

# **Improving Cold Chain Energy Efficiency: EU H2020 project for facilitating energy efficiency improvements in SMEs of the food and beverage cold chains**

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## **ABSTRACT**

Industry has a substantial potential to improve its energy efficiency. The food and beverage sector and its cold supply chain are responsible for more than 10% of the total final energy consumption of the EU-28. Accurate refrigeration is required for optimal preservation of perishable goods and can be up to 85% of the food and beverage sector's total final energy consumption. High demand for refrigeration has adverse environmental effects such as direct emissions from refrigerant leakage and indirect emissions related to electricity or fossil fuels consumption. The Horizon 2020 project ICCEE (Improving Cold Chain Energy Efficiency) aims to support and advice small and medium enterprises (SME) from the food and beverage sector's cold chains to implement energy efficiency measures (EEMs) by an energy mapping of the cold supply chain including its transport and storage activities. Shifting from the myopic single company perspective to the chain assessment leads to increased energy savings potentials and reduced implementation gaps of EEMs.

Keywords: Energy Efficiency, Cold Chains, Food and Beverage Industry, Life Cycle Analysis, Non-Energy Benefits.

## **1. INTRODUCTION**

Many large companies have undergone energy audits in recent years because of the mandatory requirements (Art. 8) of the EU Energy Efficiency Directive (2012). Depending on how the system boundaries are defined, energy audits provide essential information about the status of energy consumption of a company. The audit may focus on the entire production processes of a company with emphasis on single equipment employed in a specific production process. Results from audits have highlighted that considerable opportunities exist to improve energy efficiency in companies. In the EU food and beverage sector, there is a potential to save 26% primary energy by 2030 when sector's all technically feasible energy saving opportunities are implemented regardless of economic

viability (ICF Consulting Ltd, 2015). Despite the large potential of improving energy efficiency in companies attested by energy audits, the actual implementation rate of such measures is often no higher than 50% (Deloitte, 2016). Main barriers to unleash the potential for energy efficiency include insufficient financing, lack of information, lack of awareness and knowledge, and inappropriate indicators and tools that hinder efforts to select the most cost-effective measures. Small and medium-sized companies (SMEs) of the manufacturing industry suffer in particular from limited awareness of these opportunities and they often lack applicable methods and tools to quantify and address energy efficiency in their companies (Cagno and Trianni, 2014; Thollander and Palm, 2013).

The food and beverage sector holds around 12.8% of the added value in manufacturing (FoodDrinkEurope, 2018) and has over 280,000 companies with more than 4.3 million employees. In 2012, the sector had a turnover of over 1,000 billion Euro (equivalent to 14.6% of the total EU manufacturing sector). The embedded energy in all food consumed accounts for more than 25% of the EU-27 total final energy consumption (European Commission - Joint Research Centre, 2015). SMEs accounted for 51.6% and 64.3% of the sector's total turnover and employment, respectively (ICF Consulting Ltd, 2015). The share of energy costs in the total production costs is also relatively high. For instance, in the manufacture of dairy products, energy costs are about 11% of the production added value and in the manufacture of prepared animal feeds, it represents about 16% of the production added value (ICF Consulting Ltd, 2015).

There are number of reasons why improving energy efficiency in the food and beverage sector's cold supply chain remains key:

- **Energy:** Supply chains in the food and beverage sector rely on multiple inputs of raw materials that are processed in several steps. The processes are characterized by a considerable complexity due to strict hygiene and refrigeration requirements that highly affect their energy consumption. Addressing energy savings means benefits across a whole range of economic sectors. Worldwide, approximately 15% of the total energy is associated with cold chains and cooling systems (Coulomb, 2008) and 40% of all food deliveries require refrigeration (James et al., 2006). Hence the growth of global food demand and the subsequent demand for cold chains will put more pressure on energy resources (Vanek and Sun, 2008).
- **Economic:** Supply chains in the food and beverage sector involve many companies belonging to different industries and sectors of EU's economy. These usually face high production costs and low profit margins, and many are SMEs that have particular economic conditions and usually a lower flexibility due to their specialization.
- **Social and environmental:** The food and beverage sector is also unique since it relies on intensive land usage and other resource intensive raw materials. With about 70% of the EU's land area covered by forests or in agricultural use, production activities of the food and beverage sector have a huge impact on the integrity of rural areas in terms of preserving the natural capital, quality of life, and job creation. Thus, more efficient production processes will offer improvements in the environmental and social dimensions.

In addition, the impact on the total energy consumption of the different stages of the production process depends strictly on the considered food products. Hence, a tailored approach is required.

Energy costs in the food and beverage sector are higher than 10% and could cover up to 20% of the total production costs (ICF Consulting Ltd, 2015), and therefore they are equally important. The savings in the energy bill from investing in new and better performing equipment can typically compensate the additional investment needs. In addition to energy cost savings, individual companies that implement measures improving energy efficiency might also create savings in other supply chain stages. Energy efficiency measures also yield socio-economic and environmental non-energy benefits (Worrell et al, 2003). These include enhanced productivity and competitiveness, reduced costs for environmental compliance, operation and maintenance and waste disposal, extended equipment lifetime. For those reasons, ICCEE will include a multi-criteria life-cycle

evaluation of the energy efficiency solutions with a focus on economic and environmental impacts.

Currently, energy demand of the food and beverage sector supply chain is typically supplied largely by multiutilities which provide the energy vectors to the companies. To reduce the reliance on these external actors and/or to additionally improve the energy efficiency, it is required to consider opportunities to recover by-product wastes to generate energy and the endorsement of synergies among different companies and/or public facilities as defined in the industrial symbiosis concept (Marchi et al., 2017).

This paper deals with the Horizon 2020-funded “Improving Cold Chain Energy Efficiency” (ICCEE) project. Its aim is to help SMEs belonging to cold supply chains in the food and beverage sector for undertaking energy efficiency measures after carrying out overall supply chain energy audits. Specifically, these companies belong to different sectors and stages of the cold supply chain (from agriculture, livestock and aquaculture, food processing, packaging, logistic, waste treatment and disposal sectors). To that end, ICCEE will implement capacity building programs and support investment decisions of SMEs on energy savings by means of specific tools. ICCEE will be based on a supply chain management approach for energy efficiency improvement since it represents the major opportunity in overcoming the barriers to energy efficiency measures (Marchi and Zanoni, 2017). The focus will be on cold supply chains which consider cooled or frozen products from the initial processing of raw materials to their delivery to the final customer. The cold supply chain includes all stages that a chilled food product passes through from the farm to the final consumer: From harvesting, transport of the raw material, through the processing stage, to further warehousing of the end product and subsequent transport to the food retail. Such perishable goods need to be preserved by keeping them in a cold state along the supply chain to slow down their deterioration and to thus deliver safe and high-quality products to consumers. The understanding of the cold supply chain is limited yet there seem to be substantial energy efficiency potentials and economic advantages that can be obtained from going beyond the individual company perspective.

The remainder of this paper is organized as follows. Section 2 provides insights on the resources, supporting tools and capacity building programme to be developed in the ICCEE project. They will represent the two main pillars of the project. Section 3 gives an overview on the communication and dissemination activities. Section 4 defines the expected impacts of the project. Finally, Section 5 outlines the concluding remarks and future developments of this work.

## **2. METHODOLOGY: ICCEE RESOURCES, TOOLS AND CAPACITY BUILDING PROGRAMME**

While energy audits provide a snapshot of the current situation of energy use in a specific company, they do not necessarily involve a dimension about the magnitude of the investments needed or the benefits that may be generated from improving energy efficiency. Such a cost-benefit assessment is essential for the profitability of companies as energy costs represent a significant share of a sector’s total production costs. It is necessary to combine this techno-economic information about improving energy efficiency in a company as well as across its supply chain. This will also be essential to provide a full picture to the company decision-makers and project financiers.

ICCEE will also address behavioural aspects (such as perceived risks, barriers and drivers), since the energy culture differs across companies, but is a relevant driver for creating awareness on energy efficiency measures. In companies where energy consumption has a large share in the production costs, there are typically dedicated energy units. In others, energy is covered as a subtopic under production units and its importance is shared with other company priorities. Some companies have limited information about the role energy plays in their entire production system. Regardless of the level of importance energy receives in different companies, creating awareness about its efficient use and what this could mean in terms of cost and benefits requires more attention.

The ICCEE methodology will put this approach into practice. Firstly, it starts with the definition of the standardized best available technologies (BAT) and best practices tailored for each specific stage cooperating in the cold chains of the food and beverage sector (European Commission - Joint

Research Centre, 2017). The prioritization of the energy efficiency measures (e.g. organizational measures, investments in new technologies, maintenance, behavioural change) is defined through the outcomes of company level information collected from energy audits. When aggregated, they show the energy use across an entire supply chain, and they also provide valuable insights about the potential for energy savings compared to a sectoral benchmark, for instance a best practice plant or the efficiency of the plant next door (Saygin et al., 2011). The approach will focus on an integrated and holistic perspective of supply chain management since decisions of each company within the supply chain reciprocally influence their partners in defining their energy efficiency improvement alternatives. Decisions on best efficiency measures should thus be made at cold supply chain level considering technological, economic, environmental and organizational aspects in the entire chain.

Manufacturing systems and processes are usually seen as isolated entities where energy efficiency is targeted at the level of single companies and most companies pay relatively minor attention. With an individual perspective in which each company aims to optimize its own performance, it occurs that energy, economic and environmental issues are shifted from one production stage to another, from one geographic area to another and from one period to the following ones. In cold supply chains, companies also pay minor attention to whether their partners apply energy management systems in their business activities. However, the often small and medium scale opportunities addressed in this way (i.e. focused on the individual company or their processes) do not allow to fully understand all the consequences and benefits from the energy efficiency measures. Thus, it is important to acknowledge the potential influence that supply chain interactions may have on improving energy efficiency as well as the environmental impacts and costs of the final products identifying opportunities that are hidden in a single company perspective.

Transportation between subsequent production processes, logistic activities and disposal phases (in particular of end-of-life technologies and/or waste after specific treatment) also provide opportunities to better understand the importance of life cycle energy impacts and thus they should be integrated in the analyses for the improvement of energy efficiency. In fact, loading vehicles can be negatively affected by a poor coordination among the supply chain actors (International Energy Agency (IEA), 2017). Low payload of transport vehicles affects the refrigerated goods transport. For instance, Defra (2008) points out average payloads for refrigerated goods for the UK (2007 and 2008 data) which varies between 16% of medium rigid vehicles, to about 30% of articulated vehicles (32 and 38 tonnes). Moreover, logistics in the cold supply chains of the food and beverage sector, among which the main activities are transport and storage, is one of the most energy-requiring phase, since temperature and relative humidity for maintaining the product quality subject to restrictions determining the final product quality. Especially in the transport sector, a wide operating range, which the refrigeration systems must maintain and the external weather conditions, which the transport is exposed to, influence the performance of the cooling system, leading to a higher use of energy. Considering cold supply chains, one important aspect is the concept of temperature-dependent perishability of products. Even if the optimal temperature of products is kept along the whole cold chain, the quality of products decreases over time.

The methodology of ICCEE addresses these issues and consists of two pillars: i.e., a decision support tool and a capacity building programme.

## **2.1. Pillar 1: Analytical decision support tool customized for SMEs in the food and beverage sector.**

ICCEE will integrate the characteristics of cold chains of the food and beverage sector in an analytical decision support tool with tailor-made analyses related to the energy performance for the different process stages (e.g., logistic and warehousing operations). Cold chains of the food and beverage sector include several products which production processes present many differences in terms of required operation and of energy consumptions. For this reason, the analytical tool will be tailored to address these differences and to detect the different impact that different stages have in different sub-sectors. The essence of the tool is to remain simple and pragmatic whilst responding to the needs of the various companies and ensuring usability and accessibility to a broad range of energy experts, non-expert decision makers in a company and financing bodies.

The tool will increase awareness of managers and operational staff on cold supply chain energy efficiency measures detected through a holistic perspective instead of the classical individual single firm perspective. The tool will use the concept of life cycle assessment for an overall evaluation of the sustainability of the different steps within the cold supply chain. To this end, it will assist companies in cost-benefit assessments and also enable them to map the energy consumption of each company in the supply chain with aggregated and in-depth levels to perform an energy impact analysis. This will facilitate identifying the key processes and/or auxiliary services that account for the highest share of total energy use and total energy costs along the cold supply chain. Subsequently, the tool will prioritise the assessment of energy savings and their benefits. It will be implemented as a stand-alone downloadable version to avoid issues of data safety and incompatible software that tends to stop users from applying tools.

The first contacts established by ICCEE partners in EU countries underline the considerable interest of supply chain members in gaining knowledge on their own and other organization's relevance and potential for energy efficiency along the cold supply chain. Individual companies particularly underline that they lack information on how the others manage their refrigeration and that they are not sure which organization has the largest potential for energy efficiency.

## **2.2. Pillar 2: Capacity building program for enabling the uptake of energy efficiency measures**

ICCEE will also create a capacity building program and a community to improve the energy culture of companies and their supply chain at every organizational level (in terms of knowledge, motivations, behaviour change, mitigation of perceived risks and barriers). The capacity building program consists of direct training, gamification, workshops and seminars with external experts, the development of an e-learning concept, and of an industry informative network (IIN) which will enable learning across all EU member states. The training material will consist of a) general sections valid for each selected sub-sector on topics related to the supply chain energy efficiency, and b) specific sections tailored to the sub-sectors to facilitate sector specific learnings, providing ways to overcome the main barriers, identifying existing funding opportunities, and addressing other peculiarities to support the implementation of energy efficiency measures. Moreover, the IIN, representing a platform for discussion among stakeholders and with other experts, will foster the relationship between the various market stakeholders bridging the gap between demand and supply sides.

In particular, energy and non-energy experts in the companies will be engaged and informed about the potential of energy savings and what this would imply in terms of cost and benefits in their entire supply chain in three different steps:

- i. national, and regional workshops based on direct trainings of topics identified as most relevant (for instance supply chain management, life cycle assessment, life cycle cost, non-energy benefits, behavioural aspects);
- ii. EU-level workshops and seminars with external experts based on the training of the tailored-made tool functioning, and
- iii. training through the e-learning platform. The e-learning is aimed at attracting a number of training through the e-learning platform. In this way, it will be possible to increase the awareness about energy efficiency whilst developing an energy culture in companies and accelerating/enabling the implementation of energy efficiency measures (which may be related to supply chain management, new energy efficiency technologies and innovative operations management).

E-learning is aimed at attracting a number of professionals all around Europe, which might not be citizens of the partner countries, thus increasing the impact of the ICCEE knowledge to many other organizations. By means of a professional platform largely used by educational institutions, which at the same time is easy to handle by any Internet user, anyone interested will be able to access and increase their capacities regarding cold supply chains in the food and beverage sector.

- iv. All the defined aspects addressed in the tool and in the capacity building program allow

every company:

- to enter their own data and sector characteristics into the tool to carry out benchmarking analyses for assessing energy performance,
- to evaluate the cost-benefit of the energy efficiency measures across the supply chain through the holistic approach,
- to better evaluate the feasibility of those identified measures highlighting the existing financial schemes,
- to prioritize the same measures with the aim to improve the economic and energy performance of the whole supply chain and not of the single company that will implement the measure,
- to assess non-energy benefits,
- to perform what-if analyses to reduce the uncertainties and risks related to the decisions,
- to be informed about existing funding opportunities to improve the feasibility of implementing energy efficiency measures, and
- to raise the awareness of actors' leading to a more energy efficient world.

### **3. COMMUNICATION AND DISSEMINATION ACTIVITIES**

The target audience of ICCEE consists of the following groups: companies, their supply chains and the industrial sector associations they belong to, other market actors showing interest in improving energy efficiency, as well as policy makers, investors, ESCOs and the scientific community.

Throughout the ICCEE project and beyond its end, the acquired knowledge is disseminated to the target groups through a web platform including newsletters, social media, workshops and other types of consultations, as well as 'feedback loops'. This refers to bilateral contacts between the project partners and their national audiences that will also serve to brief them about the most relevant outcomes. Specifically, evaluation forms will be filled up by stakeholders obtaining relevant feedbacks on the training activities and on the workshops for maximizing the dissemination impacts.

Companies will also be involved in the collection of data for the development of the benchmarking datasets and the validation of the tool and in the capacity building activities to engage staff in the trainings and workshops. For the above envisaged dissemination plan, it is crucial to organise the engagement of private sector stakeholders (incl. service providers, companies) in the project well. This organisation spans the following steps:

- A categorization of stakeholders based on their needs and experiences. A good balance of stakeholders across the stakeholder groups will be ensured.
- The organisation of consultation workshops and other meetings. These events are of key importance to solicit comments from stakeholders on the project findings. A possible option for organising an event is to present project findings and invite target audience practitioners to comment on the finding as discussants, followed by wider discussions with workshop participants. This both enables active dissemination to target audiences and helps to obtain their feedback for further improvement.
- And the organisation of national and EU events, which enable partners to enter in the feedback loop, as explained above, and brief their stakeholder contacts on (intermediate) project outcomes.

Each audience group may request different levels of output details (e.g. policy makers requesting

short and concise messages and researchers interested mainly in the detailed analyses conducted). Possible products target at each group's demand are:

- briefs on highly SME relevant topics and derived from detailed analysis,
- articles for publication in open source journals (based on H2020 request),
- papers or articles for online publication in, e.g., newsletters and magazines on the food and beverage sector, and
- a project website, which will serve as an online database or repository for the deliverables and other project outputs and the e-learning platform.

#### **4. EXPECTED IMPACTS**

The EU food and beverage sector has over 280,000 companies and employs over 4.3 million persons (European Commission - Joint Research Centre, 2015). ICCEE will reach companies belonging not only to eight European partner countries but also to other EU member states thanks to the support of international/EU associations and institutes. The expected outcomes are reflected in the objectives pursued and refer to energy savings from companies and awareness raising and behavioural change. More specifically, the project is expected to achieve the following:

- In Step 1, a total of 400 companies shall be reached from all subsectors of the food and beverage sector and catering industry through 20 national workshops.
- In Step 2, four EU workshops with a total of 8 supply chains will be implemented. Each supply chain will be trained for the use of the tool.
- Step 3 proposes the same activities as in Steps 1 and 2, but this time through e-learning courses instead of direct training which will be available also beyond the project's lifetime. In this way, it is possible to reach additional 16 supply chains thanks to the communication, dissemination and exploitation plan developed.

To provide bottom-up insights on the potential impacts of ICCEE and to assess the actual needs of the various companies at different stages of supply chains in the food and beverage sector, we developed a questionnaire aiming at defining their energy consumption and the familiarity with energy management systems, energy audits, and energy saving opportunities. The main findings from the results are:

- Companies are characterized by high energy consumption and the energy mix is strictly dependent on the production process and the technologies installed. Hence, a tailored-made approach is required.
- Each company is experiencing an increasing production capacity which demonstrates an increasing demand for food and beverage products and thus an exponential increase of energy consumption if no energy savings measures are implemented, which is also evident from the results since companies are facing increased specific energy consumption (i.e., kWh/kg). This increase of the specific energy consumption can be due to inefficiencies and/or new sub processes implementation.
- Energy management systems (i.e., ISO 50001) have been implemented only by companies with obligations and the levels of energy saving reached (in average 4%) are below the potential outlined in previous reports (ICF Consulting Ltd, 2015).
- Smaller companies characterized by lower energy consumptions are lacking information on energy audits and on energy efficiency measures and financial availability. Furthermore, they show a significant interest to know more about how to improve energy efficiency and how to obtain financial support for the implementation.

- Companies with higher energy consumptions are more familiar with energy management systems and have already performed an energy audit which provides them suggestions on some energy efficiency measures. However, the recommended energy saving opportunities are mainly related to the replacement of old equipment with new and more efficient technologies which also enables to reduce energy consumption. However, no focus has been posed on operation and on supply chain management; hence, there is still a huge potential to identify additional energy saving opportunities.
- There is a gap between the potential energy saving opportunities identified and the actual level of implementation. This insight shows that energy is still seen as an auxiliary service and not as a competitive advantage. Therefore, energy culture can be highly increased also for energy experts and companies which are already familiar with the energy issue.
- All the companies which are familiar with energy audits belong to the processing stage. Other stages of the supply chain are not aware of opportunities offered by energy efficiency measures. Hence, there is a huge potential for reducing energy consumptions and improving energy culture at these stages;
- Only one company was aware of NEBs which shows there is a huge gap that needs be addressed.
- All the companies have shown great interest in the ICCEE project.

## **5. CONCLUSIONS**

The ICCEE (Improving Cold Chain Energy Efficiency) project aims to support SMEs of cold supply chains in the food and beverage sector to undertake energy efficiency measures (EEMs) after carrying out supply chain energy audits. The focus on the cold chains of the sector is due to the significant energy requirements (refrigerated transport, processing and storage) with large potentials for savings. The implementation of the holistic approach, shifting from the single company perspective to the whole chain assessment, leads to increased opportunities for EEMs. To enable the update of EEMs, ICCEE will a) implement and apply an analytical energy efficiency tool to support and facilitate decision-making at different company organizational levels and b) launch a capacity building program towards staff and relevant stakeholders and a community dedicated to support a change in energy culture of the sector. The feasibility of EEMs will be evaluated by considering economic, environmental and social impacts encompassing their life cycle and the entire supply chain. Non-energy benefits and behavioural aspects will also be addressed and recommendations on financing schemes for SMEs will be assessed.

The first part of the trainings will reach 300 companies through 20 national workshops thanks to the collaboration of associations in the consortium. 32 companies will be trained for the use of the tool in 4 EU workshops. At a final step, ICCEE will launch e-learning courses, which will be available also beyond the project's lifetime reaching at least additional 64 companies. ICCEE will introduce primary energy savings (118 GWh/year), increase invested capital in sustainable energy (64 million €), and reduce GHG emissions (40,376 tonCO<sub>2</sub>/year). Capacity building activities allow increasing stakeholders' knowledge and enhance their energy culture (2000 people). Outcomes from ICCEE will also support policymakers in defining tailored policies for the sector.

## **ACKNOWLEDGEMENTS**

The contents of the paper are a part of the program of the project Improving Cold Chain Energy Efficiency (ICCEE). ICCEE has received founding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 847040.



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