# THE APPLICATION OF LIFE CYCLE ASSESSMENT WITH GS1 SYSTEM SUPPORT

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**Summary:** The intention of this article is to present an innovative approach to life cycle assessment (LCA) procedure by integrating it with the GS1 system. Consequently, the key features of both LCA and GS1 system are discussed. Subsequently, a general framework of improving model of LCA use with GS1 System on-line database resources supporting role is presented.

**Keywords:** life cycle assessment (LCA), life cycle inventory (LCI), GS1 system

## 1. Introduction

Life cycle assessment (LCA) is one of the methods of life cycle sustainability analysis (LCSA) that enables producers to improve their environmental and economic performance of products. The application of LCA is still, however, very limited in small and medium-sized enterprises (SMEs) due to numerous barriers to its common use, including data source and intensity, costs, poor information transfer, and finally time and expertise required to run the LCA procedures. Considering the above a breakthrough in the popularisation of LCA in eco-design approaches might be the integration of this life cycle sustainability method with GS1 system that might be a very valuable source of information for LCA calculations for each member of the supply chain.

## 2. The definition and the scope of application of life cycle assessment

Life cycle assessment (LCA) is one of the techniques of life cycle management (LCM) that allows organisations to make the decision based upon the environmental, economic and social criteria. Initially, following the ISO 14040:2006 and the ISO 14044:2006 standards, LCA was perceived solely as a technique for compilation and evaluation of the inputs, outputs and the potential environmental impacts associated with a particular product or process throughout its life cycle [1, 2]. Consequently, LCA is basically a tool for the analysis of the environmental burden at all stages of the life cycle – from the extraction of resources, through the production of materials, product parts and the product itself, and the use of the product to the management after it is discarded, either by reuse, recycling or final disposal – from the cradle to grave analysis [3]. Currently, to confront the environmental performance with economic and social aspects, LCA is supported by the procedure of life cycle cost (LCC) and social life cycle assessment (SLCA).

Life cycle assessment (LCA) is regulated by the series of ISO 14040 standards that Polish equivalents are:

- PN-EN 14040:2009 Environmental management – Life cycle assessment – Principles and framework,
- PN-EN 14044:2009 Environmental management – Life cycle assessment – Requirements and guidelines.

The tool of life cycle assessment (LCA) has a very universal character and, thus, can be applied, inter alia, for:

- analysing opportunities to improve the environmental aspects of a particular product at various stages of its life cycle (eco-design),
- characterisation and comparative evaluation of the product or the service and its system of unit processes in time [4],
- comparing between a number of products or services, ad exemplum, different types of packaging materials, based upon selected categories,
- decision making in the industry, the service sector and other organisations (e.g, strategic planning, setting priorities, designing products or processes) and finally
- marketing (e.g. environmental statements or eco-labeling).

## 3. The methodology of life cycle assessment

The LCA methodology is structured "along a framework that has become the subject of world-wide consensus and that forms the basis of a number of ISO standards. This framework divides the entire LCA procedure into four distinct phases" (see Fig. 1) [3]:

1) goal and scope definition,
2) inventory analysis,
3) impact assessment,
4) interpretation.

**Goal and scope definition** is the first phase of the life cycle assessment (LCA). It incorporates a number of successive operations; the most important are determining the goal of the analysis, the definition of a product system and its functional unit, and finally defining the boundaries of the system. The goal of the study has to be formulated in a clear and appropriate way as to the intended application of the research results. The product system is a set of material and energy connected unit processes that fulfil one or more defined functions. The system boundary is "set of criteria specifying which unit processes are part of a product system" (cf. [6]).

**Life cycle inventory** (LCI) is the next phase of the life cycle assessment (LCA). It covers the collection and quantification of inputs and outputs for a given product system throughout its life cycle. The inputs and outputs are assigned to each unit process individually. Data collection is carried out in order to draw up a comprehensive balance of the energy, materials and chemicals collected from the environment that enter the system and that leave the system as emissions to the environment. The collected data can be measured, calculated or estimated.

**Life cycle impact assessment** (LCIA) is the third phase of the life cycle assessment (LCA). It defines the relationships between the environmental inventory and defined impact categories, and category indicators. Consequently, the mandatory elements of that stage are as follows:

- selection of impact categories, category indicators and characterisation models,
- assignment of LCI results to the impact categories (classification),
- calculation of category indicator results (characterisation).

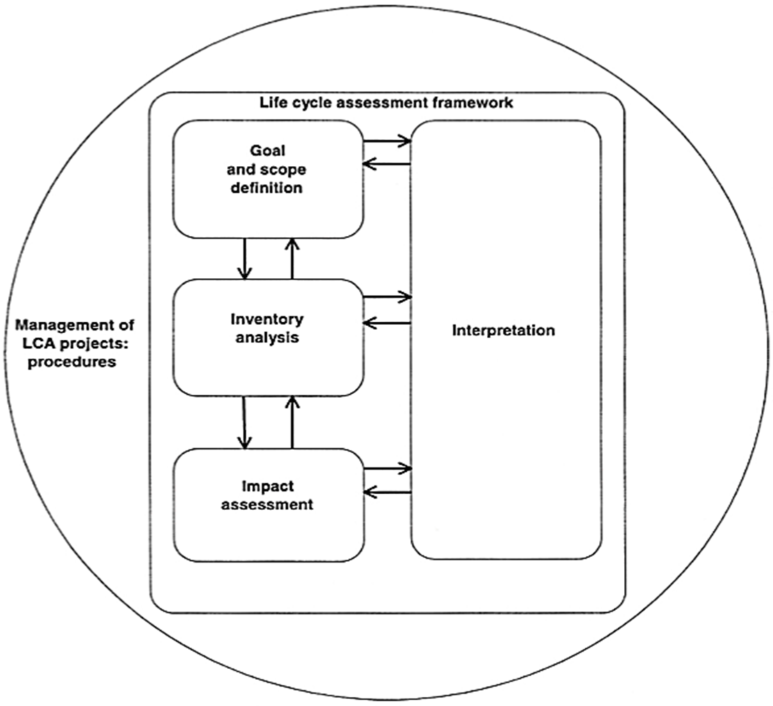


Fig. 1. Model of life cycle assessment (LCA)
Source: Arnold Tukker (cf. [3])

In practice, due to the fact that the LCIA phase is very complicated, there are adequate computer programs, ad exemplum simapro, umberto, LCA-IWM to support the analysis.

**Life cycle interpretation** is the last phase of the life cycle assessment (LCA). It is a procedure for the identification, qualification, verification and evaluation of the information obtained in the previous two phases (LCI and LCIA). Therefore, this phase ought to explain the limitations of the analysis as well as to enable the formulation of conclusions and recommendations regarding the reduction of environmental impacts.

To confront the environmental performance with economic and technical aspects, the technique of LCA can be supported by the procedure of multi-criteria decision analysis (MCDA). This is a formalised and structured process for selecting between alternatives, basing the decision on several criteria. In the case of integrated waste management systems, the criteria encompass environmental, economic and social sustainability.

## 4. GS1 system

History of GS1 [6] started in 1973 in the U.S.A., when industry leaders accepted the use of the Universal Product Code symbol for product identification. In 1974 The Uniform Code Council (UCC) was established in the U.S.A. as a standards organization (GS1 US). Identification symbol has become a global one in 1976; original GS1 barcode was extended by the addition of 13-th digit. The Europe introduced barcode identification system in 1977, when The European Article Numbering Association (EAN International) was established as an international not-for-profit standards organization (GS1) with a head office in Brussels, Belgium. The EAN developed a compatible system for use outside North America, designed as a superset of the UCC. The EAN identification system was aimed to improve supply chain efficiency in the retail sector. In 1990 The UCC (GS1 US) and EAN International (GS1) signed a cooperative agreement to co-manage global standards. In 1996 The International Organization for Standardization's technical committee for automatic identification and data capture standards (ISO/IEC JTC 1/SC 31) was launched to strengthen international cooperation around the development and use of new standards.

Nowadays, the GS1 is an international, not-for-profit organisation based in Brussels, Belgium with 111 member organisations worldwide, including Poland that is represented by the Institute of Logistics and Warehousing (GS1 Poland) since 1990. The GS1 identify itself as a facilitator of "collaboration among trading partners, organisations and technology providers, in order to solve business challenges that leverage standards and to ensure visibility along the entire supply chain". The GS1 claims, that nowadays the GS1 system is implemented in over 2 million companies operating across 150 countries in multiple sectors and industries.

The GS1 develops the GS1 System, which consist of widely recognized standards used in logistics processes to identify goods, services, assets or locations with use of "a globally unique and unambiguous numbers" called The GS1 Identification Keys. These identification numbers can be represented in printed barcodes for optical camera reading or transferred electronically into radio frequency tags for scanning with radio frequency identification (RFID ) transponders.

The GS1 Identification Keys can be for instance applied to [5]:

- trade items: any item (product or service) can be specified with pre-defined information stored in database (full name, producer name etc.) and may be priced, or ordered, or invoiced at any point in any supply chain;
- logistic units: an item of any package form for transport and/or storage that needs to be managed through the supply chain;
- assets: physical entities treated as an inventory item;
- locations: any location that needs to be uniquely identified in the supply chain or within a business scenario.

The GS1 Identification Keys falls into 4 class as follows [5]:

Class 1: Keys administered by GS1 and fully under its control;
Class 2: Keys whose framework is controlled by GS1; portion of the GS1 numbering capacity is allocated for an identification scheme administered by an external agency;
Class 3: Keys fully administered and controlled outside GS1, but supported partially in the GS1 System
Class 4: Keys that are entirely outside the GS1 System.

The GS1 Identification Keys Class 1 and Class 2 are presented in tab. 1.

Tab. 1. The GS1 Identification Keys (Class 1 and Class 2) [5]

| The GS1 Identification Key | Format | Used data structures |
|---|---|---|
| **GTIN** (Global Trade Item Number) | Numeric, terminated with a Check Digit | GTIN-8; GTIN-12; GTIN-13; GTIN-14 |
| **GLN** (Global Location Number) | Numeric, terminated with a Check Digit | Fixed length 13-digit numbers |
| **SSCC** (Serial Shipping Container Code) | Numeric, terminated with a Check Digit | Fixed length 18-digit number |

| | | |
|---|---|---|
| **GIAI** (Global Individual Asset Identifier) | Alpha-numeric | Variable length up to 30 alpha-numeric characters |
| **GRAI** (Global Returnable Asset Identifier) | Alpha-numeric | Variable length up to 30 alpha-numeric characters |
| **GSRN** (Global Service Relationship Number) | Numeric, terminated with a Check Digit | Fixed length 18-digit number |
| **GDTI** (Global Document Type Identifier) | Alpha-numeric | Variable length up to 30 alpha numeric characters |
| **GINC** (Global Identification Number for Consignments) | Alpha-numeric | Variable length up to 30 alpha- numeric characters |
| **GSIN** (Global Shipment Identification Number) | Numeric, terminated with a Check Digit | Fixed length 17-digit number |
| **GCN** (Global Coupon Number) | Numeric | Variable length up to 25 digits |

Fig. 2 illustrates data structure of The Global Trade Item Number (GTIN).

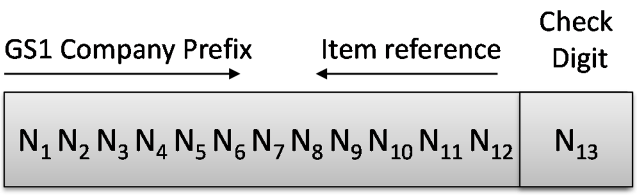


Fig. 2. GTIN-13 Data Structure [7]

All GS1 Identification Keys essentially have 3 parts:

– GS1 Company Prefix: a number assigned and managed by GS1 that uniquely identifies a system user (company) across the globe;
– Item Reference: a number assigned by the system user to identify item that is being identified;
– Check Digit: result of an algorithm that is carried out automatically to ensure that the number is correctly composed and scanned.

The GS1 Identification Keys are also used in Electronic Data Interchange (EDI), XML electronic messaging, Global Data Synchronization Network (GDSN), and GS1 Network Systems. The GDSN is designed to connect trading partners in supply chain to the GS1 Global Registry® that plays role of specific index of the registered items (See Fig. 4). A connectivity of trading partners is achieved via a network of interoperable GDSN-certified data pools. Data pools are electronic catalogues (registers) of standardised item data, which can be run by a GS1 Member Organisation or by a third party solution provider.

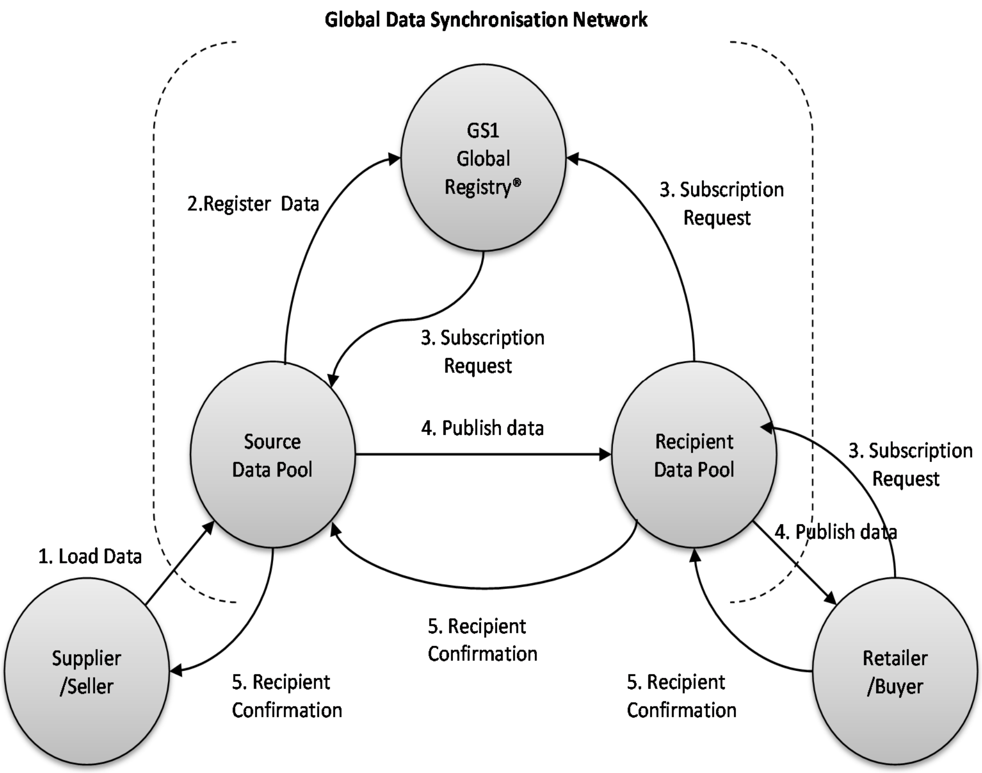


Fig. 4. GDSN Data Flow. Source: own elaboration, based on [8]

Trading partners synchronise definition data of any item and its location in 5 steps:

1. Load data. The Supplier (or seller) registers company and own product definition in its data pool with use of uniquely established a GTIN Key.
2. Register data. A subset of product's data is sent to the GS1 Global Registry.
3. Subscription Request. The Buyer (or retailer), through its own data pool, subscribes to receive information about a given product identified with a GTIN Key.
4. Publish data. The seller's data pool publishes the requested information to the buyer's data pool.
5. Recipient confirmation. The confirmation of successful data synchronization (eventually with additional information about taken actions) is send from the Buyer to the Supplier via each company's data pool.

## 5. GS1 System in Poland

The Institute of Logistics and Warehousing GS1 Poland, in cooperation with suppliers of mobile applications and online stores develops software tools that are designed to provide consumers with reliable information about the products with implementing the GS1 System.

All developed tools are powered by the Products Information Server whose core element is the Registry MojeGS1 (eng. *MyGS1*). The Registry provides basic information about the product (mandatory GTIN of the product and the name), collected by the Institute of Logistics and Warehousing from companies participating in the barcode system in Poland.

The Registry MojeGS1 is available online on the website “GS1- Poland Electronic platform for customer service” (see Fig. 5) at URL: http://www.epoka.gs1.pl [9].

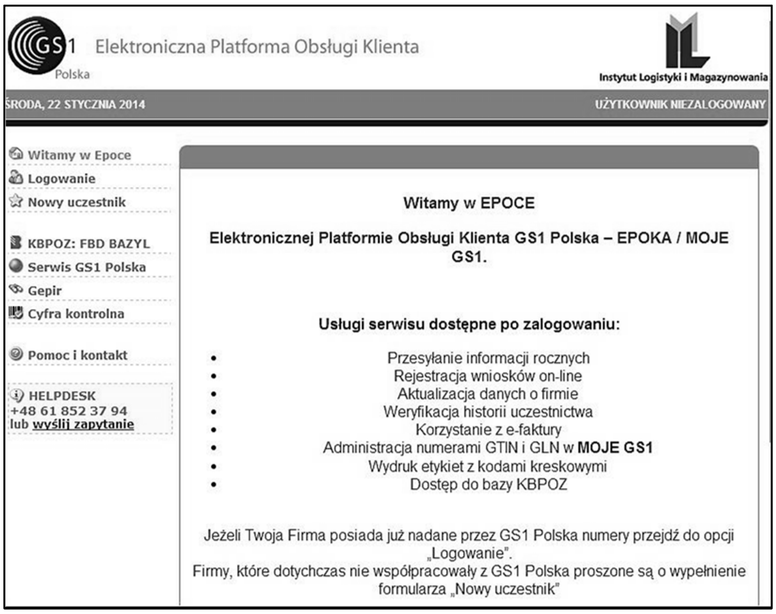

Fig. 5. The Welcome screen of The MojeGS1 portal

The Register collects information about product, among others, as follows [9]:

– The name of the product,
– Global Trade Item Number (GTIN),
– Global Location Number (GLN)
– producer or owner of trade mark contact data,
– web page or a link to a media file on the product,
– product photo,
– Polish Classification of Products and Services (PKWiU) classifier.

The Institute of Logistics and Warehousing GS1 Poland provides also application programming interface (API) named The MojeGS1-API to enable third party software developers to create applications or websites with direct access to database of MojeGs1. The actual list of MojeGs1 official partners (Nokaut, Ceneo, Skąpiec, Opineo, Amazon, eBay and oth.) proves that the one of declared objective of the MojeGs1project is to support electronic commerce in Poland.

## 6. LCA support through extended information contents of GS1 on-line resources

To perform the LCA analysis adequately, a broad spectrum of environmental information is required. They represent a set of material and energy parameters (inputs and outputs) over the life cycle of a product that are subsequently assigned to the appropriate categories of impact, including, inter alia, natural resources depletion, global warming, eutrophication, acidification, odour, noise, waste generation. A quantitative and qualitative data required in LCA analysis are usually collected among others from: a few existing (and reactively hard to reach) distributed databases including these developed by producers of goods; published research reports results; a literature of subject. In every case, because of high level of generalization or very specific nature of data taken from mentioned above sources, each analysis requires making some estimation based on experts opinions, or some kind of interpolation or extrapolation (based on existing data recalled by analogy or similarity). A current state of implementation of LCA analysis seems to be limited by input information quality in all aspects: accuracy, relevance, age, completeness, presentation and level of detail.

Access to a global database of reliable, relatively accurate quantitative and qualitative data required for the analysis of LCA would strongly positive impact on intensifying the dissemination of use of this method. Open nature of the GS1 System and potential interoperability (see MojeGs1 API) create an opportunity allow to start work on implementing the standardized set of attributes assigned to the product identified by GTIN.

Fig. 6 presents the idea of LCA-specific data flow with use of the Global Data Synchronization Network.

In presented fragment of supply chain with convergent network, ccomponents from different sources are assembled in node (1) into a final product. Node (2) represents subassembly stage in supply chain. Nodes (5), (4) and (3) subsequently supply those nodes. Each node (i) supply product that is registered in GS1 Registry and obtained $GTIN_i$. Each of nodes does own LCA analysis based on products bill of materials (BOM). It covers environmental data about own value added process (material processing, manufacturing and assembly) and from (i) suppliers via GDSN. Additionally, if we consider LCA driven optimization of product in (i) node, GDSN might power this process with supply of alternative product's characteristics.

The fact, that all required information contents of product's record is created by producer, would might radically improve quality of input information for LCA analysis. It will also improve the communication between enterprises (B2B relationship) at different stages of the production chain regarding the environmental profile of the product system. In consequence, the LCA procedures made during the whole product life cycle, from the acquisition of raw materials through manufacturing to final disposal, will be less complex and based on reliable data. Finally, it increases the accuracy and ease of use LCA analysis's results.

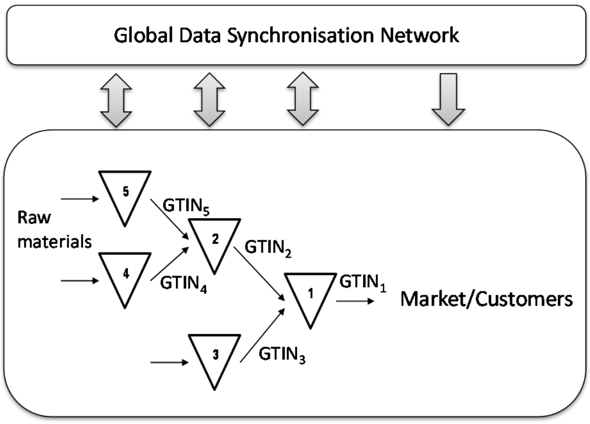


Fig. 6. The supply chain LCA results data flow with use of the GDSN

## 7. Conclusions

The GS1 System is open by definition, so there is a real possibility to implement presented idea of adding information to GS1 data pool, which are required to perform LCA analysis. A number of registered products in The MojeGS1 achieved 300.000 in the end of year 2012. Nowadays the growth of number of GTIN Identification Keys is mainly driven by the European Union regulation on consumer information on food (issued in November 2011). This regulation will enter into force 14 December 2014 and European Member States cooperate on extending GS1 System data pools information contents (number of attributes) to meet a requirements of this regulation across the EU area.

Presented idea of multi-stage LCA analysis powered with GS1 System requires future research. It covers among others: developing a repetitive LCA analysis model with employing multi-stage schema, developing a set of standardized attributes to extend information contents of GS1 data pool, create software tools for implementing presented idea.

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