*energies*

*Article*

# Reduction of the Information Gap Problem in Industry 4.0 Projects as a Way to Reduce Energy Consumption by the Industrial Sector

**Bartosz Wachnik [1,*], Michał Kłodawski [2] and Ewa Kardas-Cinal [2]**

[1] Faculty of Mechanical and Industrial Engineering, Warsaw University of Technology, Narbutta 85, 02-524 Warsaw, Poland
[2] Faculty of Transport, Warsaw University of Technology, Koszykowa 75, 00-662 Warsaw, Poland; michal.klodawski@pw.edu.pl (M.K.); ewa.kardascinal@pw.edu.pl (E.K.-C.)
* Correspondence: bartek@wachnik.eu

**Abstract:** Reducing energy consumption should be treated as crucial for contemporary information and communication technology (ICT) projects under conditions of Industry 4.0. This research proposes a wider look at the factors influencing the success of ICT industry projects, considering not only technological and procedural conditions or implementation methods but also information and competency resources, thus allowing for correct decisions to be taken during project implementation. The article analyzes the information gap in Industry 4.0 projects completed in enterprises based in Poland, following the concept of sustainable development and minimization of energy consumption. The research was completed between 2018 and 2021 in medium enterprises, and the result is a qualitative characteristic of the information gap in ICT projects from the client's perspective. The research can help develop a complete methodology for Industry 4.0 ICT projects to limit the level of uncertainty and risk while reducing energy consumption.

**Keywords:** energy consumption; information gap; Industry 4.0; IT project; Green I

check for updates

**Citation:** Wachnik, B.; Kłodawski, M.; Kardas-Cinal, E. Reduction of the Information Gap Problem in Industry 4.0 Projects as a Way to Reduce Energy Consumption by the Industrial Sector. *Energies* **2022**, *15*, 1108. https://doi.org/10.3390/en15031108

Academic Editors: Sergey Zhironkin and Michal Cehlar

Received: 3 December 2021
Accepted: 20 January 2022
Published: 2 February 2022



## 1. Introduction

Currently, the industrial sector is the largest energy consumer, and its buildings have recorded a very dynamic energy consumption increase. According to the International Energy Agency, industry is responsible for 37% of global energy consumption, a trend that is forecast to continue [1]. Changes will be possible only because of the fourth industrial revolution, which provides access to Big Data and the possibility of using it in factory operations.

Industry 4.0 leads in the digitization and networking of production as well as the related transformation of business models and strategies. It includes digitally networked production as well as assembly, maintenance and marketing. What distinguishes Industry 4.0 is its decentralized components, which make independent decisions based on digital information and feed the production system. In the future, not only autonomous but self-learning systems are expected. Thus, Industry 4.0 is based on four pillars: the cyber-physical systems (CPS), the Internet of Things, the Internet of Services, and the smart factory [2].

CPSs are physical and engineering systems in which operations are monitored, coordinated, controlled and integrated by a computational and communication core [3]. A CPS describes the combination of information and software components with mechanical and electronic parts that communicate through a data infrastructure such as the Internet. One characteristic is high complexity.

The Internet of Things is a concept that interconnects many objects into a single network. It concerns not only computers, smartphones or tablets, but also household appliances and televisions as well as industrial automation such as production lines, machines and robots.

The Internet of Services comprises modular production stations that can be flexibly modified and extended. Services are offered and bundled into value-added services by different providers, and then communicated to users and consumers through a variety of selling channels [4].

The concept of a smart factory refers to the application of modern robotics and digital systems in the efficient management of industrial production. The coordination of an enormous amount of data from sensors embedded in machines and software for internal and external processes increases production efficiency and reduces the need for constant staff supervision. The most advanced factories of this type can adapt production volume to fluctuations in demand, react to sudden changes in the supply chain, and correct irregularities to avoid production downtime by using Big Data, the Industrial Internet of Things (IIoT), and simulation techniques such as digital twins or digital shadows.

Industry 4.0 offers almost unlimited possibilities and is characterized by increased production energy efficiency, which results in maintaining energy security, lower energy expenses, and environmental protection. Therefore, the development and implementation of various types of Industry 4.0 projects are extremely important for modern economies. It should be noted, however, that very often the success of such projects depends on the appropriate flow and availability of information both from the investor and the project contractor. The lack of necessary information (information gap) in the investor-contractor relationship hinders decision making and delays or prevents project implementation.

The purpose of this paper is to identify informational components in the customer's perspective of Industry 4.0 projects to reduce energy consumption and promote sustainable growth.

The final product, which is the result of the Industry 4.0 ICT project, consists of a number of information components, which are not separate items of trade, but appear on the market as integral parts of the services provided under the project. From the customer's perspective, information on each component is necessary for the implementation of an IT project. If the client has information included in the components, the project could be carried out without involving the supplier. The scope of the client's component information significantly influences the effectiveness of the project. In Industry 4.0 project management, a noteworthy issue is how to manage the information gap between customer and supplier.

The remainder of this paper is organized as follows. Section 3 provides a formulation of research goals and methods for developing the information gap theory, including the presentation of projects selected for the study. The authors' intention is to achieve the following research goals:

G1: The identification of information components over the life cycle of the project from the client's perspective.

G2: A characteristic of information gaps to identify information components.

Section 4 presents results with information components and a discussion on inheriting information gaps. In Sections 5 and 6, the conclusions are summarized.

## 2. The Development of Industry 4.0 Considering Sustainable Growth and Reduction of Energy Consumption—Literature Review

### 2.1. Energy Consumption Review

One of the most important issues in modern economies is how to manage the demand and supply of energy. In Poland in 2019, transport accounted for the largest amount of national energy consumption—33%. Households came in second (26.3%), and industry was third (23.9%) [5]. The situation was similar across the EU: transport, 31.3%; households, 26.9%; industry, 24.6%; and services, 13.9%, [5]. This indicated that improving industrial energy performance can make an important contribution toward achieving significant improvements to local and global energy efficiency. It also reinforced the fact that industrial energy efficiency has to be considered when designing new enterprises and searching for technological, organizational and IT solutions in existing enterprises.

The problem of how to reduce energy consumption in various industries is of interest to many researchers. Publications [6,7] have reviewed research on energy savings, carbon reduction, and improved energy efficiency in the Chinese cement industry, and the potential for reduced energy consumption and $CO_2$ emissions was discussed in [8]. The same issue was analyzed for India and presented by the authors in [9], while [10] presents a comparison of energy consumption in cement production using different technologies. In addition, the authors presented the possibility of using a tool to evaluate and compare energy consumption in cement production plants based on specific variables and production parameters.

Other examples pertaining to the reduction of energy consumption include the analysis and evaluation of the benefits of efficient energy use; proposals such as electricity recovery [11] to improve efficiency; presentation of theoretical and practical aspects of energy saving in the chemical [12], paper [13] and wood industries based on a Swedish example [14] and the Chinese [15] and Polish metallurgical industries [16]. In [17] the authors presented a forecast of energy consumption connected with food production and an analysis and evaluation of alternative political solutions aiming at reducing energy consumption for food production in the medium and long term.

The implementation of new means to reduce industry energy intensity often requires a systemic approach and top-down energy policy support. Many studies have been conducted in the EU to assess the effectiveness of specific industry-focused energy efficiency measures. Many researchers have paid attention to the type of policy, its accessibility to the industry and its effectiveness [18–23].

The industry-reducing energy consumption issue is inextricably linked with the Green IT concept, defined in [24] as "the optimal use of information and communication technology (ICT) for managing the environmental sustainability of enterprise operations and the supply chain, as well as that of its products, services, and resources, throughout their life cycles". This includes energy-saving IT equipment as well as the optimization of resource requirements for workstations and cooling servers, and the sustainable life cycle of IT equipment from purchase to recycling. The different approaches to defining and understanding Green IT and the associated risks are presented in [25–28]. Energy savings in information management and processing systems can lead to significant energy savings in an area of the industry that today is almost entirely computerized.

### *2.2. Sustainable Development and Energy-Consuming*

According to Robert Solow [29], "the recipe for growth" in principle does not differ between countries. We can distinguish two basic types of growth:

- "brute force growth" [30], based on a quantitative increase of investment (more work and capital equals more product); and
- "intelligent growth", based on qualitative changes (e.g., technological development) or institutional changes [30] the key factor of which is increased efficiency.

The term "sustainable development" was introduced by Hans Carl von Carlowitz and referred to a form of forest management where each felled tree was replaced with a new seedling [31]. Concepts of sustainable development are present in different areas of human activity, like business [32–34] or environmentally positive systems. The basic task of sustainable development is to maximize the net benefits of economic growth while protecting and ensuring that natural resources are renewed over the long term [35]. The Industry 4.0 concept constitutes an intelligent form of development aimed at increasing efficiency through technological, institutional, and social progress and minimizing energy consumption. ICT projects in Industry 4.0 are an important area of sustainable growth research. Thanks to ICT solutions, it is possible to support the implementation of sustainable development concepts in the following areas:

1. Ecology—IT solutions allow for a switch from an energy-intensive economy to a model that considers the protection of the environment. This type of solution may concern

a. Limiting the energy intensity of ICT (e.g., cloud data migration); and
b. Limiting the energy intensity of industry solutions through ICT (e.g., using artificial intelligence)

In this area, we need to consider the results of research into information ecology.

2. Society—allowing direct communication between employees and contractors and taking action in real time; and
3. Economy—leading to benefits in a way that does not eliminate the social and ecological benefits of stakeholders.

Considering these areas, the solutions described as Green IT or Sustainable IT [36–38], that are used for designing, producing, and using IT systems [39] are being introduced. According to Andreopoulou [40], Green IT is a design, construction and information diffusion technique designed to achieve optimal environmental governance and optimize and improve the organization's operational processes.

Harnessing [25] offers another definition of Green IT: "the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment. Green IT also strives to achieve economic viability and improved system performance and use while abiding by our social and ethical responsibilities". Green IT is an element of sustainable development and Industry 4.0 concerning the configuration of information processing systems that will soon gain dominance, especially in industry, such as the Internet of Things or blockchain [41]. It concerns the quality of decisions made as a function of knowledge about the mechanism of future investment and may translate into aspects of sustainable development such as energy consumption [42–44].

To sum up, the completion of Industry 4.0 projects under conditions of sustainable growth bring not only economic but also social and ecological benefits. Completing this type of project requires knowledge and skills linked to the implementation of Industry 4.0 projects as well as competence in sustainable growth conditions. Consequently, this research regards project management in Industry 4.0 not only under conditions of sustainable growth, but also under conditions of rapidly increasing uncertainty and risk.

This research concerns medium enterprises in 2018 based in Poland, which was the first country from the former communist bloc to be classified as a developed country [45].

### 2.3. Project Management in Industry 4.0

An important part of Industry 4.0 projects is high-tech projects in the area of business process digitization. According to Cao and Zhang [46], many project implementation methods in current use (e.g., ITIL), will be replaced by new methods that will accommodate artificial intelligence [47], agility, a lower level of formality (especially in communication and project documentation), information asymmetry between the supplier and the client, and the possibility of strong organizational turbulences, both internal and external. The nature of Industry 4.0 project implementation is both technologically and organizationally complex, necessitating flexible project completion. Consequently, project management is expected to have an increasingly more adaptive character and require the use of different, often contradictory methods, that will lead to a combination of established routine and the use of hard skills, especially digital skills. Currently, Industry 4.0 projects are completed under conditions of uncertainty [48,49] in a highly turbulent environment. The external and internal conditions of a project stimulate the development of agile and adaptive responses that lead to further changes in structures and operating methods, resulting in a better adjustment to change.

Research indicates that it would be appropriate to include the concept of uncertainty in the management methods of Industry 4.0 projects that involve sustainable growth and reduced energy consumption and to consider the information gap theory to support decision-making.

One of the examples may be an attempt to include the hypothesis-driven development (HDD) concept to increase the effectiveness of the Agile and Waterfall implementation methods [50–52]. It is an exploratory-adaptive approach that assumes a gradual identification of uncertainties and information gaps in individual project sprints, resulting in a group of hypotheses regarding functional and technological requirements. The HDD concept assumes a method of defining functional and technological requirements where instead of the user perspective, the requirements are based on three factors.

1. A hypothesis that can refer to information components that may be characterized by the users' information gap;
2. A business result, along with benefits, when the hypothesis is proven to be true; and
3. Conditions that allow for the hypothesis to be fulfilled.

An example of decision-making support in large and advanced projects under conditions of uncertainty is Robust Decision Making (RDM) [53]. It combines an analysis of two factors: first, decision-making based on technological and organizational assumptions of project completion and predicted scenarios (which may result from information gaps of the components) and second, exploratory modelling that uses stress tests in extremely difficult conditions caused by uncertainty from the research object or its environment. The RDM concept may include guidelines regarding energy consumption reduction and sustainable growth for the specific project and the industry, especially Key Performance Indicator (KPI) criteria and process requirements.

Yet another example is Dynamics Adaptive Planning (DAP), which supports activities linked to designing a plan of adaptive possibilities as the conditions change and the knowledge resulting from uncertain events is gained. DAP includes a characteristic of a process-monitoring system within the project along with a definition of tasks that need to be undertaken to achieve goals.

To sum up, the high level of uncertainty within an organization and its turbulent environment necessitates the use of new Industry 4.0 project completion concepts that entail reduced energy consumption. To achieve this goal, the authors propose the use of the information gap theory to support decision-making under conditions of uncertainty.

### *2.4. Information Gap in Industry 4.0 Projects*

According to Ben-Haim [54], the information gap theory can support business decision-making under deep and dynamically changing uncertainty, which may result from technological and functional requirements of Industry 4.0 projects that include sustainable growth and reduced energy consumption. This study was based on the definition and characteristics of the information gap devised by Oleński [55] and Wachnik [56].

In IT projects, the range, character and dynamic of the information gap on both the client and the supplier strongly determine the degree of uncertainty in decision-making at each stage of the project life cycle.

As part of a market transaction of an Industry 4.0 project, we distinguished a cluster of contracts for the purchase of software licenses, hardware, and IT services aimed at creating a unique configuration. A project consists of many information components throughout its life cycle. These pieces of information constituting an information component are not separate subjects of trade, but appear on the market as integral parts of the services provided [55,57]. From the perspective of the client and the supplier, information consisting of components, information, and knowledge about each component are necessary to satisfy their partially conflicting goals. Hence, by having information about the components, the client and the supplier can shape mutual relations more successfully. The structure of information components changes at different stages and phases of the IT project life cycle, which results from the learning curve. The goal of this study is to identify information components from the customer's perspective to reduce energy consumption and sustainable growth, and the information gap between the client and the supplier is a noteworthy issue. Information gap management for individual components consists in decreasing it on one side and decreasing or increasing it on the other side of an economic relation: in this case, an IT project. According to Babik [57], information needs are shaped by two factors: the kind of task being solved and the person's knowledge and experience. Among these needs, two subsets can be distinguished: information necessary to solve a task but available to the system user, and necessary information that is not directly available.

Obtaining information necessary to close the gap entails costs. The bigger the gap, the higher the cost, which increases the more we attempt to close it. The types of activities undertaken to obtain information, as discussed in the literature [58,59], indicate varied approaches among information users to the solved problems, which define their information needs. Hence, information service processes offered to the users need a diversified approach for each of them. This means that it is necessary to include the user in a dynamic model, to organize effective servicing of information needs. Particularly noteworthy are the models and standards linked to the Information Literacy (IL) concept, designed in the 1990s: The Big6 [58] and SCONUL [59].

## 3. Research Methods

### 3.1. Research Goals

The research goals concern the information gap in ICT projects in Industry 4.0 completed in enterprises implementing sustainable growth and seeking to reduce energy consumption.

G1: The identification of information components in the entire life cycle of the researched project from the client's perspective.

G2: A characteristic of information gaps for the identified information components.

### 3.2. Research Method

An analysis was performed based on the results of a study of four purposefully selected enterprises. The case study method made it possible to identify and analyse the gap in an Industry 4.0 ICT project, which is discussed more extensively further on. The research performed led to conclusions and that will allow these projects to be more effective and efficient under competitive global conditions.

The research in this article is interdisciplinary, contributing to the development of the information gap theory and business informatics in enterprises developing in the conditions of sustainable growth and limiting energy consumption [60,61]. As a result of thus formulated research goals, the direct observation method was selected. The research method was selected based upon

1. A desire to perform a qualitative description of the entire life cycle of an ICT project spanning many years;
2. The relevant characteristics of the projects resulting from the characteristics of Industry 4.0 projects and sustainably developing enterprises;
3. The interdisciplinary character of the ICT projects;
4. The observation of the information gap areas that cannot be studied using interviews during the project life cycle;
5. The possibility of tracking the dynamics of the information gap during the project life cycle.

The research method phases are presented in Table 1.

The selection of cases was deliberate and made on the basis of five basic criteria: data availability, vividness of the case, diversity in multiple case studies, critical phenomenon and a metaphor that directs the researcher to a specific direction of the studied phenomenon. The first was the purely pragmatic question of the availability of data, which led to the most incisive description of those enterprises that were especially pertinent to the research question. Projects had to meet four substantive criteria to be selected:

1. Be concerned with ICT solutions belonging to the Industry 4.0 project group;
2. Be implemented in enterprises that paid particular attention to sustainable growth;

3. Be avant-garde; i.e., employees had no experience in implementing this type of projects; and
4. Be implemented in a relatively large diversification of industries.

**Table 1.** Research method phases.

| | |
|---|---|
| Stage 1 | Formulating the research question |
| Stage 2 | Selection of cases |
| Stage 3 | Development of data-collection tools |
| Stage 4 | Fieldwork |
| Stage 5 | Data analysis |
| Stage 6 | Formulating generalizations |
| Stage 7 | Confrontation with the literature |
| Stage 8 | Study conclusion—generalization |

The second criterion was the vividness of the case, which illustrated the properties being studied in an extreme form which, however, allowed for an unambiguous interpretation of them. The third concerned diversity by requiring that many cases be investigated in a manner that presents different circumstances or contradictory situations.

The number of cases ranged from 4 to 10 to allow for the analysis of phenomena that had a different course or took place in different industries. This enabled the formulation of generalizations largely free from circumstantial factors or industry. The selection then consisted in creating appropriate cases (e.g., a project with high technology, a mature market and a local–global enterprise.

The fourth was the critical phenomenon—either extreme or counter to generally accepted opinion—which allowed generalizations to be formed.

The fifth concerned a metaphor which directed the researcher's attention to a specific course of the phenomenon under study or allowed for the assumption of a specific research position. For instance, the lifecycle metaphor required the selection of cases that allowed for the observation of its emergence, development, maturity, decline and disappearance. The projects, completed between 2018 and 2021, are characterized below (Table 2).

The study, study involved observations of the phenomenon and the events as well as co-participation: receiving interpretations from the participants, making contact with the participants, assuming the position of an outsider, or not participating in the work of the observation participants but remaining in the background. As part of direct observation, the study focused on the functioning of the project group, technical and organizational conditions, and project management methods. Direct observation is characterized by a high level of difficulty and layering of all observed phenomena, resulting in a feeling of overload (selective observation). To minimize the impact of subjectivity on the evaluation during observation, a passive approach was applied, i.e., not actively participating in the project, taking on a managerial position, or not being a project group member.

During the research completion

1. The observed knew that the study was being carried out by a researcher from the Warsaw University of Technology conducting studies in IT project management;
2. The strong requirement for privacy and confidentiality by the enterprises where the research was carried out was respected. The research description did not name the enterprises and the context described was at times slightly modified while ensuring credibility;
3. The observed were treated as subjects;
4. The majority of data characterizing the project over its life cycle was accessible.

**Table 2.** Characteristic of the studied projects. Source: Own study.

| | A | B | C | D | E |
|---|---|---|---|---|---|
| Enterprise description | Furniture production | Food manufacturing | Transport services | Production of car components | Financial services |
| Project description | Infrastructure transfer to Cloud | Using Big Data to identify business-marketing data | Using IoT to monitor the work of the transport fleet | Implementation of an AI-based system identifying defective products | Digitization of the invoice documents introduced into the financial module of the ERP system |
| Benefits resulting from the project that has an impact on sustainable development | Limiting the use of Resources | Making better decisions | Extending the life cycle of the transport fleet | Limiting the number of defective components being released into the market | Lower paper usage |
| Number of participants | 50 | 40 | 120 | 5 | 25 |
| Studied project duration (phase/completion time) | F 1—3 months<br>F 2—1 month<br>F 3—2 years | F 1—6 months<br>F 2—6 months<br>F 3—1 year | F 1—6 months<br>F 2—2 months<br>F 3—2 years | F 1—6 months<br>F 2—1 month<br>F 3—2 years | F 1—3 months<br>F 2—3 months<br>F 3—2 years |

The study was conducted mainly through collecting and analyzing information, and evaluating the completed project through participation in project meetings, private conversations with project participants, and access to project documents.

## 4. Results

### *4.1. Information Components*

The identification of information components was completed over the entire cycle of the IT projects. An analysis of the methods—Sure Step (recommended by Microsoft for MIS, i.e., ERP and CRM [62]), and Accelerated SAP (recommended by SAP AG for SAP implementations [63] included in literature, and other project completion standards (PMI, PRINCE 2 [64–69]) and models (ITIL [70])—allowed for a generalization of an IT project life cycle consisting of 3 stages.

Stage one, i.e., the preparation stage, comprised two phases.

1. Pre-implementation—The creation of the problem domain model, a user-needs analysis and definition of the system's functional requirements, analysis of the organization's IT infrastructure, project group definition, identification of significant risk factors, ex ante economic analysis of the investment and preliminary definition of the implementation project;
2. System and supplier selection—The preparation of a potential suppliers' list, creation of Request for Proposal (RFP) forms, analysis and evaluation of offers according to established criteria, substantive and trade negotiations, and contract formulation. The result of the first, preparatory stage was a selection of a system and a supplier; the completion of Phase 2 was a multi-dimensional task where many organizational, legal, social, and technical factors needed to be considered.

Stage two, the completion of an IT implementation project comprised five phases.

1. Initiation—An implementation planning session as an initial meeting and a technological project consisting of the installation and configuration of components in the hardware layer, system software and application software layer;
2. Analysis—Training for key users and a functional analysis that included analytical workshops and the designing of a theoretical prototype;
3. Design—Customization of the project;
4. Implementation—Preliminary data migration and acceptance testing for the completed customization along with tuning, developing workplace instructions and training for key users; and
5. Go-live—System go-live and post-go-live support during system stabilization.

Stage three, IT system operation, comprises two phases.

1. Post-implementation analysis and identification of operational needs—covering tasks linked to an ex-post analysis of the implemented IT project and an identification of needs linked to system operation;
2. Selection of an appropriate supplier of post-implementation services linked to system operation—covering the preparation of a potential suppliers' list, creation of RFP forms, analysis and evaluation of offers according to established criteria, substantive and trade negotiations, and creation of Service Level Agreements (SLAs) [71].

Tables 3–5 present information components for the project life cycle phases where users identified information gaps. Each component was marked as C.X.Y., where X was the phase where it first appeared, and Y was the component number. The tables used color gradation for the individual components to mark the impact of the information gaps on the effectiveness of IT project completion: (1. dark grey—high impact; 2. light grey—moderate impact; 3. white—low impact). The study used a definition of IT project effectiveness that compared the results and the expected results for the following criteria: time, business range, project completion cost, and functional-technological requirements. The projects were a successes (fully met all the criteria) or partial successes, (failed to meet at most two criteria).

Table 6 outlines how the project effectiveness criteria were met.

Thirty-one components where the respondents identified information gaps throughout the entire project life cycle were identified. In Stage 1, the preparation stage, the components were characterized by the high impact of the information gap on the project's success, mainly regarding the definition of the TCO for the project life cycle and the range of functional and technological requirements resulting from the sustainable growth concept (including energy consumption reduction), the so-called Green IT. Stage 2 had the same component characterizations but mostly regarding the risk and uncertainty management methods, range of functional and technological requirements resulting from reduced energy consumption and the sustainable growth concept, methods of maintaining implementation costs according to plan and the knowledge and experience of the project group members, which allowed them to make the organization more efficient. In Stage 3, the operation stage, one component characterized by high impact from the information gap was identified: the range of functional and technological requirements resulting from the sustainable growth and reduced energy consumption concept. The project group members identified the strongest impact of information gaps on project success in three main areas:

1. Managing the TCO of an IT system,
2. Implementing functional and technological requirements linked to Green IT, and
3. Managing risk and uncertainty in an IT project.

According to the study, project managers indicated information gaps in the 31 information components, which could constitute a source of risk factors and uncertainty throughout the project life cycle. A theoretical and empirical analysis conducted during the study indicated that information gaps were independent of the class of information systems. The study showed that information gaps for the components depended upon:

1. The character of the project resulting from the energy consumption reduction and sustainable growth concept,
2. The functional-technological character of the customization based on the technical possibilities of the parameterization and software,
3. The level of investment in the knowledge of the project group regarding the project and the concept of reduced energy consumption (sustainable growth) during the first stage, and
4. The level of trust between among members of the project group.

**Table 3.** The structure of information components on the client's side during Stage 1 of the IT implementation projects. Source: Own study.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Stage 1** | Phase 1 | Competence in estimating the TCO in the entire project life cycle C.1.1 | Functional and technological requirements range resulting from the sustainable growth concept C.1.2 | | The structure of the IT implementation project group and the role and responsibility of its members during the project completion C.1.3 | | A precise definition of the technological and functional requirements for the system C.1.4 | | Project completion method C.1.5 |
| **Stage 2** | Phase 2 | Security of data access C.2.6 | Methods of charging the license fee C.2.7 | The right to modify the completed customization, inc. the right to source code modification C.2.8 | Integration with other IT systems C.2.9 | Project schedule C.2.10 | Project completion method C.1.5 | Future SI development of the producer and future license price policy C.2.11 | Functional and technological requirements |

**Table 4.** The structure of information components on the client's side during Stage 2 of the IT implementation projects. Source: Own study.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Stage 2 | Phase 3 | Project documentation and completion methods C.3.13 | Methods of risk and project uncertainty management C.3.14 | Project schedule C.2.10 | The role and responsibility of the project group members during the implementation C.3.15 | Project completion method C.1.5 | - |
| Stage 2 | Phase 4 | Knowledge and experience of the project group members that can make the organization more efficient, resulting from analogous IT projects C.4.16 | Methods of maintaining implementation costs according to plan C.4.17 | Functional and technological requirements range resulting from the sustainable growth concept C.2.13 | Methods of collecting functional requirements by the project group members during the functional analysis C.4.18 | Methods of functional and technological knowledge transfer C.4.19 | Methods of risk and project uncertainty management C.3.14 |
| Stage 2 | Phase 5 | Internal testing methods for the completed customization C.5.20 | Documentation methods of the completed customization C.5.21 | The impact of customization method selection on the TCO of the IS C.5.22 | Functional and technological requirements range resulting from the sustainable growth concept C.2.13 | Competence in the area of communication in a project based on remote working C.5.23 | Methods of risk and project uncertainty management C.3.14 |
| Stage 2 | Phase 6 | Data migration methods C.6.24 | Knowledge transfer methods C.6.25 | Functional and technological requirements range resulting from the sustainable growth concept C.2.13 | Methods of system tuning completion after receiving the results of acceptance testing C.6.26 | Competence in the area of communication in a project based on remote working C.5.23 | Methods of acceptance testing completion C.6.27 |
| Stage 2 | Phase 7 | System go-live method C.7.28 | Methods of risk and project uncertainty management C.3.14 | Project schedule C.2.10 | Competence in the area of communication in a project based on remote working C.5.23 | Functional and technological requirements range resulting from the sustainable growth concept C.2.13 | - |

**Table 5.** The structure of information components on the client's side during Stage 3 of the IT implementation projects. Source: Own study.

| | | | | | | |
|---|---|---|---|---|---|---|
| Stage 3 | Phase 8 | Identification of needs linked to the system's functional development C.8.29 | Economic evaluation (ex-post) of the IT project completion C.8.30 | Methods of risk and project uncertainty management C.3.14 | Project schedule C.2.10 | Functional and technological requirements range resulting from the sustainable growth concept C.2.13 |
| Stage 3 | Phase 9 | Range of development tasks C.9.30 | Operational task range C.9.31 | Methods of risk and project uncertainty management C.3.14 | Project schedule C.2.10 | Functional and technological requirements range resulting from the sustainable growth concept C.2.13 |

**Table 6.** Project effectiveness criteria. Source: Own study.

| | **A** | **B** | **C** | **D** | **E** |
|---|---|---|---|---|---|
| Enterprise type | Furniture production | Food manufacturing | Transport services | Production of car components | Financial services |
| Project type | Cloud migration of infrastructure | The use of Big Data for the identification of business-marketing data | The use of IoT to monitor the work of the transport fleet | Implementation of an AI-based system to identify poor quality products | Digitization of invoice documents introduced into the financial module of the ERP system |
| Time | ☑ | ☑ | ○ | ☑ | ☑ |
| Business range | ☑ | ○ | ☑ | ☑ | ☑ |
| Project completion cost | ☑ | ○ | ○ | ☑ | ☑ |
| Functional-technological requirements | ☑ | ☑ | ☑ | ☑ | ☑ |
| | ☑Criterion met | | | ○—Criterion not met | |

### *4.2. Inheriting Information Gaps*

The study identified a phenomenon accompanying the information gap, "information gap inheritance" [56,57] for the components indicated. The inheritance for each of the three stages is presented in Figures 1 and 2. A characteristic of the information gap, its impact on IT project completion efficiency, was identified, and it affected information gaps in subsequent information components. Analogously, as in Tables 3–5, color gradation was used (1. dark grey—high impact; 2. light grey—moderate impact; 3. white—low impact) to illustrate how information gaps affected IT project completion. Inheriting information gaps means that they became more widespread and ingrained, increasing uncertainty. The impact of the information gap on IT project effectiveness and the inheritance of the information gap resulted in the decreasing resilience of the information gap party—who is often the decision-maker—and directly affected their decision-making methods. Figures 1 and 2 present sequences of the components for which information gaps greatly or moderately affected IT project completion.

The inheritance and the inclusivity of information gap characteristics in Stage 1 caused the uncertainty in Stage 2 and 3 to increase. The domino effect meant that the resilience of the internal stakeholder to information uncertainty in Stages 2 and 3 decreased. Research showed that in Stage 1, the sequence of inheriting information gaps referred to components that concerned mostly three issues:

1. Agreeing on advantageous trade conditions of license purchases of the software and external outsourcing services, both for Stage 2 and 3 of the project life cycle,
2. Recommendations resulting from reduced energy consumption and the sustainable growth concept (Green IT) regarding Industry 4.0 project completion,
3. The security of business activity in influencing development possibilities of the IT system and security of data access.

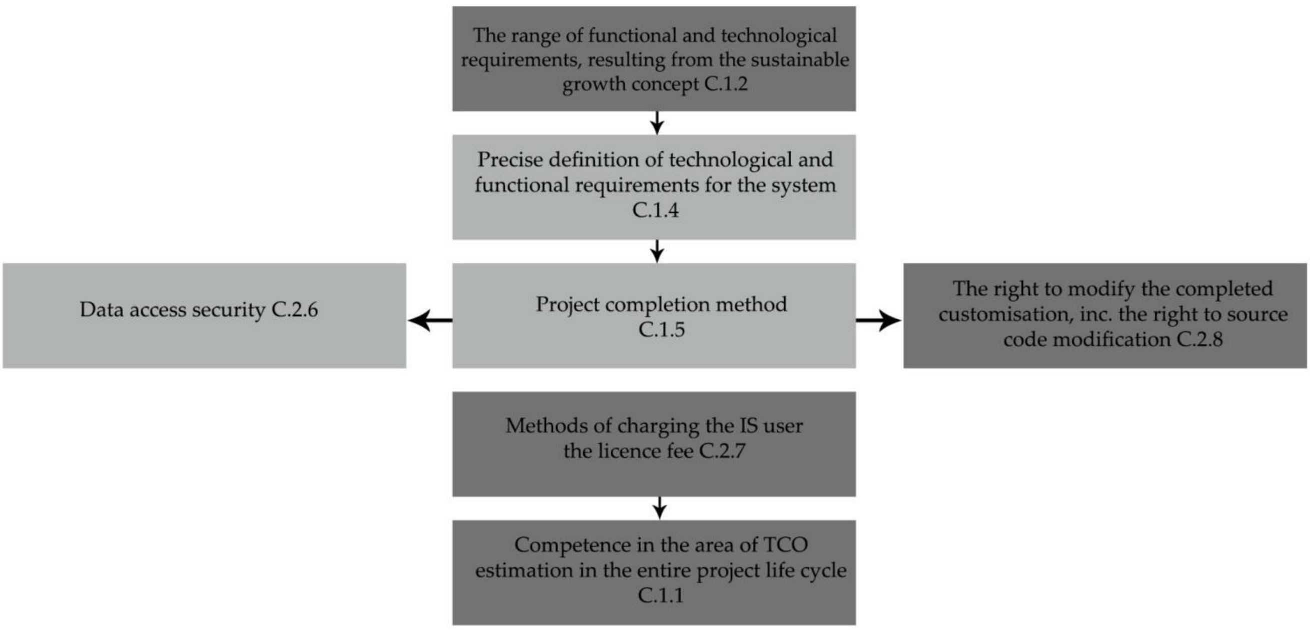


**Figure 1.** Inheriting information gaps for the relevant components in Stage 1. Source: Own study.

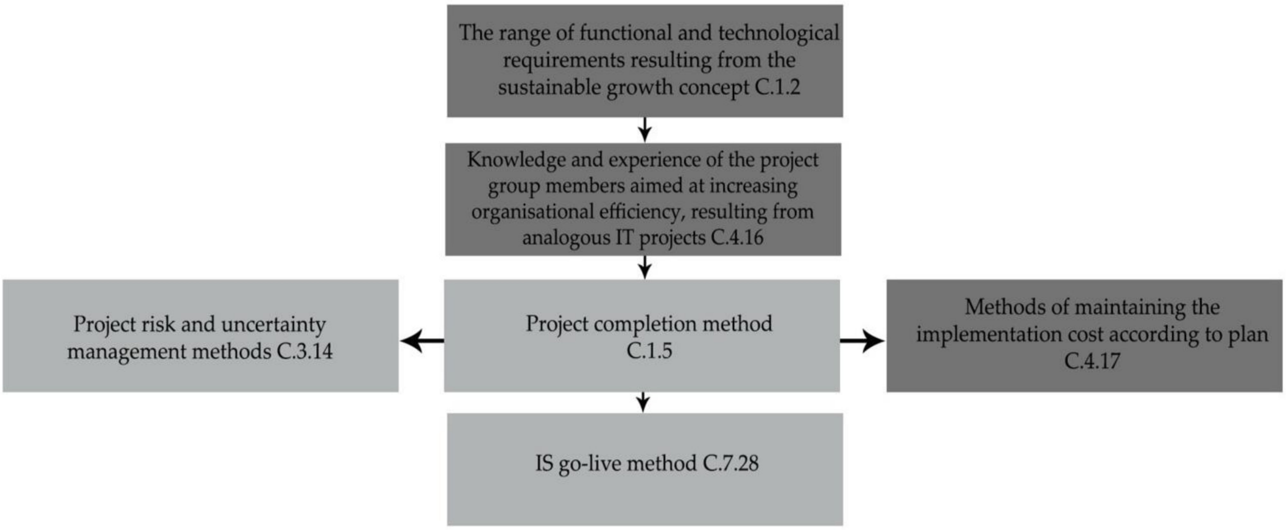


**Figure 2.** Inheritance of information gaps for the significant components in Stage 2. Source: Own study.

The research showed that in Stage 2, the sequence of inheriting information gaps referred to the components largely relating to two issues:

1. The knowledge and experience of project group members regarding the concept of sustainable growth and
2. Risk and uncertainty management following the concept of sustainable growth.

In Stage 3, the sequence of inheriting information gaps referred to two components: the range of functional and technological requirements resulting from the sustainable growth concept (C.1.2) and the methods of managing project risk and uncertainty (C.3.14).

To sum up the phenomenon of information gap inheritance throughout the entire project life cycle, the information gaps with the highest impact on the project success, concerned the components that characterized the knowledge and experience of the project group members in the sustainable growth concept as well as knowledge and experience supporting the possibility of achieving a trade relationship with an external supplier, thereby obtaining a correct TCO for the project life cycle. The cost of closing the information gap for the indicated components in Stage 1 led to project success in Stage 2.

The components organized according to the sequence of inheritance confirmed the main development determinants of the Green IT concept as presented in the literature [72–74].

## 5. Discussion

Research regarding the information gap theory mainly concerned non-probabilistic models of decision-making that allowed for the establishment of priorities or choices under conditions of uncertainty [75]. The completion of Industry 4.0 projects in organizations following the sustainable growth concept (Green IT) under conditions of Volatility, Uncertainty, Complexity, and Ambiguity (VUCA) [76] required particular knowledge and skills form decision-makers to manage risk and uncertainty. To increase the effectiveness of Industry 4.0 projects that support sustainable growth, we can use the knowledge regarding information gaps, which helps create and evaluate alternative operational what-if scenarios in

1. Structured issues (solving resource problems, scheduling turbulence, or choosing an optimal type of services or license in the context of the project's TCO) and
2. More abstract issues, based on Big Data, scientific theories, empirical knowledge, as well as contextual knowledge and understanding, i.e., selecting a model structure, completing a prognosis, or formulating a policy.

The completion of two research goals presented in Section 3.1 of this article provided insight into the development of Industry 4.0 projects based on the sustainable growth concept.

The completion of the first research goal allowed for the identification of 31 information components affected by the information gap of the project manager. The components concerned the three stages of the project life cycle. For each component, the strength of the information gap on the project completion was identified, and the information components were used to create operational what-if scenarios that were included in implementing Green IT projects in Industry 4.0. It is important to note that the components characterized by the highest or moderate strength of the impact of the information gap on the effectiveness of project completion over its life cycle mainly concerned

1. The shaping of beneficial economic relations between the supplier and the recipient of services,
2. Maintaining the TCO of the implemented IT system on the planned level,
3. Defining the functional and business requirements of the system and confronting them with the Green IT concept, and
4. Managing risk and uncertainty.

The information components affected by information gaps supported the hypothesis definition in functionality and technology as part of HDD, as a method for increasing the effectiveness of the Agile and Waterfall methods.

The completion of the second research goal allowed the identification of the sequence of information gap inheritance during the three stages. Embedding the information gap in the individual components increased the uncertainty of a given project task or goal both vertically and horizontally, which may have led to a domino effect, making the stakeholder more prone to uncertainty. The sequencing of the inheritance of the components affected by the information gap can be useful in the RDM concept supporting decision-making in exploratory modeling. The sequencing of inheritance may allow the researching the subject through stress tests in unfavorable conditions resulting from uncertain events, caused by both internal and external factors. Additionally, sequencing the inheritance of information gaps may help define constraints in individual phases and conditions for success, using the Dynamics Adaptive Planning model presented in the literature [75]. Having access to information regarding the sequencing of information gaps and their impact on project success, we can—as part of the exploratory model—perform a sensitivity analysis that will allow us to choose the best option.

The research results were in line with the current research trend concerning the information gap theory [75,77–80]. The catalog of information components along with their in-depth analysis constituted a fresh contribution to the applications of information gap theory. The results were mainly helpful in non-probabilistic decision-making models. Identifying and analyzing the information components that contain information gaps helped prioritize or alter choices when making decisions under conditions of deep uncertainty in ICT project management.

## 6. Conclusions

We need to stress that the sustainable development concept—which in the area of ICT represents Green IT in Industry 4.0 projects—aims to provide decision-makers with a wider perspective on IT investments. Rather than underlining short-term economic and non-economic gains, it indicates benefits resulting from sustainable growth such as ecological and social responsibility, and an ethical approach. The use of the information gap theory allowed for the development of methods that limited uncertainty in Green IT project completion.

The research suggested, however, that Green IT increased additional costs linked to project completion that decision-makers have to face: investing in the knowledge and skills of their employees and technology, as well as adapting project completion methods to limit information gaps over the project life cycle. Additional project costs distributed, throughout the life cycle as part of the TCO are linked to reducing the information gap.

It should be emphasized that the research is characterized by the following limitations:

1. The surveyed enterprises operated in Poland;
2. The projects were implemented in a mixed manner by both specialized suppliers and customers, but the information gap was only studied from the perspective of the client's project manager; and
3. The projects were implemented in medium enterprises and the SME group

The authors would like to explain more two main limitations of this research. The first is linked to limiting the project sample to medium enterprises conducting activity in Poland. The study included both local Polish enterprises and divisions of international companies. Limiting the study to Poland-based enterprises also meant that the results applied to a developed country, while in developing countries the map of information components and the inheritance structure could be different.

The second limitation is linked to the fact that the information gap was only studied from the perspective of the client's project manager. Future research could concern the information gap from the supplier side, which could represent the information gap between the two key project group members more thoroughly.

To sum up, the study indicated that the identification and reduction of the information gap in Industry 4.0 projects supporting reduced energy consumption and sustainable growth helps reduce uncertainty and increases the likelihood of project success at the same time. The reduction of the information gap, however, entails additional costs for the entrepreneurs.

**Author Contributions:** Conceptualization, B.W. and M.K.; methodology, B.W.; validation, B.W., M.K. and E.K.-C.; formal analysis, B.W., M.K. and E.K.-C.; investigation, B.W.; resources, B.W., M.K. and E.K.-C.; data curation, B.W., M.K. and E.K.-C.; writing—original draft preparation, B.W.; writing—review and editing, M.K. and E.K.-C.; visualization, B.W., M.K.; supervision, E.K.-C.; project administration, B.W. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Data Availability Statement:** Not applicable.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. International Energy Outlook. 2019. Available online: https://www.eia.gov/outlooks/ieo/pdf/IEO2021_Narrative.pdf (accessed on 1 December 2021).
2. Hermann, M.; Pentek, T.; Otto, B. *Design Principles for Industry 4.0 Scenarios: A Literature Review*; Working Paper No. 01, 2015; Technische Universität Dortmund: Dortmund, Germany, 2015.
3. Rajkumar, R.; Lee, I.; Sha, L.; Stankovic, J. Cyber-physical systems: The next computing revolution. In Proceedings of the 47th Design Automation Conference (DAC '10), Anaheim, CA, USA, 13–18 June 2010; Association for Computing Machinery: New York, NY, USA, 2010; pp. 731–736. [CrossRef]
4. Buxmann, P.; Hess, T.; Ruggaber, R. Internet of Services. *Bus. Inf. Syst. Eng.* **2009**, *1*, 341. [CrossRef]
5. Eurostat. [NRG_BAL_S]. Available online: http://eurostat.ec.europa.eu (accessed on 1 December 2021).
6. Madlool, N.A.; Saidur, R.; Rahim, N.A.; Kamalisarvestani, M. An overview of energy savings measures for cement industries. *Renew. Sustain. Energy Rev.* **2013**, *19*, 18–29. [CrossRef]
7. Madlool, N.A.; Saidur, R.; Hossain, M.S.; Rahim, N.A. A critical review on energy use and savings in the cement industries. *Renew. Sustain. Energy Rev.* **2011**, *15*, 2042–2060. [CrossRef]
8. Ke, J.; Zheng, N.; Fridley, D.; Price, L.; Zhou, N. Potential energy savings and CO2 emissions reduction of China's cement industry. *Energy Policy* **2012**, *45*, 739–751. [CrossRef]
9. Thirugnanasambandam, M.; Hasanuzzaman, M.; Saidur, R.; Ali, M.B.; Rajakarunakaran, S.; Devaraj, D.; Rahim, N.A. Analysis of electrical motors load factors and energy savings in an Indian cement industry. *Energy* **2011**, *36*, 4307–4314. [CrossRef]
10. Galitsky, C.; Price, L.; Zhou, N.; Fuqiu, Z.; Huawen, X.; Xuemin, Z.; Lan, W. *Guidebook for Using the Tool BEST Cement: Benchmarking and Energy Savings Tool for the Cement Industry*; (No. LBNL-1989E); Lawrence Berkeley National Lab. (LBNL): Berkeley, CA, USA, 2008.

11. Czosnyka, M.; Wnukowska, B.; Karbowa, K. Energy efficiency as a base of the energy economy in a modern industrial plants. In *Proceedings of the 2018 Progress in Applied Electrical Engineering (PAEE), Koscielisko, Poland, 18–22 June 2018*; IEEE: New York, NY, USA, 2018; pp. 1–6. [CrossRef]
12. Leites, I.L.; Sama, D.A.; Lior, N. The theory and practice of energy saving in the chemical industry: Some methods for reducing thermodynamic irreversibility in chemical technology processes. *Energy* **2003**, *28*, 55–97. [CrossRef]
13. Bujak, J. Energy savings and heat efficiency in the paper industry: A case study of a corrugated board machine. *Energy* **2008**, *33*, 1597–1608. [CrossRef]
14. Johnsson, S.; Andersson, E.; Thollander, P.; Karlsson, M. Energy savings and greenhouse gas mitigation potential in the Swedish wood industry. *Energy* **2019**, *187*, 115919. [CrossRef]
15. Shao, Y. Analysis of energy savings potential of China's nonferrous metals industry. *Resour. Conserv. Recycl.* **2017**, *117*, 25–33. [CrossRef]
16. Wolniak, R.; Saniuk, S.; Grabowska, S.; Gajdzik, B. Identification of energy efficiency trends in the context of the development of industry 4.0 using the polish steel sector as an example. *Energies* **2020**, *13*, 2867. [CrossRef]
17. Xu, Y.; Szmerekovsky, J. System dynamic modeling of energy savings in the US food industry. *J. Clean. Prod.* **2017**, *165*, 13–26. [CrossRef]
18. Diaz, N.; Ninomiya, K.; Noble, J.; Dornfeld, D. Environmental impact characterization of milling and implications for potential energy savings in industry. *Procedia CIRP* **2012**, *1*, 518–523. [CrossRef]
19. Price, L. Voluntary Agreements for Energy Efficiency or GHG Emissions Reduction in Industry: An Assessment of Programs Around the World. Presented at the Proceedings of the 2005 ACEEE Summer Study on Energy Efficiency in Industry, New York, NY, USA, June 2005. Available online: https://www.osti.gov/servlets/purl/881402 (accessed on 1 December 2021).
20. Modig, G. Evaluation of the Industrial Energy Efficiency Network in Norway. Report Prepared within the AID-EE Project, Ecofys. Available online: www.aid-ee.org/documents (accessed on 1 June 2017).
21. Schüle, R. Evaluation of Energy Concepts for Trade and Industry Sectors (ECTIS) in North Rhine-Westphalia. ECOFYS/Active Implementation of the European Directive on Energy Efficiency. 2006. Available online: https://www.academia.edu/50048010/Evaluation_of_Energy_Concepts_for_Trade_and_Industry_Sectors_Ectis_in_North_Rhine_Westphalia (accessed on 1 December 2021).
22. Rezessy, S.; Bertoldi, P. Top down energy efficiency indicators in the scope of Directive 2006/32/EC. In Proceedings of the ODYSSEE—MURE Workshop, Madrid, Spain, 21–22 June 2010.
23. SenterNovem. *Long-Term Agreement on Energy Efficiency in the Netherlands LTA3. Results of 2009*; SenterNovem: The Hague, The Netherlands, 2010.
24. Mingay, S. Green IT: The New Industry Shock Wave. Gartner Inc., 2007. Available online: http://download.microsoft.com/download/E/F/9/EF9672A8-592C-4FA2-A3BF-528E93DF44EA/VirtualizationPublicSafety_GreenITWhitepaper.pdf (accessed on 1 December 2021).
25. Murugesan, S. Harnessing green IT: Principles and practices. *IT Prof.* **2008**, *10*, 24–33. [CrossRef]
26. Murugesan, S. Making IT green. *IT Prof.* **2010**, *12*, 4–5. [CrossRef]
27. Chou, D.C.; Chou, A.Y. Awareness of Green IT and its value model. *Comput. Stand. Interfaces* **2012**, *34*, 447–451. [CrossRef]
28. Chou, D.C. Risk identification in Green IT practice. *Comput. Stand. Interfaces* **2013**, *35*, 231–237. [CrossRef]
29. Solow, R. A contribution to the theory of economic growth. *Q. J. Econ.* **1956**, *70*, 65–94. [CrossRef]
30. Baumol, W.J.; Litan, R.E.; Schramm, C.J. *Good Capitalism, Bad Capitalism, and the Economics of Growth and Prosperity*; Yale University Press: New Haven, CT, USA, 2009; ISBN 978-0-300-15832-8.
31. Mazur-Wierzbicka, E. Koncepcja zrównoważonego rozwoju jako podstawa gospodarowania środowiskiem przyrodniczym. In *Funkcjonowanie Gospodarki Polskiej w Warunkach Integracji i Globalizacji*; Kopycińska, W.D., Ed.; Wydawnictwo Uniwersytetu Szczecińskiego: Szczecin, Poland, 2005.
32. Rudyk, T.; Szczepański, E.; Jacyna, M. Safety factor in the sustainable fleet management model. *Arch. Transp.* **2019**, *49*, 103–114. [CrossRef]
33. Jacyna, M.; Wasiak, M.; Lewczuk, K.; Chamier-Gliszczyński, N.; Dąbrowski, T. Decision problems in developing proecological transport system. *Rocz. Ochr. Srodowiska* **2018**, *20*, 1007–1025.
34. Pyza, D.; Jacyna-Gołda, I.; Gołda, P.; Gołębiowski, P. Alternative fuels and their impact on reducing pollution of the natural environment. *Rocz. Ochr. Srodowiska* **2018**, *20*, 819–836.
35. Pearce, D.W.; Turner, R.K. *Economics of Natural Resources and the Environment*; Harvester Wheatsheaf: London, UK, 1990; ISBN 0-7450-0225-0.
36. Molla, A.; Cooper, V. Green IT readiness: A framework and preliminary proof of concept. *Australas. J. Inf. Syst.* **2009**, *16*, 5–23. [CrossRef]
37. Howard, G.R.; Lubbe, S. Synthesis of Green IS Frameworks for Achieving Strong Environmental Sustainability in Organisations. In Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference, Pretoria, South Africa, 1–3 October 2012. [CrossRef]
38. Izdebski, M.; Jacyna-Gołda, I.; Gołebiowski, P.; Pyza, D.; Żak, J. Decision problems in designing database architecture for the assessment of logistics services. *Zesz. Nauk. Transp. Politech. Śląska* **2020**, *108*, 53–71. [CrossRef]

39. Penzenstadler, B. *Infusing Green: Requirements Engineering for Green in and through Software Systems*; University of California: Irvine, CA, USA, 2015; Available online: http://ceur-ws.org/Vol-1216/paper8.pdf (accessed on 16 April 2021).
40. Andreopoulou, Z.S. Green informatics: ICT for green and sustainability. *J. Agric. Inform.* **2012**, *3*, 1–8. [CrossRef]
41. Lewczuk, K.; Kłodawski, M. Logistics information processing systems on the threshold of IoT. *Zesz. Nauk. Transp. Politech. Śląska* **2020**, *107*, 85–94. [CrossRef]
42. Lewczuk, K.; Kłodawski, M.; Gepner, P. Energy consumption in a distributional warehouse: A practical case study for different warehouse technologies. *Energies* **2021**, *14*, 2709. [CrossRef]
43. Cieśla, M.; Sobota, A.; Jacyna, M. Multi-Criteria decision making process in metropolitan transport means selection based on the sharing mobility idea. *Sustainability* **2020**, *12*, 7231. [CrossRef]
44. Stypułkowski, K.; Gołda, P.; Lewczuk, K.; Tomaszewska, J. Monitoring system for railway infrastructure elements based on thermal imaging analysis. *Sensors* **2021**, *21*, 3819. [CrossRef]
45. Radu, S. Poland Graduates to Developed Status. U.S. News, 2 October 2018. Available online: https://www.usnews.com/news/best-countries/articles/2018-10-02/poland-reclassified-as-a-developed-economy-by-the-ftse (accessed on 16 April 2021).
46. Cao, J.Q.; Zhang, S.H. ITIL Incident management process reengineering in industry 4.0 environments. In Proceedings of the 2nd International Conference on Advances in Mechanical Engineering and Industrial Informatics (AMEII 2016), Hangzhou, China, 9–10 April 2016; Volume 73, pp. 1011–1016. [CrossRef]
47. Izdebski, M.; Jacyna-Gołda, I.; Wasiak, M.; Jachimowski, R.; Kłodawski, M.; Pyza, D.; Żak, J. The application of the genetic algorithm to multi-criteria warehouses location problems on the logistics network. *Transport* **2018**, *33*, 741–750. [CrossRef]
48. Walker, W.E.; Marchau, V.A.W.J.; Swanson, D. Addressing deep uncertainty using adaptive policies: Introduction to section 2. *Technol. Soc. Change* **2010**, *77*, 917–923. [CrossRef]
49. Jacyna, M.; Semenov, I. Models of vehicle service system supply under information uncertainty. *Eksploat. I Niezawodn. Maint. Reliab.* **2020**, *22*, 694–704. [CrossRef]
50. Bland, D.J.; Osterwalder, A. *Testing Business Ideas: Field Guide for Rapid Experimentation*; John Wiley & Sons, Inc.: Hoboken, NJ, USA, 2019.
51. Geissdoerfer, M.; Bocken, N.M.P.; Hultink, E.J. Design thinking to enhance the sustainable business modelling process—A workshop based on a value mapping process. *J. Clean. Prod.* **2016**, *135*, 1218–1232. [CrossRef]
52. Cosenz, F.; Noto, G. A dynamic business modelling approach to design and experiment new business venture strategies. *Long Range Plann.* **2018**, *51*, 127–140. [CrossRef]
53. Marchau, V.A.W.J.; Walker, W.E.; Bloemen, P.J.T.M.; Popper, S.W. *Decision Making under Deep Uncertainty from Theory to Practice*; Springer International Publishing: Berlin/Heidelberg, Germany, 2019; ISBN 978-3-030-05252-2.
54. Ben-Haim, Y. *Info-Gap Decision Theory: Decisions under Severe Uncertainty*; Academic Press: London, UK, 2006; ISBN 978-149-330-098-3.
55. Oleński, J. *Ekonomika Informacji. Metody*; PWE: Warsaw, Poland, 2003; p. 20.
56. Wachnik, B. *Luka Informacyjna w Przedsięwzięciach Informatycznych. Problemy i Rozwiązania*; Polskie Wydawnictwo Ekonomiczne: Warszawa, Poland, 2020; ISBN 978-83-208-2416-2.
57. Babik, W. Zarządzanie Informacją we Współczesnych Systemach Informacyjno-Wyszukiwawczych—Nowe Wyzwania Współczesności. *Zag. Inf. Nauk.* **2000**, *1*, 51–63.
58. The Big6. Available online: http://www.big6.com (accessed on 16 April 2021).
59. The Society of College, National and University Libraries (SCONUL). Available online: http://www.sconul.ac.uk (accessed on 16 April 2021).
60. Ciesielska, M.; Wolnia-Bostrom, K.; Ohlander, M. Obserwacja. In *Badania Jakościowe. Metody i Narzędzia*; Jemielniak, D., Ed.; Wydawnictwo Naukowe PWN: Warszawa, Poland, 2012; Volume 2, pp. 41–67.
61. Czakon, W. *Podstawy Metodologii Badań w Naukach o Zarządzaniu*; Oficyna Wolters Kluwer Business: Warszawa, Poland, 2011.
62. Microsoft. Available online: https://www.microsoft.com (accessed on 16 April 2021).
63. SAP. Available online: http://www.sap.com (accessed on 16 April 2021).
64. Bradley, K. *Podstawy Metodyki PRINCE II CRM S.A.*; Centrum Rozwiązań Menadżerskich: Warszawa, Poland, 2002.
65. Esteves, J.; Bohorquez, V. An Updated ERP Systems Annotated Bibliography: 2001–2005. *Commun. Assoc. Inf. Syst.* **2007**, *19*, 1–59.
66. Esteves, J.; Pastor, J.A. Organizational and technological critical success factors behavior along the ERP implementation phases. In Proceedings of the 6th International Conference on Enterprise Information Systems, Porto, Portugal, 14–17 April 2004; Seruca, I., Filipe, J., Hammoudi, S., Cordeiro, J., Eds.; pp. 45–53. [CrossRef]
67. Chang, S.I. ERP Life cycle implementation, management and support. Implications for practice and research. In Proceedings of the 37th Annual Hawaii International Conference on System Sciences, Hawaii, HI, USA, 5–8 January 2004. [CrossRef]
68. Nguyen, T.H.; Sherif, J.S.; Newby, M. Strategies for Successful CRM Implementation. *Inf. Manag. Comput. Secur.* **2007**, *15*, 102–115. [CrossRef]
69. Best Practice Solutions. Available online: https://www.axelos.com/best-practice-solutions/prince2 (accessed on 16 April 2021).
70. Itil. Available online: https://www.itlibrary.org/ (accessed on 16 April 2021).
71. Auksztol, J. *Outsourcing Informatyczny w Teorii i Praktyce Zarządzania*; Wydawnictwo Uniwersytetu Gdańskiego: Gdańsk, Poland, 2008.
72. Deng, Q.; Ji, S. Organizational Green IT adoption: Concept and evidence. *Sustainability* **2015**, *7*, 16737–16755. [CrossRef]

73. Bayo-Moriones, A.; Lera-López, F. A firm-level analysis of determinants of ICT adoption in Spain. *Technovation* **2007**, *27*, 352–366. [CrossRef]
74. Greenpeace International. Make IT Green: Cloud Computing and Its Contribution to Climate Change. Greenpeace International: Amsterdam, The Netherlands, 30 March 2010. Available online: http://www.greenpeace.org/international/Global/international/planet-2/report/2010/3/makeit-green-cloud-computing.pdf (accessed on 27 February 2016).
75. Wall, T.A.; Walker, W.E.; Marchau, V.A.W.J.; Bertolini, L. Dynamic adaptive approach to transportation-infrastructure planning for climate change: San-Francisco-Bay-Area case study. *J. Infrastruct. Syst.* **2015**, *21*, 05015004. [CrossRef]
76. U.S. Army Heritage and Education Center. Who First Originated the Term VUCA (Volatility, Uncertainty, Complexity and Ambiguity)? Available online: https://usawc.libanswers.com/faq/84869 (accessed on 27 August 2021).
77. Ben-Haim, Y. *Info-Gap Economics. An Operational Introduction*; Palgrave Macmillan: London, UK, 2010.
78. Ben-Haim, Y. What Strategic Planners Need to Know, Workshop on Strategic Uncertainty in National Security, Samuel Neaman Institute, Technion, 26 June 2018. Available online: https://info-gap.technion.ac.il/files/2018/06/stpl007.pdf (accessed on 7 September 2020).
79. Ben-Haim, Y. Robust satisficing and the probability of survival. *Int. J. Syst. Sci.* **2014**, *45*, 3–19. [CrossRef]
80. Regev, S.; Shtub, A.; Ben-Haim, Y. Managing project risks as knowledge gaps. *Proj. Manag. J.* **2006**, *37*, 17–25. [CrossRef]