Introducing energetic and capacitive energy efficiency measures in the sector of chilled and frozen food storage via an electronic platform

Raphael M. Heereman von Zuydtwyck
Institute GEMIT of University of Applied Sciences Niederrhein, Moenchengladbach, Germany,
Raphael.Heereman@hs-niederrhein.de

Holger Beckmann,
Founder and head of Institute GEMIT of University of Applied Sciences Niederrhein, Moenchengladbach, Germany, Holger.Beckmann@hs-niederrhein.de

Judith Evans,
London South Bank University, Churchill Building, Langford, N. Somerset, England,
j.a.evans@lsbu.ac.uk

Abstract

The freshness of agricultural products is kept well when chilled or frozen. Additionally, chilled and frozen food is en vogue due to convenience reasons. The growing demand for chilled and frozen food on a global scale has some negative ecological side effects, though. The GEMIT Institute for Business process Management and IT developed the idea to combine an electronic market place for idle cold storage capacities with a tool that helps coldstores increase their energy efficiency. It is ecologically worthwhile in a branch characterized by high CO2-emissions and energy consumption. A future marketplace does not only serve as a spot market for short term demand in storage, where it guarantees cheaper storage space in proximity and higher independency from common cold storage services. Additionally, the supplier of empty cold storage space generates new revenues and at the same time spends the maintenance energy more efficiently. Finally, the participating suppliers can benefit from a benchmarking tool and information about their own energy savings potentials. The current market situation is especially advantageous for an introduction of ECO-Store, with growing cold storage spaces in Germany and an increasing consumption of chilled food worldwide. Aspects that can impose a barrier to the project are considered as well. It was found out that companies might not want to disclose data or cooperate with possible competitors and operating providers of cold storage space fear a decline in prices. Reaching a critical mass of participants in order to assure the cost effectiveness of the investment and to increase the attractiveness itself is a crucial issue. Finally, resembling concepts already exist on the market. Yet, what it makes unique is the combination of the electronic market place and a tool aiming at reducing individual energy consumption.

Keywords: ***Cold Chain Management, electronic marketplaces, Green logistics, energy efficiency measures***

1 Introduction

1.1 The project Green² - Green logistics in Agrobusiness

Within the European-funded project *Green² - green logistics in agrobusiness*[1], led by the research institute GEMIT of the University of Applied Sciences Niederrhein (Germany), 21 partners from the German-Dutch cross-border region rhine-maas-north were greening the supply chain of agri-logistics and improving the environmental performance of companies from the food and food logistics sector between summer 2013 and spring 2015. In four different work packages the project dealt with issues such as modal shift actions (Beckmann, et al., 2014), warehouse optimization (Gruner, et al., 2015), energy efficiency (Alsmeyer, et al., 2015) and electronic marketplaces (Krehl & Heereman von Zuydtwyck, 2015).

In the work package IV *electronic marketplaces* scientists and practitioners to focus on the utilization rates of cold store warehouses and tries to validate the thesis of improving the former by allocating demand and supply for cold store capacity in a more efficient way. The realization of new cold store

[1] www.green2logistics.eu/mediathek/downloads

capacity consumes high amounts of financial and ecological resources. Identifying idle capacity and prioritizing its usage through a future electronic marketplace before building new warehouses could lead to higher efficiency and therefore to an improved cost performance. Whereas electronic logistics marketplaces (ELMs) are increasingly implemented since the 1990's (Wang, et al., 2007) (Zellerhoff, 2008), allocation of idle CSC is still not addressed to a satisfying degree.

The exact constraints among warehouse operators that impede the realization of an ELM for CSC shall be identified. The overall objective is to reduce energy consumption per pallet in the cold store warehouses in Germany and the Netherlands. As it is a project that bridges theory and practice, the goal was to identify what an ELM for CSC is able to offer in real life and what participants could expect. Finally the project participators tried to define a sound business case for an ELM for CSC in Germany and the Netherlands.

The basic idea of this project is that existing cold storage capacities on the market could be used more efficiently if there was an electronic market place for it. The research team at the GEMIT Institute of Business Process Management and IT is working on the development of such market place while cooperating with the London South Bank University which is providing a benchmarking tool for participating companies that was developed during the European funded project ICE-E. Thus, participants can benefit from getting information about their individual energy savings potential while improving their capacitive utilization rate.

1.2 Current effect of the global cold chain and cold store sector

About 77% of cold store space is effectively used in Germany, leaving more than 20% unused (VDKL, 2013). But instead of using the existing storage space more intensely, new cold storage capacities are being created every year. In addition to that, the food cold chain causes about 2.5% of the CO_2 –emissions through direct and indirect energy consumption effects and consumes 15% of the generated electric energy worldwide (James & James, 2010, pp. 1946). Therefore, companies cannot only save costs by increasing their utilization rate. By allocating demand for and supply of cold store capacity market participants can reduce their energy consumption and cause less CO_2 e-emissions per stored pallet.
In addition, the market conditions are highly advantageous for an electronic platform. The market for chilled and frozen food is growing steadily with rates of over 100% per year in China in 2008 and 2009 (Salin, 2010). However, not only in emerging markets but also in European economies as Germany, cold storage capacity is growing at rates of 7% and 8% in the same time frame (Salin, 2010). As consumption of chilled and frozen food is augmenting worldwide, this evolution is expected to continue in the following years.

1.3 Current characteristics of the cold storage sector

Work package four in Green² aimed at identifying market behaviour and attitude towards an electronic marketplace for cold store capacity in the Dutch-German cross-border region. Such marketplaces already exist in the field of logistics. However, they rather are applied to cover short term differences in demand and supply of transportation capacities since the transport sector shows many characteristics of a spot market (Heereman von Zuydtwyck & Beckmann, 2015).
Storage capacity does not underlie such strong oscillations as they are shown in the transport business but flexible capacity is more often needed due to changing business habits.
Firstly, global supply chains and retailers urge wholesalers to react without delay to changing routes and supply amounts. Therefore, a clean cross-docking process without storing the goods cannot be assured all the time. Not depending on particular cold stores but being able to access cold store capacity wherever and whenever needed leads to higher flexibility for wholesalers. In the market of chilled and frozen produce, this can be very attractive to a lot of companies.

Secondly, binding capital through the construction of cold store warehouses leads to excessive financial cost for food-producing and –processing companies. Service providers, however, cannot always provide the needed flexibility.
Thirdly, the fruits and vegetable business is characterized by peak season in harvesting different types of products. Participants along the supply chain have to handle huge amounts of the same goods in short time. This has severe effects on the storage capacities. Since natural products are concern, forecasting is only possible to a limited extent and the utilization rates are not firmly set.
Fourthly, the so-called bull-whip effect is a phenomenon that occurs along several supply chains of different services and goods and is especially strong in case of produce. This leads to extreme peaks in storage.

1.4 Initiative to reduce energy use in cold stores: project ICE-E

The ICE-E project was carried out between May 2010 and April 2012 by nine partners from seven different European countries with the aim to foster the uptake of new efficient technologies within the cold storage sector, through a combination of knowledge-based information packages, mathematical models and education programmes (Evans, 2012).
Previous surveys showed that cold stores' energy consumption can dramatically exceed the average energy consumption of 60-70% of the total employed energy by at least double (Evans, 2012). These surveys also demonstrated that energy savings of 30-40% were achievable by optimising usage of the stores, repairing current equipment and by retrofitting of energy efficient equipment. However, cold store operators are often unwilling to install new equipment without sufficient information on savings that could be achieved. Via a benchmarking survey, cold stores were offered in a first step the possibility to receive a detailed energy audit. Based on these audited the project team could areas where the most energy could be saved and areas of common problems. Audited cold stores were encouraged to take up new technologies and equipment and were re-audited at the end of the project to determine take up and energy savings. Based on the audits a web application was developed in form of a survey that allowed participants to initially register their details and then to enter data on as many refrigeration systems as they wished. Data from 329 cold stores was collected during the project duration thanks to the possibility of realizing a web-based pre-audit (Evans, 2012).

1.5 Current process of allocating demand and supply in cold store space

Research among 65 German and Dutch cold stores during the Green² project has shown that in case of excessive demand for cold store capacity public and private cold stores[2] mainly refer to their net of cooperative partners. It is also very common to store goods for a short period of time in buffer zones. This could cause a downturn in performance since detours or even new process planning within the cold store might be necessary. Is was also discovered that one in five survey participants would not accept further inquiries in times of peak utilization (Heereman von Zuydtwyck & Beckmann, 2015). Leaving clients unattended is a highly risky behaviour in such a competitive market. Figure 1 shows the further reactions in case of peak utilization:

[2] *Public cold stores* are cold stores that realise the storage of chilled and frozen food as their core business whereas *private cold stores* are companies that operate cold store warehouses in order to fulfil their core business.

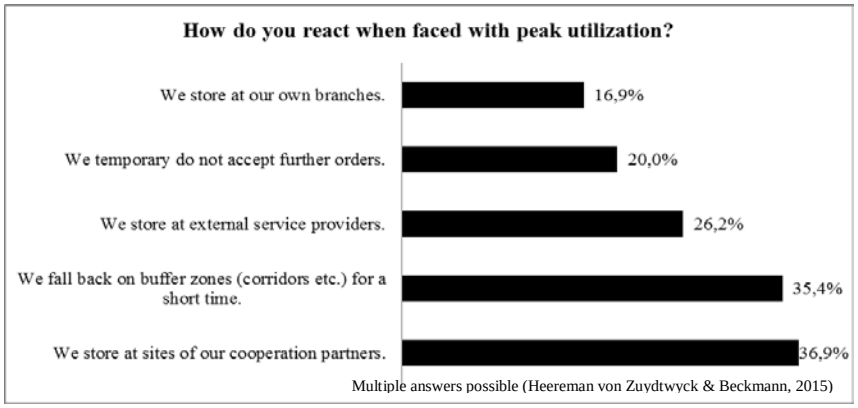

Figure 1: Behaviour at peak utilization

Asked for their behaviour in times of low utilization, survey participants were strongly engaging in acquiring new customers. However, 'not reacting at all' was the second best answer and revealed further lack in customer care (see Figure 2).

Figure 2: Behaviour at low utilization

In case cold store operators attend a client in times of peak utilization, they will check for their own availability (see Figure 3). If own cold store capacity (CSC) is available, the client can be served immediately. Satisfying clients' needs, however, becomes more difficult if they cannot be served on the first level. Identifying adequate partners (in terms of available storage space and period) can be very time consuming. Moreover, the smaller the cooperation network is, the less matches are detected.

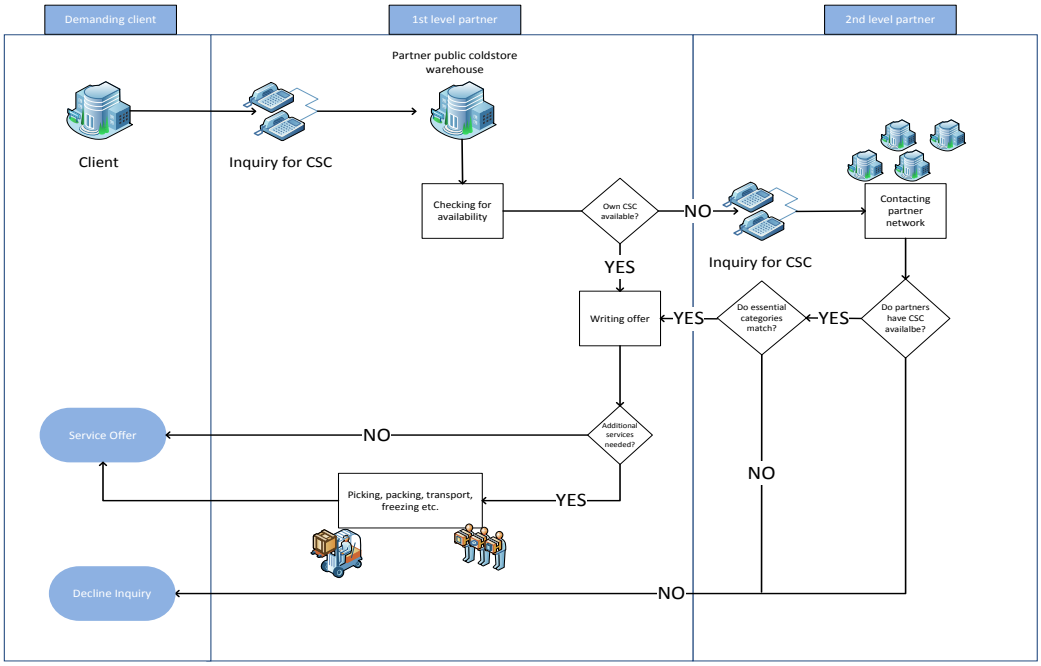

Figure 3: Conventional process of acquiring CSC

2 Improving individual and capacitive energy efficiency performance simultaneously

Depicting the projects Green[2] and ICE-E showed that there is a market demand for improving cold store energy efficiency in both dimensions: individual energy consumption and overall use of capacity. The web tool developed in ICE-E has proven that companies accept an online assessing tool. Combining this approach could generate previously unknown synergies for public and private cold stores and foster sustainability in the sector.

2.1 Conceptualizing the marketplace

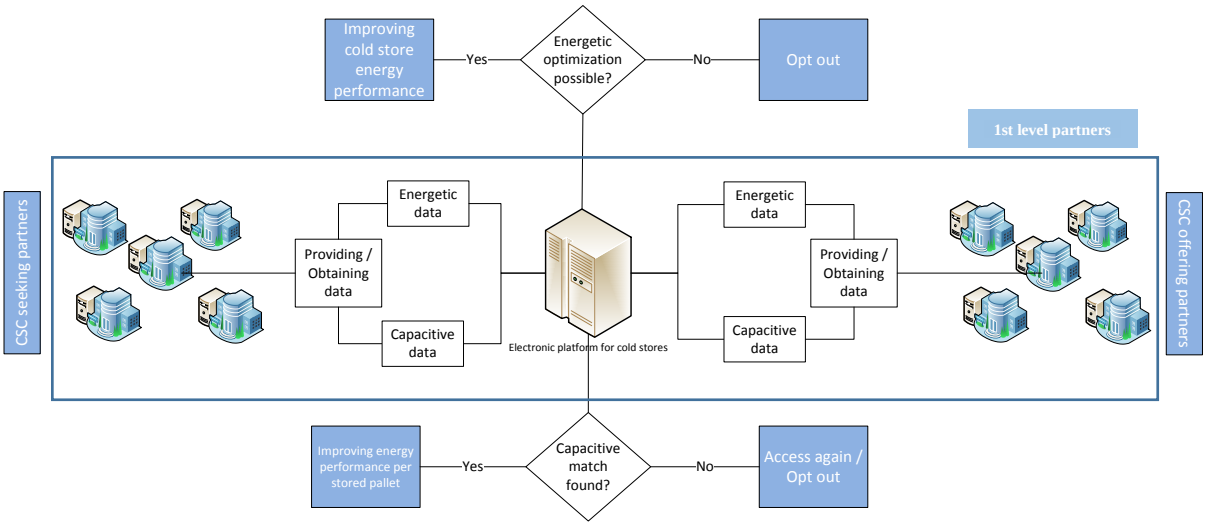

Figure 4: Process diagram of the future electronic platform for cold stores

The joint platform for energetic and capacitive energy performance of cold stores will be able to encounter the up-to-date changes in the supply chain of chilled and frozen goods by bringing supply and demand closer together. Figure 4 shows that only first-level partnerships are maintained thanks to the fact that the platform is the only intermediary in the matching and assessing process. Companies

have the possibility to directly access data via the platform and select relevant partners when looking for capacitive improvement. In case a cold store aims only to improve its individual energetic performance the integrated modules developed within ICE-E will be accessed.

2.2 Possible stakeholders of a joint electronic platform

A future electronic platform for cold stores will deal with a varied number of stakeholders. These are:

- First-level clients:
  Suppliers and buyers of cold store space belong to the direct clients of the platform as well as non-audited cold stores with the will to improve their energetic performance. These will be both private and public cold stores.
- Second-level clients:
  Associations and research institutes belonging to the cold chain will have an interest in the data provided and acquired through the platform. This brings up questions in terms of data security that have to be taken into account.

2.3 SWOT Analysis

In theory, a future electronic platform as described shows different strengths, weaknesses, opportunities and risks:

2.3.1 Strengths

The platform can satisfy spontaneous demand of cold store space for certain areas, given a critical mass of participants. It can also serve as an alternative for the existing practice of using mobile cold trucks as temporary storage space. Moreover, the platform offers a unique combination of information for cold store operators both on their energy performance and new possibilities of maximizing capacity usage.

2.3.2 Weaknesses

The success of the platform depends on the willingness to offer and introduce data. Suppliers and buyers of capacity differ in some way in what they regard as being sensitive data. This could lead to less openness among platform participants.

2.3.3 Opportunities

Since cold store numbers are still growing, it is highly likely that the prospective customer base is also increasing. Additionally, global market trends (global supply chains, green logistics, energy optimization) oblige cold stores to keep on improving. The future platform would offer the possibility to keep up with the market developments.

2.3.4 Threats

The European landscape of chilled and frozen stores is very heterogeneous. Matching is rather depended not on a critical mass but on the right offer at the right time. If the group of participants / subscribers shows high heterogeneity in storage occupation and products stored, allocating idle cold store will get challenging.

Acknowledgments

The project consortium is looking for cold stores willing to participate in the development and testing of the platform. We also welcome prospective European project partners from the fields of electronic information management (e-logistics), cold chain management, refrigeration processes and partners with expertise in electronic B2B marketplaces.

References

Alsmeyer, F., Newiadomsky, C., Bruchmann, J. & Schäfer, C., 2015. *ARBEITSPAKET III - Energieeffiziente Lager- und Kühltechnik.* [Online] Available at: http://www.green2logistics.eu/fileadmin/userfolders/downloads/pdf/News_Dokumente/Abschlussbericht_Green__AP3_Druck.pdf [Accessed 14 March 2015].

Beckmann, H., Waaden, T. & Wagner, H., 2014. Grüne Logistik - von der strategischen zur operativen Verkehrsverlagerung. In: *Jahrbuch Logistik 2014.* Korschenbroich: free beratung GmbH, pp. 101-105.

Evans, J., 2012. *Improving Cold Storage Equipment in Europe - ICE-E.* [Online] Available at: http://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/ice-e_ice_e_publishable_report_en.pdf [Accessed 10 April 2015].

Gruner, S., Köppen-Spielmann, N., Kreetz, J. & Tißen, K., 2015. *ARBEITSPAKET II - Lageroptimierung.* [Online] Available at: http://www.green2logistics.eu/fileadmin/userfolders/downloads/pdf/News_Dokumente/Abschlussbericht_Green__AP2_Druck.pdf [Accessed 15 March 2015].

Heereman von Zuydtwyck, R. M. & Beckmann, H., 2015. Optimal allocation of idle coldstore warehouse capacities through an e-spotmarketplace – A German-Dutch market research analysis. In: H. Zijm, M. Klumpp, U. Clausen & M. ten Hompel, eds. *Bridging the Gap – Logistics Theory and Practice.* Wiesbaden: Springer.

James, S. & James, C., 2010. The food cold-chain and climate change. *Food Research International,* 43(7), pp. 1944-1956.

Krehl, F. & Heereman von Zuydtwyck, R., 2015. *ARBEITSPAKET IV - Elektronischer Marktplatz für Kühlkapazitäten.* [Online] Available at: http://www.green2logistics.eu/fileadmin/userfolders/downloads/pdf/News_Dokumente/Abschlussbericht_Green__AP4_Druck_v02.pdf [Accessed 14 03 2015].

Salin, V., 2010. *Global Cold Storage Capacity Report,* Alexandria, Virginia: International Association for Refrigerated Warehouses.

VDKL, 2013. *Jahresbericht.* Bergisch Gladbach: Heider Druck GmbH.

Wang, Y., Potter, A. & Naim, M., 2007. *An exploratory study of electronic logistics marketplaces and its impact on customised logistics.* Dallas, Texas, USA: Cardiff University Innovative Manufacturing Research Centre.

Zellerhoff, J., 2008. *Modellierung eines Informationssystems für ein "Virtuelles Lager",* Dortmund: Universität Dortmund.

Author biographies

RAPHAEL M. HEEREMAN VON ZUYDTWYCK received a B.A. in International Business and Management at the University of Applied Sciences Bochum, Germany and holds a master's degree in Project Management with distinction from the Manchester Metropolitan University since 2011 as well as a Spanish master in Translation and Interpreting. After starting as a junior lecturer in linguistics he came to GEMIT as a research fellow in 2013. Since then he is a project member of Green² - Green logistics in Agribusiness and co-developed the ideas presented in this paper.

HOLGER BECKMANN received a diploma in engineering studies at the Ruhr University Bochum. He was employed as research fellow at the Fraunhofer Institute for material flow and logistics (IML) since 1987. With profound experience in the planning of logistic systems, strategy and structure he works for more than 25 years as a business consultant. In 1996 he received a doctorate degree with his dissertation "theory of an evolutionary logistic planning approach" and was awarded the Federal Science Award of Logistics in 1996. Since 1999 he holds a professorship for Procurement and Logistics at the University of Applied Sciences Niederrhein (HSNR), Germany and also for plant construction at the University of Dortmund, Germany. He runs the masters' program for business engineering and is head of the Institute GEMIT for business process management and IT at HSNR.

JUDITH EVANS works on food refrigeration operations throughout the food cold chain from harvest/slaughter to the consumer. She previously worked at FRPERC (Food Refrigeration and Process Engineering Research Centre) at the University of Bristol where she was a Senior Research Fellow. Before then Judith worked for the Meat Research Institute and AFRC Institute of Food Research. During her career Judith has worked on a number of topics including frozen storage of meat, consumer handling of food and studies to improve the performance of domestic and commercial refrigerators, energy labelling, instrumentation performance, decontamination of food, cook-chill systems, novel refrigeration systems, optimising refrigeration systems and improving performance and temperature control in chilled and frozen storage rooms. Judith's current work revolves around reducing energy use and emissions from the food cold chain, the use of novel refrigeration systems (in particular air cycle) and optimising food refrigeration processes.