Green Logistics’ Tools as Corporate Environmental Management Information System (CEMIS)

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Abstract

Global warming, climatic disasters and the depletion of the ozone layer illustrate the negative impact of economic growth on the ecological system and the societies that function within them. As a result, customers and many governments around the world are developing a more conscious and respectful attitude toward the environment, propelling environmental concerns to the forefront of many companies’ competitive strategies. The implementation of green practices into logistics systems is gaining worldwide importance. Corporate Environmental Management Information System (CEMIS) is the solution for companies to comply with environmental regulation by providing the necessary information to monitor and analyze environmental effects of business activities. In this paper, general information about CEMIS will be invoked accompanied by a focus on green logistics tools. The architecture and interface of each tool will be demonstrated.

1 Introduction

The climate change and the natural disasters happening nowadays, as a result of the negative impact of the industrial waste and pollution, require companies to improve their business by developing a more conscious and respectful attitude toward the environment. Environmental concerns need to move to the forefront of companies’ competitive strategies.

However, companies need to update their business steps e.g. logistics and make it environmental friendly, creating as a result a new term called "Green Logistics". In order to define the new term "Green Logistics", a definition of each word alone is necessary:

- Logistics is defined as "the planning, organization, and control of all activities in the material flow, from raw material until final consumption and reverse flows of the manufactured product, with the aim of satisfying the customer’s and other interest party’s needs and wishes i.e., to provide a good customer service, low cost, low tied-up capital and small environmental consequences" (Mattsson & Jonsson, 2005).

- Greenness can be described as "a code-word for a range of environmental concerns, and is usually considered positively" (Rodrique, et al., 2009).

Combining both definitions creates a new transport and distribution system which is more efficient and environmentally friendly. Thus, Green Logistics can be defined as follows: "Supply chain management practices and strategies that reduce the environmental and energy footprint of freight distribution. It focuses on material handling, waste management, packaging and transport" (Rodrique, et al., 2009).

The goal of Green Logistics is to show how logistics and transport operations can be continuously improved for economic benefit while taking care of the environment. Therefore, it helps companies to be more socially and environmentally responsible while improving the bottom line of their activities.

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Green Logistics stands for sustainable logistics. Hence, logistics should be by considering ecological, economic and social factors without changing the environment’ characteristics. Figure 1 shows the relationship between the three aspects to be harmonized.

To obtain green logistics in a company, tools are needed in order to calculate the rate of energy consumption, gas emission, pollution's rate etc. Thus, new logistics techniques are developed to preserve the business profit and consider the environment simultaneously.

2 Tools

Different tools are used in order to reach the goal of Green Logistics’ principles. This paper will focus on two different tools that deal with transportation and material handling.

3 Railenergy project

The Railenergy project is an integrated project which provides a joint platform for communication between the main industrial stakeholders. Its goal is to reduce the life cycle costs of railway operations and carbon dioxide emissions by decreasing the energy consumption on the railway system. This can be achieved by addressing the energy efficiency of the integrated railway system. Hence, this leads to an investigation and validation of solutions starting from the introduction of innovative techniques and methods of transportation, components and layouts to the development of the now used equipment, operation and infrastructure management strategies.

The increasing energy consumption related to the increasing transport demands worldwide, especially in Europe, leads to an intense pressure on fossil fuel resources as well as increasing emissions of toxic gases. Railway system is considered as one of the most important transportation's mode. In order to maintain the economical profit while making it more environmentally friendly, increasing energy efficiency is a necessary step. There are three main reasons to act now:
1. High energy cost: the continuing increase in oil prices, up to $100 per barrel.
2. Energy security: more important for all countries, especially to be independent from foreign energy supplies. Reducing the energy demand of the railways will reduce this risk.
3. Climate protection: climate change has become one of the most important issues to be taken into account in the railway systems, but it is impossible for all industrial electricity consumers to switch to...
renewable energy sources at once. Thus, improving energy efficiency is necessary when the railways are trying to achieve their individual CO2 targets.

The special feature of the Railenergy project is the holistic approach to energy efficiency, i.e. no technical or operational measure is better than its global contribution to the system efficiency. Railenergy is considered as a platform for an integrated development of new methodologies, techniques and technologies. According to this approach, the outputs of the Railenergy project (Railenergy, 2010) are:

- Relevant baseline energy consumption figures and scenarios for selected reference systems.
- System-based concept for modelling energy consumption.
- Common and standardized methodology to determine energy consumption by rail sub-systems and components in the development and procurement phases.
- Integrated railway energy efficiency calculator & decision support tool.
- Strategic energy efficiency recommendations for rolling stock, infrastructure and traffic management.
- New validated energy efficiency-oriented railway technologies for trackside and on-board sub-systems and equipment, developed in compliance with the new integrated approach.
- Refined best practices for Railway Operators and Infrastructure Managers.
- Incentives framework.

3.1 Railenergy methodology

As shown in Figure 2, The Railenergy assessment methodology consists of three levels: technical, operational and strategic level.

1. **Technical Level**: In this level the system simulates all the related studied technologies. This simulation facilitates the evaluation step of these technologies based on assessment reports.

2. **Operational Level**: commercial multi-train simulation tools are used in a harmonized and transparent way in order to simulate the energy savings data on selected lines and operation (demo scenes and use cases) building a so-called global modelling methodology. The simulation results are described in evaluation reports per used case or service type.

The energy simulations are measured by the Railenergy Key Performance Indicators (KPI’s). The simulations are performed on three levels where the first two are real multi-train simulations on system or subsystem level and the third is based on quantitative estimations based on expertise and experience.

- The Baseline Scenario (Railenergy Performance Baseline): this has been obtained from the current values of the KPI's and will be used to assess the improvements in terms of energy efficiency performance. This can be achieved by applying the Railenergy technologies to the railway system comparing the current performance (Railenergy, 2010).
- The New Technology Application scenario: the simulation, in the use cases, of the new technologies defined in the technology matrix for the assessment of the energy efficiency improvements that can be achieved by applying the Railenergy technologies to the railway system (Railenergy, 2010).

**Example**

Considering two cases, Table 1 shows two ICE 3 rolling stocks that are moving in two different railways and two different countries.
Infrastrucure on the French side is the state of the art technology which is not representative for European high speed line infrastructure configuration. The German infrastructure for the second use case 1.2.
case is not a real high speed line, but it is typical for high speed operations in the conventional rail network. Thus, this use case is quite representative for the European situation. The simulation results are given below in Figure 3.

By comparing the simulation results, the "Asymmetrical AT system" attribute was reduced till 0.0 % in the 1.2 use case, the "Reduce line impedance" attribute was increased by 3.2% to reach 3.7%; therefore, saving the energy wasted on the line impedance. The "super conduction transformer ad inductances for railway" attribute was reduced by 1.0%, and finally the "medium frequency energy distribution" attribute was decreased by 0.7%. All the previous results refer to a good solution in saving energy; therefore, reducing the consumption of fuel for generating the necessary energy and thus, reducing the pollution.

3. **The Strategic Level:** as it is clear from its name, in this level the decision making board get the economic evaluation to set the new strategy of the company regarding the energy saving potential of the different available technologies and service types.

![Simulation Results (Railenergy, 2010).](image_url)

3.2 **Key Performance Indicators (KPI)**

The railenergy project set seven Keys Performance Indicators (KPIs) to measure the saving potential (Railenergy, 2010):

1. KPI 1 - Final Energy consumption per traction effort.
2. KPI 2 – Final Energy consumption per offered transport.
3. KPI 3 – Primary Energy consumption per actual traffic output.
4. KPI 4 – Final Energy consumption per actual traffic output.
5. KPI 5 – Share of energy consumption for parked trains.
6. KPI 6 – Energy recuperation rate.
7. KPI 7 – Efficiency of the railway distribution grid.

These indicators are constructed to describe the energy efficiency of railway systems. It is very important to not focus only on the indicator values themselves nor to depend on certain KPIs values since they may give false results in some cases e.g. "if the total weight of the rolling stock is reduced or increased through some technical measures the KPI 1 might not reflect this change sufficiently, thus; the KPIs values must be used as a supplement together with analysis of the total energy consumption or savings values compared to the total traffic performed" (Railenergy, 2010). Key Performance Indicators are distributed as shown in the following:

- KPI 1 and KPI 2 represent the "technical indicators" which divide the energy consumption according to weight and number of seats.
• KPI 3 and KPI 4 illustrate the "commercial indicators" that are used for passengers only. They divide primary or final energy consumption with respect to the actual passenger’s kilometres including the load factor.
• KPI 1, KPI 2 and KPI 4 can generate the CO2 Key Performance Indicator by using "CO2" instead of "Energy" at those indicators.
• KPI 5, KPI 6 and KPI 7 characterize the potential within the system. Both technical and commercial indicators define the overall system performance indicators.

3.3 System Boundaries
Railway system is defined under two main system boundaries (Figure 4 Sketch of System Boundaries) as follows:
1. Point of common coupling (CC):
   a) It separates rail specific electric infrastructure or railway distribution grid consisting of transformers, substations and overhead catenary system (OCS), and high voltage power supply system.
   b) The energy consumption at this point defines the system level/ consumption.
2. Pantograph:
   c) It is the point that separates the train within the railway system.
   d) The energy consumption at this point defines the train level consumption.

4 myWMS LOS
Warehouse Management System (WMS) is a software application that helps organizations to manage the operations of a warehouse or distribution centre (Hill, 2011). MyWMS LOS is an open source Warehouse Management System designed for the special needs of manual operated warehouses. It supports all the basic processes for managing a warehouse (incoming goods, picking with mobile terminals, stock taking, shipping). MyWMS LOS is an implementation of the framework of myWMS developed by the Frauenhofer-Institutes for Material Flow und Logistic. The primary language is JAVA.
LOS is an open, scalable and powerful platform that supports the JEE5 specification and based on the approach of SOA (Service Oriented Architecture), SaaS (Software as a Service) and web services. Therefore, it is in a position to provide a services-based architecture. It has three main areas (LOS, 2010):
1. The logic.
2. The client application(s).
3. The database.

The logic is the core component. It is responsible for providing the interface used by the client application and the persistence of the database after it has been executed by the application server. The logic contains simple tasks such as the creation of database inquiries. The responsibility of the client application is the display and recording.

4.1 Graphical User interface GUI
The interface of myWMS LOS is simple. It is like working on an ordinary window of Microsoft, Mac or Linux containing three main areas: the menu Bar, the entity explorer and the working area.
1. The menu bar consists of different menus (file, window, action, reports, etc). Each one has different submenus allowing the user to do many tasks.
2. The entity explorer shows the data of the system and allows a fast access to them.
3. The working area is the user’s main field to get work down. It contains different lists, dialogs and views, which by the user can create new data, access processed data and modify them.

4.2 Master Data

Master Data is divided into three main categories (LOS, 2010):
1. Program Master Data: consists of clients, user, roles and system properties.
2. Store Master Data: contains zones, areas, unit load types, storage location types, capacity constraints, storage location types and fixed location assignment.
3. Material Master Data: contains item data, item units, EAN-codes and bills of material.

Program Master Data:

Consists of:
1. Clients: The functionality of the client is implemented for the purpose of 'One store with one responsible operator and some big clients' (LOS, 2010). Two different types of clients exist:
   a. The System Client (Operator): is permitted to work with the data of all clients.
   b. One simple client (none operator): is permitted only to work with own private data i.e. material, storage locations, stock units and orders.

Different ways are used for the client control:
   a. Only one (system) client: where the functionality of client control is eliminated
   b. More than one client, all users are assigned to the system client: where processes can be done by every user.
   c. More than one client and client-assigned users: where the simple client (non-operator) can only process own data.
2. Users: To use myWMS LOS, a “user account” should be created. Accessing the user data is possible after providing the username and password.
3. Roles: in myWMS LOS, a “role based concept” is used to give permissions. That means every role specifies permission for the user and every user has one role or more.
4. System Properties: through the system properties are assigned to “client and workstations”, the user can modify every property of the system separately.

Store Master Data:

Consists of:
   a. Zones: “Zones” are the division of the storage area of the materials and they are assigned to storage location or materials. When searching for goods location, the” Zones” classification is considered. The classification’s types are ABC classification, dangerous goods chilled products.
   b. Areas: are used to describe a logical and physical classification of the store (LOS, 2010). The functionality is assigned to the area by giving it a so called type such as goods in, goods out, store etc. It is possible to build more than one area with the same type and everyone has the same functionality.
   c. Unit Load Types: every unit load is assigned to a unit load type. The type describes general properties of the unit loads, like “measurements”. The allocation of storage locations is done by reference to the unit load type and the storage location type (LOS, 2010).
   d. Storage Location Types: it is the same as unit load types. A type is assigned to the storage location and it describes the physical storage location. By defining the unit load types and the storage location types, we can allocate the storage location.
   e. Capacity Constrains: the capacity constraints are rules to define the occupation of storage locations (LOS, 2010). The unit load types and the storage location types are related and they are used to allocate the storage location. Through the capacity constraints, a rule to the dialog is given to
specify which unit load of a certain type is allowed to be put in storage location of a certain type. However, if there is no rule given (no capacity constrains) to a storage location, all unit loads are allowed to be put in this location. Capacity constrains orders the system locations or handover locations.

f. Storage Location: it is very useful to organize the storage location or to think about labels. A simple code "A4-021-3" is shown below in figure 4 to explain the storage location:

- The first part (A4) is assigned to what so called Rack (aisle), it is accessible via an alley and each rack consists of storage shelves that are aligned in a horizontal and vertical direction. Every shelve has specific admmeasurments and single depth intake of loading devices.
- Every storage location has a label with its name represented by barcode and text.
- The second part (021) is assigned for two different things: the first one (02) shows the number of a field in a rack and the second one shows the possession or the location of the unit (good) in the field.
- The last part (3) is assigned to the level of the shelves in a rack. So reading the whole example as (A4-021-3) means the location of the unit is in the fourth rack in hall A in the second field in the first possession at the third level.

![Figure 4: Warehousing Code Example (LOS, 2010)](image)

g. Fixed Location Assignment: with fixed location assignment, there are some areas in the storage location designed to store specific materials. This means there is a specific picking of the location for such materials.

4.3 Main Process

Consists of:
1. Advice: creating advice in the warehouse system means the system is waiting for a specific article from a named client. In other words, a client has made an order from the system. The charge of the advice can be added to an existing charge or a new one can be created. The article is saved into the system once the order is created. The advice has certain attributes such as article, amount, delivery date, charge, etc.
2. Goods Receipts (Goods In): after creating an advice, the process of good receipt means that the advice of the selected goods is accepted in the stock, and a good receipt will be created to give order to the lading device to allocate the goods. Also a good receipt has attributes such as supplier, advice, loading device id, quantity per loading device, charge, etc.
3. Picking: the process of putting together a client’s order or a production order from different goods out of a whole assortment (LOS, 2010).
4. Goods Out: Via the goods out, we can check the goods which are ordered and what remains in the storage location.
5 Green Logistics’ Tools as CEMIS

In recent years, the concentration on the environment has been increased as a result of the climate change caused by high proportion of toxic gases’ emission from factories. Therefore, focusing on the environmental responsibility was directed towards companies. A variety of highly specific, heterogeneous solutions for different environmental issues was created comprising a specific category of information system termed Corporate Environmental Management Information Systems (CEMIS). Corporate Environmental Management Information Systems advancements and trends address the continuing need for companies to take a holistic and strategic approach towards material and energy efficiency, emission and waste reduction, recycling, stakeholder engagement and legal compliance. (Gómez, et al., 2010).

Lots of challenges are faced by logistics operations of any company to ensure being environmentally friendly. Those challenges were listed by Rodrigue et al. as follows (Rodrique, et al., 2001):

- Costs: the purpose of logistics aims at efficiency gains and thus reducing costs, e.g. using diesel instead of gasoline etc. However, such solutions could be least environmentally friendly.
- Time/Speed: logistics tries to increase flexibility and to reduce the delivery time. Reducing the product's delivery time might make it less environmentally friendly.
- Service Reliability: successful logistics also means successful customer service such as delivery on time and no quality degradation. However, this is achieved by least environmentally friendly modes of transport such as air and road.
- Warehousing systems: modern logistics systems economies depend on the speed and reliability of shipments to reduce the number of inventories as long as it eliminates the need to store and stockpile. However, inventories are shifted in part to public roads (or in containers), contributing to congestion, space consumption and pollution.
- E-Commerce: it is a flourishing market sector, as the number of the small parcels being shipped is astonishing. However, the most efficient transport systems are air and road even though they are the most environmentally unfriendly modes of transportation.

Green logistics' software usually interacts directly with data from mobile devices like bar code scanner, printer or RFID (Radio Frequency IDentification) – systems (Jamous & Mueller, 2010). In general these tools have common features as displayed in table 2 bellow.

<table>
<thead>
<tr>
<th>Environment &amp; Organization</th>
<th>Strategy</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business objective</td>
<td>Certification / presentation</td>
<td></td>
</tr>
<tr>
<td>Time frame</td>
<td>Medium-term</td>
<td></td>
</tr>
<tr>
<td>Function level</td>
<td>Information / communication</td>
<td></td>
</tr>
<tr>
<td>Addressees</td>
<td>Management / public</td>
<td></td>
</tr>
<tr>
<td>Specific criteria</td>
<td>Type</td>
<td>KPI / sustainability reporting / accounting</td>
</tr>
<tr>
<td>Database</td>
<td>Organizational / material / energy</td>
<td></td>
</tr>
<tr>
<td>Environmental medium</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>Object</td>
<td>Waste / emission / energy</td>
<td></td>
</tr>
<tr>
<td>Methods / tools</td>
<td>Data warehouse</td>
<td></td>
</tr>
<tr>
<td>Integration level</td>
<td>Stand-alone</td>
<td></td>
</tr>
<tr>
<td>System boundary</td>
<td>Company</td>
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</tbody>
</table>
Concentrating on some of the very basic dimensions of any organization (strategy, business objective, and time frame), the following common features of both tools can be obtained:

- Both tools’ strategies are precautionary because both tools (myWMSLos & Railway Energy) aim to reduce CO2 emission and make companies more environmentally friendly.
- Both tools’ business aims to achieve the eco-efficiency via reducing the environmental impact per unit of product or service value.
- myWMSLos tools’ time frame is set to short-term because it aims to reduce the pollution produced by companies in a short time (6 months - 24 months) while Railway Energy tool aims to reduce pollution produced by companies in a long time (minimum 5 years).

However, some missing features do still exist, like some important environmental performance indicators (EPIs), e.g. carbon footprint of a specific, ordered transport offers and provides possible customers with transportation alternatives with different environmental impact. Therefore, such tools still need more improvement in order to fulfil the needs of the companies and the customers, in addition so much work still missing to allow companies integrate such tools into their systems.

6 Conclusion

This paper consists of three main parts. The first part, the introduction, contains general information about the term "Green Logistics". The second part, "Green Logistics Tools", mentions two different tools; the first one is "Railway Energy" which is a project done by the Europe Union. Its goal was to reduce the amount of CO2 emission by focusing on electricity as the main power supply for railway transportation modes instead of diesel. The second tool is "myWMSLos" which is an open source warehouse management system that automates all the basic processes of managing a warehouse, by providing a barcode and radio frequency identification (RFID) to allow companies reduce or even stop using paper in their business. myWMS LOS is supported by many technologies such as (JEE5, JBoss, Netbeans RCP, iReport, SOAP, XML). Hence, it is very powerful and scalable software. The last part was about "Green Logistics as CEMIS" containing information about the definition of CEMIS and what kind of challenges a company will face ensuring to have green logistics. After all the placement of the previous tools according to CEMIS classification was explained by taking in consideration "the environment & organization" part of the table and its basic five dimensions beside the missing feature in both tools.

Finally, Railenergy project has made a great effort to make railways' transportation modes more environmentally friendly. However, depending more on electricity faces another dangerous problem which is the electromagnetic pollution which has harmful effects on humans such cancer. Therefore, more variant resources that have less impact on human kind are needed to be discovered e.g. using hydrogen gas to power the engine instead of diesel engine resulting in CO2. However, the production of hydrogen today is expensive. Hence, it hinders the fact of the sustainability logistics of Figure 1 Contact points of sustainable logistics. myWMS LOS provides a powerful tool for green logistics by reducing cost, time using automation and the ordered distributed sorting of the store location that makes it more reliable and scalable for packing and shipping the goods.

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