Integrating a Method for Achieving Activity-Oriented Sustainability into the Design Science Research Methodology

Full papers

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Abstract

Sustainability increasingly becomes an effective argument in the public and academic discourse. However, in the scientific design process of IT artifacts, the notion of sustainability is often misused. IT artifacts and consequences resulting from their operation are characterized to be sustainable without truly reflecting the meaning of the characteristics of sustainability. By subscribing to a view of sustainability as a characteristic of an activity, we propose a method for the systematic integration of sustainability into the design of IT artifacts. Our so-called "activity-oriented sustainability method" is situated within the design science research methodology (DSRM) and allows to perform an ex-ante domain-specific sustainability analysis of activities, which are supported by an IT artifact. This article contributes to research and praxis by spurring discourse on the consideration of sustainability in design research endeavors and by providing a method for the systematic integration of sustainable activities into IT artifacts.

Keywords

Activity-Oriented Sustainability, Design Science Research Methodology (DSRM), Method Engineering, Electric Vehicle Domain, Green IS.

Motivation

Sustainability continues to become a highly misused concept within both academia (Chasin 2014) and practice (Laufer 2003). On the one hand, industry companies aggressively invest in sustainability campaigns that can be often characterized as "greenwashing" and merely emphasize the firms' pseudo-philanthropic attitudes (Pettenella et al. 2008). Whole enterprises are called sustainable without their full activity range being examined in order to satisfy this claim. On the other hand, academic literature, including publications in the information systems (IS) discipline, lacks rigor when it comes to the use of the sustainability concept (Chasin 2014).

To avoid the "inflation of sustainability", a value system that incorporates the full range and depth of sustainability aspects must be put into action. For that, sustainability should inevitably be defined on an activity level in order to safeguard that the operations, carried out for achieving a certain goal, are sustainable. Hence, different dimensions of sustainability need to be considered including the economic, social, and ecological dimensions (Elkington 1994). Although the importance of each dimension depends on the context (Pargman and Raghavan 2014), the consideration of all dimensions is crucial for making a holistic judgment of an artifact's sustainability at hand (Chasin 2014).

Since the design of IT artifacts for solving real world problems is one of the central goals in IS research, the consideration of sustainability is imperative (Bengtsson and Ågerfalk 2011; Malhotra et al. 2013; Melville 2010; Watson et al. 2010). IT artifacts either tackle problems such as the instability of economy, the degradation of the natural environment, and unacceptable or even inhuman working conditions through the manifestation of sustainable processes or they ignore and thus aggravate the problems' magnitude (Melville 2010; Watson et al. 2010). The design science research methodology (DSRM) (Peffers et al. 2007) is applied to scientifically design and evaluate IT artifacts for solving problems that are relevant to society (Gregor and Hevner 2013; Hevner et al. 2004; Peffers et al. 2007) and is widely accepted and adopted in the IS community. However, only limited research within design science research (DSR) has been done to align IT artifacts with the important premise of the supported activities to be sustainable. In this paper, we argue for integrating a systematic approach in the process of designing IT artifacts where sustainable activities are manifested ex-ante to the artifacts' design instead of merely focusing on the ex-post identification and evaluation of often unreliable and misleading sustainability indicators and measures. Consequently, we define the research goal to *systematically integrate domain-specific and activity-oriented sustainability into the design of IT artifacts*.

The remainder of this paper is structured as follows. After reviewing related work on the intersection of sustainability and DSR (Section 2) and presenting method engineering as the applied research approach (Section 3), we extend the DSRM by a method that fosters the systematic integration of sustainable activities into the design of IT artifacts (Section 4). Subsequently, the method's application is demonstrated in the context of two DSR projects located in the electric vehicle (EV) domain (Section 5). The article concludes by discussing the findings, elaborating on the article's limitations, and by outlining directions for further research (Section 6).

Research Background and Related Work

The concept of sustainability has its origins in the forestry domain and dates back to the 18th century, when it was understood as the long-term wood productivity (Paavilainen 1994). In the course of the 19th century, the productivity-oriented view on sustainability in forestry was extended by a dimension for considering "benefits" for future generations. Accordingly, the aim of the greatest possible resource utilization became restricted through the goal of future generations having at least as much benefit from the resource as the living generation (Wiersum 1995).

Currently, the concept with its competing and overlapping definitions has spread to various disciplines (Barkemeyer et al. 2011; Johnston et al. 2007; Kuhlman and Farrington 2010; Penzenstadler 2013; Pezzey 1992), including IS (Berthon and Donnellan 2011; Dao et al. 2011; Elliot 2011). The concept is, however, difficult to define. The only widely-adopted and yet too abstract definition that exists is the Brundtland's definition of the related concept of "sustainable development" (WCED 1987). However, it rather defines the development process instead of the sustainability itself and is therefore unsuited to methodically operationalize sustainability as a concept (Chasin 2014).

The most popular examples of sustainability operationalization comprise various indicator sets for assessing sustainability of an organizational entity. After the introduction of the sustainable development notion (WCED 1987), numerous assessment techniques were proposed within and outside of academia. One of the first frameworks by Dalal-Clayton (1993) already accounted for three explicit dimensions of sustainability. Historically, the economic dimension of sustainability, which can be understood as a source of competitive advantage (Porter and Kramer 2006), was extended by a social and an ecological dimension (Chasin 2014; Melville 2010). Over the years, rather general indicators were proposed by both governmental organizations (e.g., IIED, US EPA (Fiksel and Frederickson 2012), UNECE/Eurostat/OECD (UNECE/Eurostat 2013)) and research institutions (e.g., Ferrarini 2008; Hardjono and de Klein 2004; Heijungs et al. 2010; Starik and Rands 1995; Waggoner and Ausubel 2002). Beside the general indicator sets, more specific indicators and indicator frameworks were proposed to assess sustainability in specific domains, e.g., sustainable supply chain management (Carter and Rogers 2008), carbon capture and storage systems (Ramírez et al. 2008), car transport systems (Smith et al. 2013), or soil salinization (Zhou et al. 2013). Despite their wide adoption, the use of indicators is limited to post factum analyses (ex-post) and does not support the development of new IT artifacts that need to be defined ex-ante for achieving sustainable activities.

In the IS discipline, the topic of sustainability increasingly gains momentum since IT artifacts are considered to be both problems and solutions in regard to sustainability (Corbett 2013; Elliot and Binney 2008). IT artifacts as a problem are discussed under the umbrella term "Green IT", whereas "Green IS" sets the focus on enabling sustainability through IS (vom Brocke and Seidel 2012). In line with possible research agendas (Melville 2010; Watson et al. 2010), IS researchers request for more impactful research on sustainability (Malhotra et al. 2013), which is limited, especially when considering top-ranked publications (Bengtsson and Ågerfalk 2011; Malhotra et al. 2013; Melville 2010). As yet, the discipline of IS research in general and the design of IT artifacts in particular do not provide a systematic guidance for breaking down the IS' complexity in regard to what we call "activity-oriented sustainability". However, attempts to assess ecological impacts on the artifacts' level during design-time have already been discussed (vom Brocke and Seidel 2012).

For justifying the proposition of missing techniques and methods that facilitate the systematic integration of activity-oriented sustainability into the design of IT artifacts, literature queries for the search string *("sustainability" AND ("design science" OR "DSR" OR "DSRM") AND ("activity" OR "task" OR "process" OR "action"))* were conducted on April 21st, 2016 in the scientific literature databases Scopus (total hits: 58; relevant hits: 0), AISEL (searching abstracts only; 3; 0) and Web of Science (15; 0). No present methods for achieving activity-oriented sustainability in the design of IT artifacts were identified. The closest to what we see as a way to integrate sustainability into the design of IT artifacts is a design framework that includes a sustainability analysis of an IS on a "microscopic" level (Chen and Kazman 2012). However, the application domain is narrowed down to what the authors call the "Ultra Large Scale (ULS) Green IS" (p. 69)—a system with many unknown stakeholders, missing design goals, and non-deterministic system behavior. Although we value the idea of considering sustainability as an integral part of IS design, the approach is regarded to be insufficient for *systematically integrating meaningful sustainability aspects into the design of domain-specific IT artifacts*.

Research Approach

For the construction of innovative IT artifacts, design science research is the predominant research paradigm in the IS community (Gregor and Hevner 2013; Hevner and Chatterjee 2010; Hevner et al. 2004; Peffers et al. 2007). Because IT makes a great impact on the surrounding, a notion of sustainability becomes imperative to be included into design research. For manifesting an understanding of sustainability in DSR, we set out to add a method for achieving activity-oriented sustainability to the well-known design research methodology proposed by Peffers et al. (2007). We used method engineering for tailoring the DSRM accordingly. Amongst others, method engineering allows for tailoring existing methods to solve new and emerging problems (Brinkkemper 1996).

In order to back this integration process, we conducted a literature review that identifies the lack of suitable understandings of sustainability in the IS literature and the missing systematic integration of sustainability to DSRM. For embedding the proposed method into DSRM, we develop and provide a line of argumentation in order to support the adoptions made to DSRM. The method is exemplarily demonstrated by analyzing two IS research projects within the EV domain. For conducting the analyses, we consulted literature on the lifecycle of EVs and the production of energy. In addition, we conducted 8 informal interviews with experts from the domains legal, energy supply, technical inspection, battery manufacturing, battery research, reverse logistics, and battery recycling for better understanding the domain.

Method Design

Design of a Method for Achieving Activity-Oriented Sustainability

The method for achieving activity-oriented sustainability comprises six method steps that primarily focus on the activities taking place in a specific domain of research and that are supported by an intended IT artifact (Figure 1). Subsequently, the single method steps as well as their inputs, aims, and outputs are elucidated.

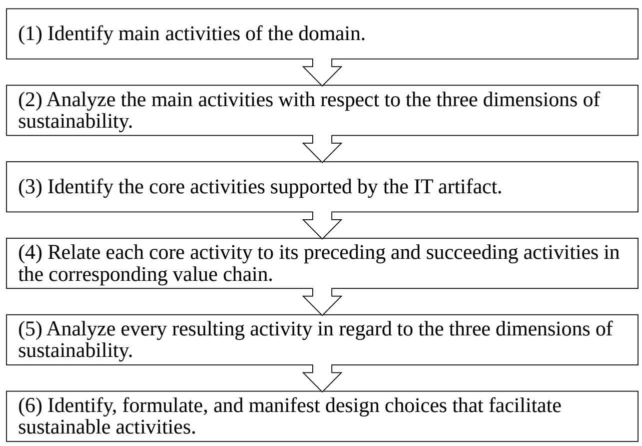

Figure 1. Method for achieving activity-oriented sustainability

The **domain's main activities** (step 1) are primarily derived from the high-level goals that have to be achieved in the domain of interest. The rationale behind identifying the main activities is to get a holistic understanding of the domain for the contributing scientists before developing the IT artifact. Hence, by considering the basic goals of a domain, the stakeholders can early reflect on the systemic influences of the project outcomes on the society and the natural environment. The output of this step is a list of the main activities characterizing the domain.

The previous step is important because the main activities need to be analyzed (step 2) in order to determine if the domain itself, wherein the IT artifact is embedded, can be aligned to sustainability goals. For that, the analysis takes account for the three proposed dimensions of sustainability (economic, social, and ecological). For each dimension, suitable sustainability indicators must be defined on the domain level. The social dimension includes indicators such as competitive wages, working conditions, and industrial safety, whereas the economic dimension is characterized by indicators such as long-term profitability, competitive advantage, and efficiency and effectiveness measures. In the ecological dimension, indicator candidates are measures of emissions, toxic waste, energy consumption, and the carbon footprint. If this analysis reveals that the domain's main activities primarily focus on rather unsustainable activities, the project itself has to be critically questioned. Nevertheless, an IT artifact could improve activities of such a domain by reengineering available business processes (activities) and by introducing more sustainable activities. Therefore, a further step of breaking down the IT artifact to the level of its core activities is required.

Based on the type of an IT artifact (March and Smith 1995) and its requirements, the **artifact's supported core activities** are identified (step 3). Despite the fact that the IT artifact type "language" (e.g., modeling languages, programming languages) (March and Smith 1995) does not comprise activities at its heart, languages may be used for conceptualizing, modeling, and implementing IS' supported core activities, which in turn can be analyzed. However, we consider it to be more obvious to identify supported core activities of the IT artifact types "software implementations", "methods", and "models" (March and Smith 1995) since these types are fundamentally aligned to business processes and, hence, activities. In regard to models, this proposition primarily holds true for (business) process models and process reference models (e.g., SCOR), since other conceptual models may deal with rather abstract domain facets. The output of this step is a list of detailed activities that are enabled or supported by an IT artifact.

Subsequently, for each supported core activity, its preceding and succeeding activities in the respective value chain must be identified (step 4). This value chain analysis is important to sensitize the designers for the sources and effects of the single core activities' sustainability issues in the surrounding environment of an IT artifact. The artifact's supported core activities can belong to several and disjoint value chains, which should be documented as well. Consequently, the output of this method step is a list of surrounding activities that either lead to supported core activities or that are triggered by supported core activities of an IT artifact.

Next, all supported core activities and their surrounding activities in the value chains must be analyzed with respect to the three dimensions of sustainability (step 5). Hence, suitable indicators for each sustainability dimension must be defined and explicated either in dependence on the specific domain (general indicators) or in regard to the specific industry or research project (specific indicators). Despite the fact that IT artifacts are constructed within the same domain, they highly differ in scope and structure and usually do not consist of activities that could be assessed by generic sustainability indicators, which apply for the domain level. Thus, sustainability assessment techniques (Dalal-Clayton 1993; Zhou et al. 2013 as introduced in Section 2) can be applied to support this analysis. Although these assessment techniques are used for post factum analyses (ex-post), they can be used to inform the indicator selection of ex-ante assessments, too. Consequently, the output of this analysis is a list of rated activities of the IT artifact—hereafter this concept is called **rated activity map** (Figure 2). The rating of activities regarding the three dimensions of sustainability is represented by black tripartite circles. For instance, the rated activity "mine uranium" contains dubious indicators in the social (e.g., poor working conditions and safety) and ecological (e.g., high waste production) dimensions, whereas the economic (e.g., high efficiency and profitability) dimension contains favorable indicators.

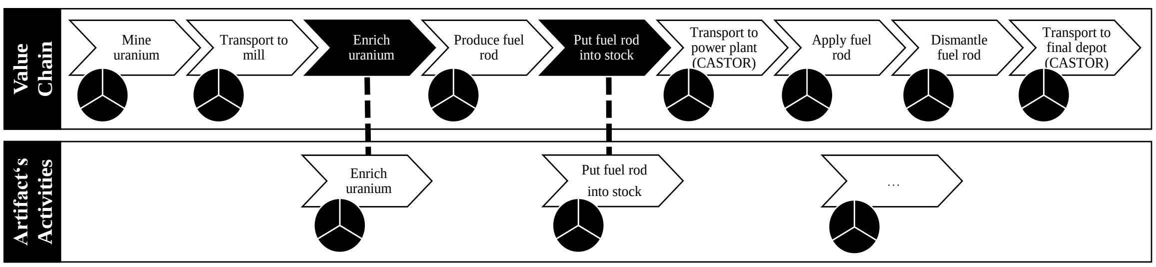

Figure 2. Rated activity map of supported core activities by an exemplary IT artifact used for the production of fuel rods

Finally, based on the gained insights by the analysis in step 5, a **plan of design choices** is defined (step 6). This is the most important step of the entire method as the resulting design choices deeply impact the development of the IT artifact. All design choices need to be provided with reasonable arguments, which can be derived from the outcomes of the previous analyses (steps 1–5). The design choices should be focused on those activities that do not satisfy the notion of activity-oriented sustainability. For these activities, the developers of the IT artifact can consider three possible alternatives to deal with the unsustainable impacts of the activities. First, suitable technical *design mechanisms* (e.g., fault tolerance, content or semantic filters, two-man rules, ergonomic controls, redundancy, encryption strategies) could be applied to the implementation in order to remove the unsustainable character of the respective activities. Second, *already existing or new alternatives* for compensating the unsustainable activities could be adopted (best practices) or developed. Third, activities that have been identified to be inherently unsustainable must be *omitted from implementation*. Clearly, there are cases where unsustainable activities cannot be improved, substituted, or omitted, e.g., due to hard constraints on the surrounding circumstances such as the political course of action. However, the manifestation of these unsustainable activities in an IT artifact to achieve the overall project goals may lead to the emergence of other sustainable activities. If this ambivalent case arises, the method still helps developers to, at least, be aware of these unsustainable activities and to consider complements (e.g., in the implementation) later on, such as a substantial change, e.g., in the political course of action, occurs (for instance, exit from nuclear and fossil-fuel energy).

Integrating the Method into DSRM

DSRM shapes the scientific process of building and evaluating innovative, useful, and impactful IT artifacts (Hevner et al. 2004). According to Peffers et al. (2007), the DSRM consists of six sequential phases. First, the development's scope is set by motivating and explicating the necessity and, thus, innovativeness of the artifact. Second, the objectives are defined to guide the subsequent design with requirements that must be met. Third, the design phase covers the construction of the intended IT artifact. Fourth, an instance of the IT artifact is demonstrated by putting it into action. Fifth, an evaluation is conducted to reveal the IT artifact's utility. Sixth, the results of the designed artifact are communicated to spread the knowledge and, hence, to contribute to the scientific community.

Following the rationale argumentation that a sustainable action results from a reasonable decision made beforehand, the method for achieving activity-oriented sustainability integrates to DSRM in the phases (2) definition of objectives and (3) design and development (cf. Figure 3) of an IT artifact. Since the latter phases of DSRM (4–6) deal with an already implemented and instantiated IT artifact, the notion of activity-oriented sustainability needs to be considered at the early stages in the research cycle for the following three reasons.

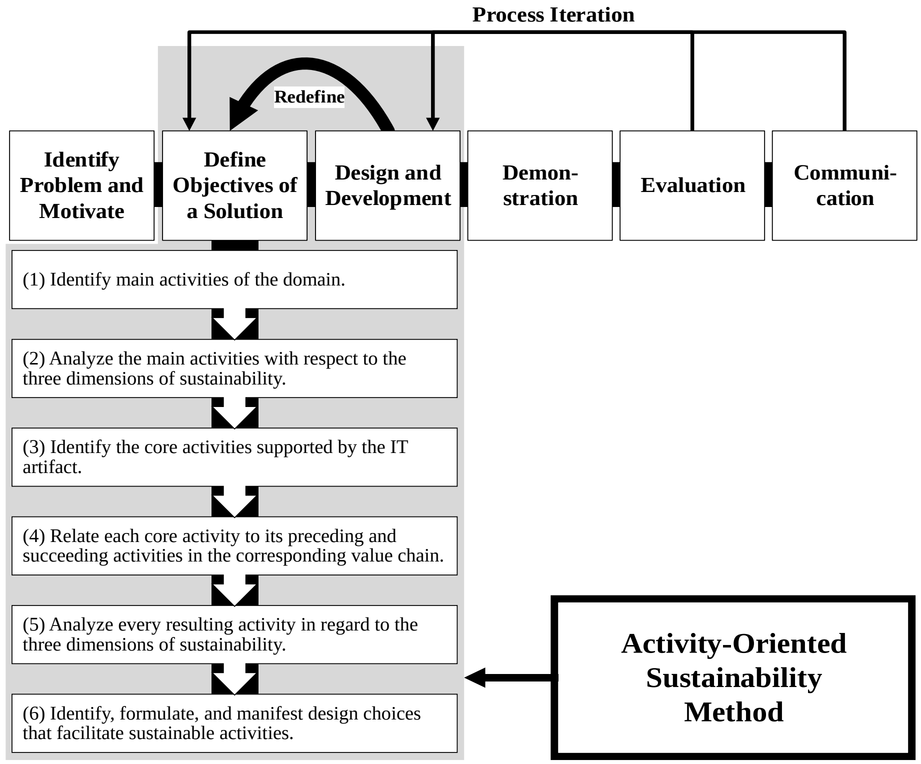

Figure 3. Integrating the activity-oriented sustainability method into DSRM (Peffers et al. 2007)

First, after having designed an IT artifact that is about to be demonstrated, evaluated, or communicated, the willingness to change this artifact in accordance with the activity-oriented sustainability concept is expected to be low (e.g., because of protection of investment in terms of exceeding costs, close deadlines, and already invested efforts). Consequently, we argue that the notion of activity-oriented sustainability must be considered in the early DSRM phases (2) and (3), as the intended solution is early work in progress and many sustainability facets may be included in the design.

Second, during the design of an IT artifact, the understanding of the artifact's domain rises (Gregor and Hevner 2013) while moving along the learning curve. Hence, domain problems and other related problems to sustainability can only be discovered with some delay. Furthermore, the artifact's objectives may change considerably with respect to the revealed issues during design-time. Both, the sustainability insights gained during the design of the artifact and the redefinition of objectives result in an iterative cycle of reflection and self-reflection, which will consequently saturate in sustainable activities that are supported by an IT artifact.

Third, the traditional DSRM encompasses process iterations in order to design IT artifacts (Peffers et al. 2007). After designing and demonstrating an IT artifact, the result's (5) evaluation and (6) communication are conducted. Both phases can trigger an artifact's iteration continuing with either the phase of (2) (re)defining the artifact's objectives or with its (3) (re)design. Hence, anchoring the method for achieving activity-oriented sustainability to both continuation points of DSRM iterations consequently leads to a closed-loop of considering and reflecting activity-oriented sustainability in the design of IT artifacts.

Demonstration of the Method

Based on the method for achieving activity-oriented sustainability, analyses of two DSR projects located in the EV domain are conducted in the following. First, the EV domain is introduced. Second, after describing the scope of the two research projects, third, the domain's core activities, the projects' artifacts (a decision support system (DSS) and a charging infrastructure management system) and their respective activities are exemplarily outlined and analyzed.

Domain Layer: Introduction to the Electric Vehicle Domain

EVs are considered to be a ground-breaking innovation for achieving sustainable transportations (NPE 2012). On the one hand, propelling cars, buses, motorcycles, and other means of transportation by electric current might reduce the dependency on fossil fuels that are still indispensable today. On the other hand, if the required electricity is produced unsustainably by nuclear or coal-fired power plants, the overall sustainability of EVs remains questionable. For launching EVs successfully, it is necessary to take a holistic view on the domain in order to foster the EVs' further evolvement. In turn, these thorough considerations might have the potential to address several environmental pollution issues such as carbon-dioxide, noise, and fine-dust emissions (NPE 2012).

There are major domain problems that create great qualms of companies and customers towards EVs. In many countries (including Germany) the charging infrastructure for fueling EVs is underdeveloped. In addition, immature and expensive battery technologies lead to long charging times, short driving ranges (Teichmann et al. 2012), and high EVs' initial costs (Hanna et al. 2013). These domain problems lower the customers' willingness to adopt such vehicles, which utility is arguably below traditional gas-operated vehicles.

For dealing with these high-level problems, a plethora of solutions is required. Since individual resources are scarce (e.g., financial budget and time), the EV domain must cope with the aforementioned issues, e.g., by lowering the EVs' purchase prices (e.g., by large-scale battery and vehicle production), establishing a sufficient charging infrastructure (e.g., tight-knit network of charging stations), and optimizing the vehicles' charging behavior (e.g., improved battery technology). To sum up, despite the domain's inherent sustainability potential, the high economic pressure can lead to solutions being developed that do not satisfy the notion of activity-oriented sustainability.

Project and Artifact Layer: Introduction to Research Projects and IT Artifacts

In general, the two considered research projects deal with the market penetration of EVs. Both projects strictly apply DSR since IT artifacts (software implementations) are their major outcomes. Both projects are facilitated by national funding and are conducted in the spirit of consortium research (Österle and Otto 2010). Consequently, the development involves scientific and practical stakeholders both defining different requirements and objectives in regards to the IT artifacts. The activity-oriented sustainability method can help to understand the sources of contradicting design priorities set by the different stakeholders and may help to resolve conflicts by finding the most reasonable alternative.

EOL-IS (Project 1): Decision Support for Repurposing Used Electric Vehicle Batteries

Electric vehicle batteries (EVBs) are responsible for up to 50% of the initial costs of EVs. Because of degradation effects, EVBs must be replaced after approximately ten years of usage. Since used EVBs still contain around 80% of their initial capacity, they can be repurposed in various stationary applications, e.g., as buffer storages in wind parks or smart homes. A considerably high number of used EVBs are expected to appear during the next years, because EVs are increasingly penetrating the market. As a consequence, by generating additional revenues through the repurposing of used EVBs, their decreased total costs of ownership may result in significantly lower EVs' purchase prices.

However, bringing together suppliers and demanders of used EVBs is a complex decision problem as many technical, legal, economic, and ecological properties of both batteries and second life scenarios (SLSs) need to be taken into account. In the spirit of lemon markets (Akerlof 1970), buyers of used EVBs never know their factual quality as each battery degrades individually. Hence, transparency mechanisms (e.g., quality measures and labels) and services (e.g., warranties, transportation, installation, maintenance, and revocation) become imperative to actively reduce the individual risk of buyers of used EVBs. Consequently, the design of service bundles is required for making an attractive and feasible offer to individual SLSs. In the context of EOL-IS, a DSS is developed to support the decision-maker during all phases of the complex decision process. For that, the DSS serves for (1) generating an optimal plan of used EVBs feasibly matching to SLSs and (2) configuring required services for the desired application (Beverungen et al. 2015).

CrowdStrom (Project 2): Crowdsourced Charging Infrastructure for Electric Vehicles

The success of the EV domain depends on the development of a tight-knit charging infrastructure suitable to support the operation of a high quantity of EVs. According to the experts of the NPE (2012), a total of 950,000 public and non-public charging points will be needed by 2020, in order to achieve a sufficient nation-wide charging infrastructure (NPE 2012). However, a typical "chicken-and-egg problem" occurs, with potential customers waiting for the infrastructure and investors waiting for a substantial number of EVs to be on the road.

The project's goal is the development of a service that encourages private persons as well as small-sized firms to share their charging stations by granting public access to them. This concept addresses the challenges to develop novel, standardized processes covering diverse requirements such as the initial operation of a charging infrastructure, the billing of customers, and economic and legal challenges that surface as customers become suppliers. The implementation of the IT artifact aims at a combination of a web application and digital platform. The IS manages (1) service processes, (2) information flows between participating parties, and (3) the communication between the charging points and the central server.

Activity Layer: Systematic Analysis of the IT Artifacts' Supported Activities

In the following, systematic analyses of the EV domain and the two research projects are conducted. Method steps (1) and (2) are conducted for both projects simultaneously, since both projects are located in the same domain. For brevity, method steps (3) to (6) are exemplarily shown for only one core activity of each project.

Method Steps (1) and (2) for Both Projects

Step (1) of the method revealed seven main activities of the EV domain: "manufacture vehicles", "generate energy", "distribute vehicles", "charge vehicles", "use vehicles", "maintain vehicles", and "recycle or repurpose vehicles". The application of the analysis of the domain's main activities, which is part of method step (2), identified a number of critical sustainability issues in all three sustainability dimensions that relate to the production process of EVs and components such as the dangerous lithium recovery process or unclean and dangerous energy productions (e.g., nuclear and coal). However, we have also realized that the main activities are strongly related to the political agenda of an individual country and to the existence of suitable and more sustainable alternative activities. In Germany, where the projects are conducted, the political goals include the shift to renewable energy sources. These political trajectories were considered to assess the sustainability of the domain's main activities. The overall analysis has shown that the EV domain contains some inherent sustainability issues especially in regards to the ecological (e.g., resource utilization) and social (e.g., working conditions and safety) dimensions. Nevertheless, the domain can be regarded to be worthwhile for investing efforts into since the overall goal of achieving low-emission transportations is one of today's key challenges (NPE 2012).

Method Steps (3) to (6) for EOL-IS (Project 1)

Referring to method step (3), there are nine core activities to put used EVBs to a second life. Relating the core activities in method step (4) to the surrounding activities in the different value chains resulted in 18 further activities. In method step (5), we investigated the exemplary activity "*transport EVB*" (blue activity illustrated by Figure 4), which revealed that all three dimensions contain questionable issues. In the social dimension unsustainable activities regarding the driver's working conditions (e.g., high work and time pressure, many night shifts, noisy traffic) and wages (e.g., missing labor agreements, wage dumping) are identified. Since EVBs' transportations are carried out by gas-operated trucks, which result in high emissions of carbon-dioxide, noise, and fine-dust, the ecological dimension contributes to an unsustainable character of this activity, too. Furthermore, in the event of an accident, cracked EVBs may cause severe damages to the environment and human body by, e.g., toxic outflows, chemical burns, electric shocks. Economically, the transportation may cause high costs as it is strictly regulated by law (Klör et al. 2014). Thus, it needs to be conducted carefully to avoid legal punishments, which would negatively influence the profitability criterion in the economic dimension.

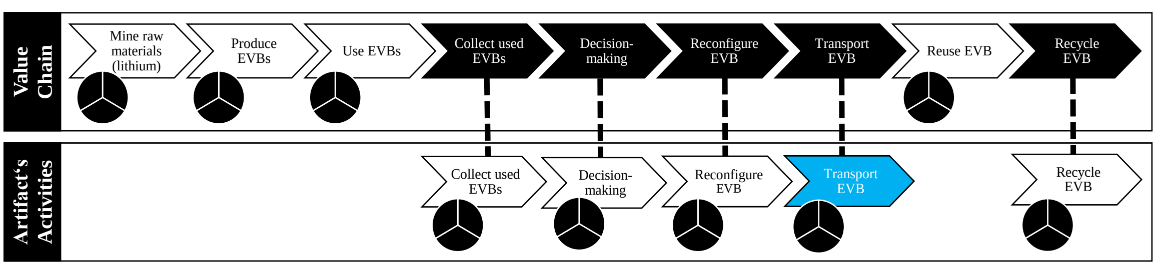

Figure 4. Rated activity map of the DSS's supported activities of EOL-IS

With regards to method step (6), three design choices for the activity "transport EVB" are exemplarily outlined. To cope with the unsustainable characteristics of the transportation, the DSS's component is envisioned to safeguard the preparation of transportation in terms of packaging, loading, and planning. Technically, the DSS should provide a documentation of the preparation process by (i) EVB-specific digital step-by-step operating plans for assigning required resources in accordance with business rules (e.g., fully equipped trucks, required certificates, qualified personnel) and (ii) should compute legal, safe, and cost-optimal (short) transportation routes by a route planning component.

Method Steps (3) to (6) for CrowdStrom (Project 2)

During method step (3), we identified twelve core activities in total supported by the artifact that are required to allow private persons to use and provide private charging stations for EVs. The consideration of the preceding and succeeding activities in step (4) revealed further 24 activities. For brevity, we elaborate on the analysis of a single activity "*register charging station*" and its related activities (blue activity illustrated by Figure 5). During the activity, a private person registers a charging point by providing information in regard to the individual charging station to the IT system. The analysis of this activity, which is done in step (5), revealed that the major sustainability issues are concentrated around the operation of the charging point. From the ecological perspective, the charging procedure requires energy, which mainly comes from non-renewable energy sources. This fact is problematic in regard to the environmental pollution (coal) or toxic waste (nuclear power). Economically, the operation of a private charging station can represent a barrier for the public charging infrastructure to evolve. Low prices that individuals can offer are difficult for public infrastructure providers to compete with. For instance, similar effects can be observed with the economic pressure that Uber taxi drivers apply to traditional taxi enterprises (Cellan-Jones 2014). From the social perspective, the registration of a charging station in the system may result in social pressure on the charging station's owner. The increasing monetization of every day's life was found to be an issue, which forces a modern consumer to transfer more and more aspects of life into the area of business. Related to this issue is the emerging competition not only between peer-providers of the charging stations and public infrastructure but also among the participating individuals, which may result in imperfect competition. Further negative social impacts can result from price scams that arise when the providers' individual pricings of the offered charging operations are too expensive.

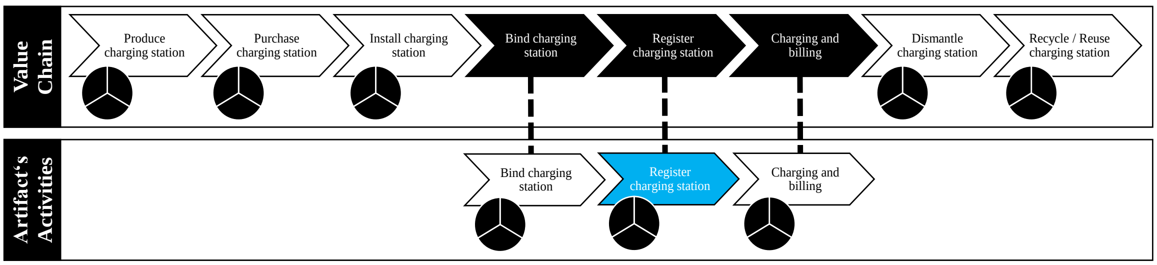

Figure 5. Rated activity map of the digital platform's supported activities of CrowdStrom

Identifying design choices in method step (6) for the exemplarily investigated activity "register charging station" resulted in the formulation of two design choices. To cope with the unsustainable elements, the registration is envisioned (i) to include an obligation to specify the condition of the provider's contract with an energy supplier in regard to the percentage of energy coming from renewable energy sources. Technically, the implementation makes use of form validations and a component for document checks. Furthermore, the registration is about (ii) to enable fair competition and thus includes algorithms for price recommendation and price control. The price recommendation calculates an average of the prices offered by adjacent charging stations. Depending on the local area, the price control mechanism considers minimum and maximum prices that are included as numerical constraints in the system and cannot be violated without administrator rights for performing a manual validation.

Discussion and Conclusion

The integration of the proposed method into the scientific design of IT artifacts systematically aims at the sustainability of actions taking place. In the following, a criteria-based discussion of the method concludes the article and considers the insights gained by the method's prototypical demonstration. The discussion focusses on the qualitative criteria of the method's practicability, implications, utility and contribution, limitations, and further development.

The method's *practicability* is assessed to be high, because of the method's general ease of use. Especially, the effort for the construction of the surrounding value chains and the rated activity maps was easily manageable. However, we emphasize the importance of domain knowledge, which is also imperative for deriving meaningful design choices. In addition, the identification, formulation, and manifestation of the design choices were further facilitated and simplified by the two indicator-based analyses of main activities (step 2) and supported core activities (step 5). Reconstructing the main activities of a domain is supposed to result in a deeper understanding of the inherent domain problems. Moreover, this domain analysis further simplifies the succeeding phase of assessing the activities in the IT artifact's nearer scope (supported core activities) and wider scope (activities of the value chains).

Several *implications* are derived from the method's demonstration. Most importantly, applying the proposed method to the two DSR projects resulted in many reasonable design choices that can be considered for the upcoming developments of the respective IT artifacts of the research projects. Furthermore, these design choices potentially resolve contradictions that are inherent to the EV domain such as the supply of fossil power in crowdsourcing charging operations of EVs (crucial for the digital platform of CrowdStrom) or scenarios requesting used EVBs for peak-shaving operations of fossil power plants (crucial for the DSS's decision models of EOL-IS).

In regard to the method's practical *utility and contribution* we observe a present lack of awareness in regard to the compliance of holistic sustainability considerations in the design of IT artifacts. This lack of awareness is mainly due to the inherent complexity of the domains and their related problems. Adding another dimension of consideration (sustainability) to both the identification of domain problems and the design of IT artifacts without any support, might lead to an overextension of the designers so that they may lose track of this important design aspect. Hence, the straightforward application of a structured method that forces designers to make systematic sustainability decisions goes far beyond the decisions that are already made. Consequently, we argue that especially the systematic and step-wise application of an ex-ante method leads to a higher compliance of sustainability during the definition of requirements, objectives, and goals within the common design cycle of IT artifacts.

As yet, the proposed method still faces *limitations*. We are conscious that the method could be applied without the use of strong and meaningful indicators in order to make pseudo-positive sustainability assessments on projects and their respective IT artifacts that are, e.g., located in domains which do not allow for any positive assessment at all. Hence, applying the method without a strong individual commitment to the notion of sustainable activities and without a sound set of sustainability indicators is of a limited value. This attitude would either serve for greenwashing purposes or result in self-deception. We are convinced that IT developers should follow an overall ethical course of action in the design of IT artifacts and most of them are interested in doing so. Thus, a generic guideline—like our method—that fosters sustainable activities seems to be overdue, crucial, and helpful. Both, the method and its integration to DSRM contribute to the discourse on the design of IT artifacts supporting sustainable activities. However, the integrational aspects of the method to both DSR projects were not considered in the presented demonstration.

Following up the outlined limitations, the *further development* of the method should focus on four aspects. First, for multiple domains, the definition of meaningful domain-specific indicator sets is required. Second, based on these indicators, prototypical instantiations in several domains are required to show the method's generic utility and applicability. Third, the identified design choices for both considered DSR projects and their inclusion to the succeeding implementation and evaluation phases are necessary. Fourth, it is our hope that the activity-oriented view on sustainability will gain recognition and fosters the further discourse in (green) IS research.

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