law texts to improve organizational decision-making, e.g., to achieve a higher awareness for sustainability issues.

Contributing to second-life and end-of-life domains: Due to the overrepresentation of DSSs providing manifold solutions for the first-life domain, future research should especially cover the design of second-life and end-of-life DSS applications, too. Because of the scarcity of natural resources, the design of second-life and end-of-life DSSs seems to be worthwhile for contributing to an overall sustainable course of action. For example, to achieve an optimal reusing of used goods, the solving of complex assignment problems seems to be of great importance. Furthermore, the design of sophisticated DSSs dealing with recycling strategies and reverse logistics networks to achieve an optimal recovery of scarce materials and resources is crucial, too.

Clarifying the relationship between DSSs and environmental management information systems (EMISs): As indicated, several of the identified papers develop an EMIS that comprises different DSS-related functionalities for the purpose of processing environmental information. However, it turns out that the relationship between DSSs and EMISs is not clear since this information systems' type is inconsistently defined and described in the literature. Thus, future research should strive for a clear definition, especially in terms of the systematic involvement of component drivers of DSSs.

Subscribing DSS contributions proactively to green IS research: Contributions that are positioned to the stream of green IS research may benefit from its inherent paradigms. This might be valuable for strengthening both the importance of and the line of argumentation for the addressed research problems. While DSS research papers in this domain are currently underrepresented, subscribing future DSS research to this research stream can result in impactful publications. Furthermore, DSS research that is positioned in line with green IS research refers to a highly new and paradigmatic stream of IS research. By addressing the grand challenges for (green) IS research (Becker et al., 2015; vom Brocke et al., 2013; Melville, 2010), contributions made to this field might have a considerable impact for both researchers and practitioners, which might also inspire further DSS researchers and practitioners to contribute to this domain. By increasing the number of DSS contributions it is possible to emphasize the importance of DSSs for the field of green IS research.

#	Finding
1	Model-driven and data-driven DSSs shape the dominant component drivers of present (compound) DSS instances within green IS research. Document-driven DSSs cannot be identified.
2	IT artifacts that are mainly used to present DSS contributions in green IS research are instantiations and models. As yet, only few methods and no constructs for describing and modeling DSSs have been created in this research field. Especially the design of decision processes (methods) could improve the understandability of the addressed decision problems in green IS research.
3	DSS contributions to green IS research are mainly created by design-oriented research endeavors. Only few literature reviews for structuring the research field can be identified. However, this is necessary to better understand possible areas to contribute with DSSs to green IS research.
4	The reviewed contributions to green IS research highly address decision support for the first-lifecycle and often support business contexts in the energy domain. In the field of green IS, especially the second-life and end-of-life domains for reusing, repurposing, refurbishing, reprocessing, recycling, and disposing goods need further investigations and contributions by DSS research.
5	While the paradigm "green by IS" is highly targeted by DSS contributions in green IS research, there are only few contributions dealing with decision support for becoming "green in IS".
6	While most of the identified model-driven DSSs introduce a model as an IT artifact, only half of them are visibly presented as an instantiation. Hence, a practical contribution by implementing a solution to the addressed research problem remains questionable.
7	Many DSSs created in green IS research are inconsistently presented and positioned as environmental management information systems for which a clear definition is still missing. The relationship between DSSs and EMISs remains unclear.
8	DSS contributions, which address the idea of green IS, are mostly written by researchers residing in Germany and are often initiated by researchers affiliated at the same universities.
9	In the broad scientific literature, many DSS contributions address the idea of green IS research but do not subscribe to this research stream.

Table 3: Overview of concept-related (1–5) and concept-overarching (6–9) findings

Acknowledgments

This article was written in the research project "end-of-life information systems (EOL-IS)—decision support for repurposing used electric vehicle batteries". EOL-IS (funding label: 01FE13023E) is funded by the German Federal Ministry of Education and Research (BMBF). Furthermore, we thank the project sponsor German Aerospace Center (DLR) for their advice.

References

Abdelhamid, M. (2014), *A Comprehensive Assessment Methodology Based on Life Cycle Analysis for On-Board Photovoltaic Solar Modules in Vehicles*, available at: http://tigerprints.clemson.edu/all_dissertations/1458/.

Alter, S. (1977), "A Taxonomy of Decision Support Systems", *Sloan Management Review*, Vol. 19 No. 1, pp. 39–56.

Angeles, R. (2013), "Understanding Nike's 'Considered Index' Green Initiative Using the Technology-Organization-Environment Framework", *Proceedings of the International Conference on Information Resources Management (CONF-IRM)*, Natal.

Arnott, D. and Pervan, G. (2008), "Eight key issues for the decision support systems discipline", *Decision Support Systems*, Vol. 44 No. 3, pp. 657–672.

Arnott, D. and Pervan, G. (2012), "Design Science in Decision Support Systems Research: An Assessment using the Hevner, March, Park, and Ram Guidelines", *Journal of the Association for Information*, Vol. 13 No. 11, pp. pp. 923–949.

Arnott, D. and Pervan, G. (2014), "A critical analysis of decision support systems research revisited: The rise of design science", *Journal of Information Technology*, Nature Publishing Group, Vol. 29 No. 4, pp. 269–293.

Becker, J., vom Brocke, J., Heddier, M. and Seidel, S. (2015), "In Search of Information Systems (Grand) Challenges", *Business & Information Systems Engineering*, Vol. 57 No. 6, pp. 377–390.

Beverungen, D., Klör, B., Bräuer, S. and Monhof, M. (2015), "Will They Die Another Day? A Decision Support Perspective on Reusing Electric Vehicle Batteries", *Proceedings of the Twenty-Third European Conference on Information Systems (ECIS 2015)*, Münster, pp. 1–12.

Bodenstein, C., Schryen, G. and Neumann, D. (2011), "Reducing datacenter energy usage through efficient job allocation", *Proceedings of the Nineteenth European Conference on Information Systems (ECIS 2011)*, Helsinki, pp. 1–12.

Brandt, T., Wagner, S. and Neumann, D. (2012), "ROAD TO 2020: IS-SUPPORTED BUSINESS MODELS FOR ELECTRIC MOBILITY AND ELECTRICAL ENERGY MARKETS", *Proceedings of the Thirty Third International Conference on Information Systems (ICIS 2012)*, Orlando, pp. 1–10.

Brauer, B., Eisel, M. and Kolbe, L.M. (2015), "The State of the Art in Smart City Research – A Literature Analysis on Green IS Solutions to Foster Environmental Sustainability", *Proceedings of the Nineteenth Pacific-Asian Conference on Information Systems (PACIS 2015)*, Singapore, pp. 1–17.

vom Brocke, J. and Seidel, S. (2012), "Environmental Sustainability in Design Science Research: Direct and Indirect Effect", in Peffers, Ken and Rothenberger, Marcus and Kuechler, B. (Ed.),*Design Science Research in Information Systems. Advances in Theory and Practice*, pp. 294–308.

vom Brocke, J., Simons, A., Niehaves, B., Riemer, K., Plattfaut, R. and Cleven, A. (2009), "Reconstructing the giant: On the importance of rigour in documenting the literature search process.", *Proceedings of the Sixteenth European Conference on Information Systems (ECIS 2009)*, Verona, Vol. 17, pp. 1–13.

vom Brocke, J., Watson, R.T., Dwyer, C., Elliot, S. and Melville, N. (2013), "Green information systems: Directives for the IS discipline", *Communications of the Association for Information Systems*, Vol. 33, pp. 509–520.

Cooper, H. and Hedges, L. V. (2009), "Research Synthesis as a Scientific Process", in Cooper, H., Hedges, L. V. and Valentine, J.C. (Eds.),*The Handbook of Research Synthesis and Meta-Analysis*, Russell Sage Foundation, 2nded., pp. 3–16.

Corbett, J. (2011), "Demand Management in the Smart Grid: An Information Processing Perspective", *17th Americas Conference on Information Systems (AMCIS)*, Detroit, pp. 1–8.

Corbett, J. (2013), "Designing and Using Carbon Management Systems to Promote Ecologically Responsible Behaviors", *Journal of the Association of Information Systems*, Vol. 14 No. 7, pp. 339–378.

Dalal-Clayton, D. (1993), *Modified EIA and indicators of sustainability: first steps towards*

sustainability analysis, *Twelfth Annual Meeting of the International Association for Impact Assessment*, available at: http://pubs.iied.org/pubs/pdfs/7766IIED.pdf (accessed 26 January 2014).
Doyle, A. and Lewis, B. (2015), "With landmark climate accord, world marks turn from fossil fuels", available at: http://www.reuters.com/article/us-climatechange-summit-idUSKBN0TV04L20151212 (accessed 26 January 2016).
Eickenjäger, M. and Breitner, M. (2013), "REFUSA: IS-Enabled Political Decision Support with Scenario Analyses for the Substitution of Fossil Fuels", *Proceedings of the International Conference on Information Systems (ICIS 2013)*, Milan, pp. 1–20.
Elkington, J. (1994), "Towards the suitable corporation: win-win-win business strategies for sustainable development", *California management review*, No. June 1992, pp. 90–101.
Elliot, S. and Binney, D. (2008), "Environmentally sustainable ICT: Developing corporate capabilities and an industry-relevant IS research agenda", *Proceedings of the Pacific Asia Conference on Information Systems (PACIS 2008)*, Suzhou, Vol. 2004, available at: http://aisel.aisnet.org/pacis2008/209/ (accessed 28 January 2014).
Esfahani, M.D., Rahman, A.A. and Zakaria, N.H. (2015), "Influence Processes for Information Technology Acceptance: An Elaboration Likelihood Model", available at: ftp://163.25.117.117/ckuo/MScIM_101_1/Paper/Ch9_Bhattacherjee2006.pdf.
Frehe, V., Stiel, F. and Teuteberg, F. (2014), "A Maturity Model and Web Application for Environmental Management Benchmarking", *Proceedings of the Twentieth Americas Conference on Information Systems (AMCIS 2014)*, Savannah, pp. 1–14.
Golding, P.A., Hylton, O.D. and Tennant, V.M. (2013), "The Impact of a ZigBee enabled Energy Management System on Electricity Consumption", *Proceedings of the Nineteenth Americas Conference on Information Systems (AMCIS 2013)*, Chicago, pp. 1–8.
Gräuler, M.., Teuteberg, F.., Mahmoud, T.. and Marx Gomez, J.. (2013), "Requirements prioritization and design considerations for the next generation of Corporate Environmental Management Information Systems: A foundation for innovation", *International Journal of Information Technologies and Systems Approach*, Vol. 6 No. 1, pp. 98–116.
Gregor, S. and Hevner, A.R. (2013), "Positioning and Presenting Design Science Research for Maximum Impact", *Management Information Systems Quarterly*, Vol. 37 No. 2, pp. 337–355.
Hasan, H. (2012), "Unordered business processes, sustainability and Green is", *Green Business Process Management: Towards the Sustainable Enterprise*, Vol. 9783642274, pp. 39–58.
Hasan, H. (2016), "SIGGreen - Green IS Taxonomy", available at: https://siggreen.wikispaces.com/Welcome+to+the+SIGGreen+Wiki+Homepage (accessed 12 February 2016).
Hasan, H., Molla, A. and Cooper, V. (2014), *A Green IS taxonomy*, A publication of the THEORI Research Group, available at: http://eurekaconnection.files.wordpress.com/2014/02/p-98-107-a-green-is-taxonomy-theori-ebook_finaljan2014-v3.pdf.
Hasan, H. and Smith, S. (2012), "Increasing demands on information systems and infrastructures for complex decision-making", *Proceedings of the Pacific Asia Conference on Information Systems (PACIS 2012)*, Hochiminh City, pp. 1–15.
Hevner, A., March, S., Park, J. and Ram, S. (2004), "Design science in information systems research", *MIS quarterly*, Vol. 28 No. 1, pp. 75–105.
Hilpert, H., Friedemann, S. and Schumann, M. (2011), "Improved emission data collection in air cargo processes using ADS-B", *Proceedings of the Twenty Second Australian Conference on Information Systems (ACIS 2011)*, Sydney, p. Paper 16.
Hilpert, H., Kranz, J. and Schumann, M. (2013), "Leveraging green is in logistics: Developing an artifact for greenhouse gas emission tracking", *Business and Information Systems Engineering*, Vol. 5 No. 5, pp. 315–325.
Holsapple, C.W. (2008), "DSS Architecture and Types", *Handbook on Decision Support Systems 1: Basic Themes*, pp. 163–189.
Kossahl, J., Busse, S. and Kolbe, L. (2012), "THE EVOLVEMENT OF ENERGY INFORMATICS IN THE INFORMATION SYSTEMS COMMUNITY - A LITERATURE ANALYSIS AND RESEARCH AGENDA", *Proceedings of the Twentieth European Conference on Information*

Systems (ECIS 2012), Barcelona, available at: http://aisel.aisnet.org/ecis2012/172/ (accessed 3 May 2014).

Koukal, A. and Breitner, M.H. (2014), "Offshore wind energy in emerging countries: A decision support system for the assessment of projects", *Proceedings of the Annual Hawaii International Conference on System Sciences (HICSS 2014)*, Big Island, pp. 865–874.

Loeser, F. (2013), "Green IT and Green IS: Definition of Constructs and Overview of Current Practices", *Proceedings of the Nineteenth Americas Conference on Information Systems (AMCIS 2013)*, Chicago, pp. 1–13.

Loock, C., Staake, T. and Landwehr, J. (2011), "GREEN IS DESIGN AND ENERGY CONSERVATION: AN EMPIRICAL INVESTIGATION OF SOCIAL NORMATIVE FEEDBACK", *Proceedings of the Thirty Third International Conference on Information Systems (ICIS 2011)*, Shanghai, pp. 1–15.

Loos, P., Nebel, W., G??mez, J.M., Hasan, H., Watson, R.T., Brocke, J. Vom, Seidel, S., et al. (2011), "Green IT: A matter of business and information systems engineering?", *Business and Information Systems Engineering*, Vol. 3 No. 4, pp. 245–252.

March, S.T. and Smith, G.F. (1995), "Design and natural science research on information technology", *Decision Support Systems*, Vol. 15 No. 4, pp. 251–266.

McGrath, G.M., Whitelaw, P.A., Lipman, G.H., Meijerink, H., Law, A. and Lacy, T. De. (2013), "A Conceptual Information Model for a 'Green Economy Tourism System'(GETS)", *Proceedings of the Nineteenth Americas Conference on Information Systems (AMCIS 2013)*, Chicago, pp. 1–12.

Melville, N.P. (2010), "Information Systems Innovation for Environmental Sustainability", *MIS Quarterly*, Vol. 34 No. 1, pp. 1–21.

Mora, M., Gelman, O., Paradice, D. and Cervantes, F. (2008), "The Case for Conceptual Research in Information Systems", *Proceedings of the International Conference on Information Resources Management (CONF-IRM)*, Niagara Falls, ON, available at: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:The+Case+for+Conceptual+Research+in+Information+Systems#0.

Nishant, R., Teo, T.S.H. and Goh, M. (2013), "Understanding the Environmental Impact of Sustainable IT: An Empirical Examination", *Proceedings of the Seventeenth Pacific Asia Conference on Information Systems (PACIS 2013)*, Jeju Island.

Nuss, C. (2015), "Developing an Environmental Management Information System To Foster Sustainable Decision-Making in the Energy Sector", *Proceedings of the Twenty-Third European Conference on Information Systems (ECIS 2015)*, Münster, pp. 1–15.

Oates, B.J. (2006), *Researching information systems and computing*, SAGE Publications, London ; Thousand Oaks, Calif.

Peffers, K., Tuunanen, T., Rothenberger, M. a. and Chatterjee, S. (2007), "A Design Science Research Methodology for Information Systems Research", *Journal of Management Information Systems*, Vol. 24 No. 3, pp. 45–77.

Power, D. (2000), "Web-based and model-driven decision support systems: concepts and issues", *Proceedings of the Sixth Americas Conference on Information Systems (AMCIS 2000)*, Long Beach, pp. 352–355.

Power, D.J. (2004), "Specifying An Expanded Framework for Classifying and Describing Decision Support Systems", *Communications of the Association for Information Systems Volume*, Vol. 13, pp. 158–166.

Power, D.J. and Sharda, R. (2007), "Model-driven decision support systems: Concepts and research directions", *Decision Support Systems*, Vol. 43 No. 3, pp. 1044–1061.

Rickenberg, T.A.A., Gebhardt, A. and Breitner, M.H. (2013), "A Decision Support System For The Optimization Of Car Sharing Stations", *Proceedings of the Twenty First European Conference on Information Systems (ECIS 2013)*, pp. 1–12.

Rush, D. and Melville, N. (2012), "Do Carbon Management System Adoption Announcements Affect Market Value?", *Proceedings of the Thirty Third International Conference on Information Systems (ICIS 2012)*, Orlando, pp. 1–11.

Seidel, S., Recker, J. and vom Brocke, J. (2012), "Green Business Process Management", in vom

Brocke, J., Seidel, S. and Recker, J. (Eds.),*Green Business Process Management: Towards the Sustainable Enterprise*, Springer-Verlag, Berlin Heidelberg, 1sted., pp. 3–13.

Simkin, P. and Schrödl, H. (2014), "Environmental Management Information Systems (EMIS) Revisited: Towards a Research Agenda for Energy", *Proceedings of the International Conference on Information Resources Management (CONF-IRM)*, Hochiminh City, p. Paper 23.

Simon, H.A. (1977), *The new science of management decision*, Prentice Hall, Englewood Cliffs, NJ, USA, revised.

Smith, S., Winchester, D.W., Hasan, H. and Finnegan, P. (2011), "IS for Government Climate Change Adaptation Activities: An Exploratory Case Study", *Proceedings of the Twenty Second Australian Conference on Information Systems (ACIS 2011)*, Sydney, available at: http://aisel.aisnet.org/acis2011/48.

Sodenkamp, M., Kozlovskiy, I. and Staake, T. (2015), "Gaining IS Business Value through Big Data Analytics: A Case Study of the Energy Sector", *Proceedings of the Thirty Sixth International Conference on Information Systems (ICIS 2015)*, Fort Worth, pp. 1–19.

Sonneberg, M.-O., Kühne, K. and Breitner, M.H. (2015), "A Decision Support System For The Optimization Of Electric Car Sharing Stations", *Proceedings of the Thirty Sixth International Conference on Information Systems (ICIS 2015)*, Fort Worth, pp. 1–12.

Stindt, D., Nuss, C., Bensch, S., Dirr, M. and Tuma, A. (2014), "An Environmental Management Information System for Closing Knowledge Gaps in Corporate Sustainable Decision-Making", *Proceedings of the Thirty Fifth International Conference on Information Systems (ICIS 2014)*, Auckland, pp. 1–18.

Sutter, J.D., Berlinger, J. and Ellis, R. (2015), "Obama: Climate agreement 'best chance we have' to save the planet", available at: http://edition.cnn.com/2015/12/12/world/global-climate-change-conference-vote/ (accessed 25 January 2016).

Thompson, S., Ekman, P. and Raggio, R. (2015), "The Green Fingerprint : Decreasing Energy Consumption with Decision Support Systems", *Proceedings of the Twenty First Americas Conference on Information Systems (AMCIS 2015)*, Puerto Rico, pp. 1–14.

Turban, E., Aronson, J.E., Liang, T.-P. and Sharda, R. (2007), *Decision Support Systems and Business Intelligence Systems*, Pearson Prentice Hall, Upper Saddle River, NJ, 8th ed.

United Nations. (2015), "Adoption of the Paris Agreement", *Conference of the Parties on its twenty-first session*, Vol. 21932 No. December, p. 32.

Watson, R.T., Boudreau, M.C. and Chen, A.J. (2010), "Information systems and environmentally sustainable development: energy informatics and new directions for the IS community", *MIS Quarterly*, Vol. 34 No. 1, pp. 23–38.

Webster, J. and Watson, R.T. (2002), "Analyzing the Past to Prepare for the Future: Writing a Literature Review", *Management Information Systems Quarterly*, Society for Information Management and The Management Information Systems Research Center, Minneapolis, MN, USA, Vol. 26 No. 2, pp. xiii–xxiii.