



DIVISION OF ENVIRONMENTALLY SUSTAINABLE SOLUTIONS IN WAREHOUSE MANAGEMENT AND EXAMPLE METHODS OF THEIR EVALUATION

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ABSTRACT. Background: Environmentally sustainable solutions are entering the domain of logistics. More and more frequently do we hear of sustainable or "green" warehouses, although the scale and scope of implementations in specific investments is not incomparable, and the adjective "green" is added rather for marketing, not utility-related, purposes. Furthermore, it is difficult to confront implemented solutions differently than with the use of evaluations dedicated to broadly-understood sustainable buildings. In order to identify the solutions, it is necessary to prepare a key for their division first. Identification, classification, popularisation and, in the long-run, implementation of sustainable solutions in warehouse management requires them to be organised.

Methods: On the basis of available information, chiefly primary and secondary sources, but also legal documentation developed in countries with high environmental awareness, materials which allow indicating the structure of division of sustainable solutions have been collected. The division has been prepared by means of analysing solutions, creating homogenous groups, and their further unification. The comparison of evaluations given to sustainable solutions has been prepared on the basis of information made available by certifying institutions.

Results: Sustainable solutions have been divided into groups, although the division is not disjoint. Three basic groups of solutions (reducing harmful emissions, reducing consumption of resources, increasing ecological value of facilities) have been distinguished. One is homogenous, the other two are divided into further subgroups.

Conclusions: Division of sustainable solutions and specification of particular groups are a basis for identification, qualification, popularisation and, in the long term, implementation of sustainable solutions for warehouse management, consequently leading to lower emission of greenhouse gases and resource consumption, and, in the long-run, to a "green" warehouse.

Key words: sustainability, sustainable warehouse, green warehouse, sustainable solutions.

INTRODUCTION

Environmentally sustainable buildings (hereinafter: sustainable buildings) also include warehouse facilities. Broadly promoted trend for "green" buildings is entering the domain of logistics.

A sustainable warehouse, understood as a "set of organisational and technological solutions whose aim is to efficiently execute warehouse processes, with the highest social

standards met, with the lowest possible environmental impact and taking financial effectiveness into account" [Żuchowski 2014], should be "equipped" with sustainable solutions. Organisational and technological solutions mentioned above might be described as "environmental technologies", defined back in 1995 as [Shrivastava 1995] "production equipment, methods and procedures, product designs, and product delivery mechanisms that conserve energy and natural resources, minimize environmental load of human activities, and protect the natural

environment". In order to identify the solutions, it is necessary to prepare a key for their division first. Identification, classification and, last but not least, implementation of sustainable solutions requires them to be organised.

The basic motives of the use of sustainable technologies should be classified concern for the conditions of life of future generations and economic benefits. Two distinct themes can go hand in hand - there is nothing to prevent that to reconcile them. "When my employer began ramping up its sustainability initiatives, I thought we'd be faced with a lot of tough choices between economy or eco-friendliness," says logistics engineer Dr. Rajiv Saxena. "But as we've progressed, I've been pleasantly surprised to discover that much of good logistics engineering is not only compatible with greener business practices, it's actually synonymous with it." [Underwood 2008].

DIVISION OF SUSTAINABLE SOLUTIONS

One of broader divisions of widely-understood environmental technologies was presented in the 2007 Energy Independence and Security Act of the Congress of the United States of America [110th Congress Public Law 140] and it includes the following activities:

1. reducing the use of energy, water and natural resources,
2. improving the quality of internal environment (working conditions), including reducing the level of internal

contaminations, improving thermal comfort and quality of lighting, and level of noise, influencing the health and productivity of users,

3. reducing negative impact on the environment, especially caused by air and water pollution or waste generation, throughout a building's lifecycle (A building's lifecycle mainly comprises the following stages: construction (including the design), use, upgrade (renovation, adaptation etc.) and final demolition),
4. increasing the use of environment-friendly materials, particularly the ones which are non-toxic, renewable and recycled,
5. increasing the possibility to reuse and recycle,
6. integrating systems in buildings,
7. reducing environmental impact and transport energy consumption, related both to building location and its development.
8. taking a building's influence on human health and natural environment into account, including:
 - increasing the effectiveness of employees,
 - influence of materials and processes carried out in the building throughout its lifecycle.

The definition of a "green building" developed by the US Environmental Protection Agency included a list of architectural factors influencing natural environment, presented in Table 1. To a considerable degree, these factors are compliant with, or even synthesize, the definition provided in the Energy Independence and Security Act.

Table 1. List of buildings' factors influencing natural environment
 Tabela 1. Zestawienie czynników wpływu budynków na środowisko naturalne

Construction site factors	Consumption	Environmental factors	Effects
Location Project Construction Operation Maintenance / conservation Renovation Demolition	Energy Water Materials Natural resources	Waste Air pollution Water pollution Internal environment pollution Heat islands Rain water	Impact on human health Degradation of natural environment Loss of resources

Source: Environmental Protection Agency 2014

Beneficial impact of the above factors on the environment may assume several forms, therefore in terms of effects of their application in buildings, sustainable solutions may be divided into three basic groups:

- solutions reducing harmful emissions, both to natural and internal environment,
- solutions reducing the consumption of resources, also by supplying them from alternative sources,
- solutions increasing ecological value of a facility

The first group of technologies includes technologies reducing negative impact on warehouse micro- and macroenvironment by limiting emissions of harmful substances. It is also applied to noise. Emissions may be limited directly (e.g. by reducing the volume of waste or minimising the emission of exhaust fumes) or indirectly, by using biodegradable or recycled resources.

The second group of solutions is related to consumption - minimising the absorption of resources, directly by using alternative sources available in the vicinity of a warehouse, and employing more effective or cost-saving solutions.

The third group of sustainable solutions is related to the use of possessed resources, but not with the aim to produce alternative energy, but to maximise positive impact of a warehouse facility on natural environment. Properly maintained biologically active areas, preservation of existing fauna and flora to a possible degree or minimisation of landscape "interruptions" may serve as examples.

Suggested division of sustainable technologies together with factors they may influence has been presented in Table 2.

Table 2. List of buildings' factors influencing natural environment
 Tabela 2. Zestawienie czynników wpływu budynków na środowisko naturalne

Sustainable solutions		Factors / solutions
Reducing harmful emissions	Directly	Waste Toxins, exhaust fumes Noise Wastewater / grey water Heat / Cold
	Indirectly	Construction materials Usable materials Spare parts
Reducing the consumption of resources	Minimisation	Heating Lighting Running water / Irrigation Electricity Fuels Materials (e.g. packaging)
	Alternative sources	Water Heating Lighting Electricity Environment-friendly external sources
Increasing ecological value of a facility / complex, integration with natural environment		Biologically active areas Preservation of natural fauna and flora Care about landscape

Source: Own study

The division is not disjoint - certain solutions may belong to both groups, such as thermal insulation, which may be qualified as a solution allowing the reduction of energy

consumption, as well as the reduction of excessive heat generation / emission. The reduction of harmful emissions may be directly ensured by minimising energy consumption for

example by using devices with low energy intensity. This, in turn, may be qualified as belonging to the group of solutions reducing resource consumption.

METHODS OF EVALUATING ENVIRONMENTALLY SUSTAINABLE WAREHOUSE FACILITIES

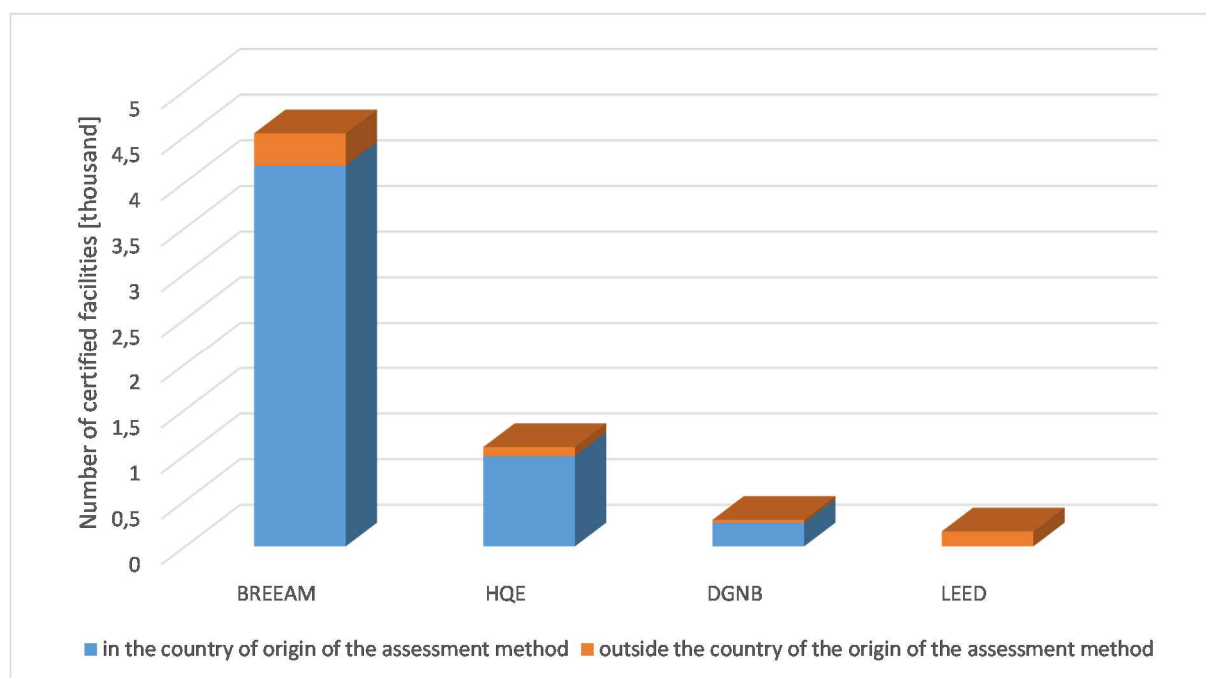
Sustainable facilities require the possibility of verification. The purpose of developing methods of evaluating sustainable buildings was transparent comparison and differentiation of buildings aspiring to be called "sustainable". Increasing promotion of evaluations results in the stimulation of demand for sustainable buildings and for enabling potential owners or users of evaluated buildings to make conscious decisions. Promotion of sustainable buildings' evaluation finally leads to the reduction of their negative impact on natural environment [Rouach 2013].

No dedicated system for evaluating sustainable warehouses has been implemented

so far. General building evaluation systems, however, allow evaluating specialised facilities, including warehouses. Among four certification methodologies applied most frequently in Europe there are (certification system's country of origin provided in brackets):

- Building Research Establishment Environmental Assessment Methodology BREEAM (United Kingdom),
- Haute Qualité Environnementale HQE (France),
- Deutsche Gesellschaft für Nachhaltiges Bauen - DGNB (Germany),
- Leadership in Energy and Environmental Design LEED (USA).

A number of certificates granted in Europe is presented in Figure 1. The fact that a vast majority of certificates by a given system has been issued in a methodology's country of origin, although they go beyond local legal regulations, is interesting. LEED, originating in the USA, but successfully employed in Europe (second largest number of certified facilities outside the certification system's country of origin), is an example here.



Source: RICS 2012

Fig. 1. Number of certified European facilities divided into certification methodologies
Rys. 1. Ilość certyfikowanych europejskich obiektów w podziale na metodologie certyfikacji

Table 3. Comparison of basic parametres of systems evaluating sustainable buildings
 Tabela 3. Porównanie podstawowych parametrów systemów oceny zrównoważonych obiektów

Parametre	Evaluation system			
	BREEAM	LEED	DGNB	HQE
Evaluated aspects				
Construction, materials	X	X		X
Management	X			X
Internal environment	X	X	X	X
Land development	X	X	X	
Water usage	X	X	x	
Water and waste	X			x
Innovations	X	X		
Energy usage	X	X		
Processes	x			
Economic effectiveness			X	
Evaluated buildings				
New	X	X	X	X
Expanded	X	X		
Existing/used	X	X	X	X
Redecorated	X	X	X	X
Shell & Core *	X	X		
Facility evaluation schemes				
Office	X	X	X	
Commercial	X	X	X	
Industrial	X		X	
Of special purpose	X		X	
School				X
Other	X	X		X
Number of levels of positive evaluations	5	4	3	4
Warehouse evaluation				
	X	X	X	X

* A building with finished common areas and unfinished office, commercial, production and warehouse space etc.

Source: RICS 2012

The comparison of basic parametres of systems evaluating the sustainability of buildings is presented in Table 3.

Each of the described systems for evaluating sustainable buildings allows warehouse evaluation. With regard to the evaluation of energy usage, however, BREEAM and LEED seem most suitable.

SUMMARY

Literature lacks studies which organise results of implementing sustainable solutions in warehouse facilities. In general, however, green buildings prove their advantage over "classic" ones, which leads directly to a conclusion that warehouses as sustainable buildings will show their supremacy in terms of financial savings, working conditions, "green" added value and, last but not least,

benefits to environment and to an entrepreneur - a typical win-win situation.

On the basis of available information developed in countries with high environmental awareness, materials have been collected with the purpose of preparing a structure of a division of sustainable solutions in terms of warehouse management. The division has been prepared by means of analysing solutions, creating homogenous groups, and their further unification.

Finally, sustainable solutions have been divided into three groups, although the division is not disjoint. Three basic groups include solutions which reduce harmful emissions (directly and indirectly), reduce the consumption of resources (by minimising consumption or using alternative energy sources) and increasing ecological value of facilities.

Division of sustainable solutions and specification of particular groups form a basis for identification, qualification, popularisation and, in the long term, implementation of sustainable solutions for warehouse management, consequently leading to lower emission of greenhouse gases and consumption of resources, and, in the long-run, to a "green" warehouse.

Specialists in logistics have a task to identify, study and promote sustainable solutions which allow achieving results achieved by sustainable buildings, but also to trigger a domino effect, initiating further research, which would specify achieved results in more detail or extend their scope to other fields of management.

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PODZIAŁ ZRÓWNOWAŻONYCH POD WZGLĘDEM ŚRODOWISKOWYM ROZWIĄZAŃ W GOSPODARCE MAGAZYNOWEJ ORAZ PRZYKŁADOWE METODY ICH OCENY

STRESZCZENIE. Wstęp: Zrównoważone pod względem środowiskowym rozwiązania wkraczają na grunt logistyki. Coraz częściej słyszymy o zrównoważonych czy "zielonych" magazynach, choć skala i zakres wdrożeń w poszczególnych inwestycjach nie jest nieporównywalny, a miano "zielony" jest nadawane raczej pod względem relacji marketingowych, niż utylitarnym. Trudno jest też implementowane rozwiązania konfrontować, poza stosowaniem ocen dedykowanych ogólnie pojętym zrównoważonym budynkom. W celu identyfikacji rozwiązań uprzednio konieczne jest przygotowanie klucza ich podziału. Identyfikacja, klasyfikacja, popularyzacja i ostatecznie implementacja zrównoważonych rozwiązań w zakresie gospodarki magazynowej wymaga ich systematyzacji.

Metody: Na podstawie dostępnych informacji, przede wszystkim źródeł pierwotnych i wtórnych, ale także dokumentacji prawnej, rozwijanej w krajach o znacznej świadomości środowiskowej, zebrane zostały materiały w celu przygotowaniu struktury podziału zrównoważonych rozwiązań. Podział został przygotowany poprzez analizę rozwiązań, tworzenie homogenicznych grup, a następnie ich ujednoczenie. Porównanie ocen zrównoważonych rozwiązań zostało przygotowane na podstawie informacji udostępnianych przez instytucje certyfikujące.

Wyniki: Zrównoważone rozwiązania zostały podzielone na grupy, choć podział nie jest rozłączny. Wyszczególnione zostały trzy podstawowe grupy rozwiązań (redukujące niekorzystne emisje, redukujące konsumpcję zasobów, zwiększające ekologiczne walory obiektów), jedna homogeniczna, dwie podzielone na dalsze podgrupy.

Wnioski: Podział zrównoważonych rozwiązań i specyfikacja poszczególnych grup są podstawą do identyfikacji, kwalifikacji i popularyzacji, a w dłuższej perspektywie implementacji zrównoważonych rozwiązań w zakresie gospodarki magazynowej, w rezultacie prowadząc do redukcji emisji gazów cieplarnianych i konsumpcji zasobów, a docelowo do "zielonego" magazynu.

Słowa kluczowe: zrównoważony rozwój, zrównoważany magazyn, zielony magazyn, zrównoważone rozwiązania

UNTERTEILUNG DER NACHHALTIGEN, ÖKOLOGISCHEN LÖSUNGEN IN DER LAGERWIRTSCHAFT UND IHRE BEISPIELHAFTEN BEWERTUNGSMETHODEN

ZUSAMMENFASSUNG. Einleitung: Nachhaltige Lösungen finden Eingang in die Logistik. Immer häufiger hört man von nachhaltigen bzw. "grünen" Lagern, obwohl die Skala und der Umfang der Implementierungen bei den einzelnen Investitionen unvergleichbar sind und die Bezeichnung "grün" eher im Hinblick auf Marketing- als auf utilitäre Zwecke vergeben wird. Es ist auch schwierig, die implementierten Lösungen gegenseitig zu konfrontieren - ausgenommen die Anwendung von Bewertungen, die generell für die nachhaltigen Lager-Gebäude gelten. Zur Identifizierung der Lösungen ist es notwendig, vorher einen Unterteilungsschlüssel zu erarbeiten. Die Identifizierung, Klassifizierung, Popularisierung und schließlich Implementierung von nachhaltigen Lösungen in der Lagerwirtschaft erfordern deren Systematisierung.

Methoden: Aufgrund verfügbarer Informationen, insbesondere Primär- und Sekundärquellen, sowie der in den Ländern mit hohem Umweltbewusstsein entwickelten Rechtsakten, wurden Materialien zur Vorbereitung der Unterteilungsstruktur von nachhaltigen Lösungen zusammengestellt. Die Unterteilung wurde durch die Auswertung von Lösungen, die Bildung von homogenen Gruppen und ihre darauffolgende Vereinheitlichung vorbereitet. Der Vergleich von Bewertungen der nachhaltigen Lösungen wurde aufgrund von Informationen bereitgestellt, die von den Zertifizierungsstellen zur Verfügung gestellt wurden.

Ergebnisse: Die nachhaltigen Lösungen wurden in Gruppen unterteilt, obwohl die Unterteilung nicht disjunktiv ist. Aufgeführt wurden drei grundlegende Lösungsgruppen (Verminderung der schädlichen Emissionen, Verminderung des Ressourcenverbrauchs, Verbesserung der Umweltschutzvorteile der Lager-Gebäude), wovon eine homogen ist und zwei in weitere Gruppen unterteilt sind.

Fazit: Die Unterteilung der nachhaltigen Lösungen und Spezifikation von einzelnen Gruppen sind eine Grundlage für die Identifizierung, Qualifizierung sowie Popularisierung, und in einer längeren Perspektive, für die Implementierung von nachhaltigen Lösungen in der Lagerwirtschaft, was zur Reduktion der Emission von Treibhausgasen, ferner zur Reduktion des Ressourcenverbrauchs und im Endergebnis zum "grünen" Lager führt.

Codewörter: nachhaltige Entwicklung, nachhaltiges Lager, "grünes" Lager, nachhaltige Lösungen

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