Improving Cold Chain Energy Efficiency in food and beverage sector

Grant Agreement N° 847040



Deliverable 2.2

Report on an intervention strategy to non-energy related benefits and energy-related behavioural aspects in the cold chain and their implications for the ICCEE tool

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The ICCEE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 847040.

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Project information

Project Title	Improving Cold Chain Energy Efficiency
Project Acronym	ICCEE
Project Number	847040
Project dates	September 2019 – August 2022
Abstract	The ICCEE (Improving Cold Chain Energy Efficiency) project will facilitate Small and Medium Enterprises (SMEs) in the cold chains of 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 chain assessment, lead 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 organisational 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 entire 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 tonCO2/year). Capacity building activities allow to increase stakeholders' knowledge and enhance their energy culture (2000 people). Outcomes from ICCEE will also support policymakers in defining tailored policies for the sector.

Rev.	Written by	Date	Checked by	Date
01	Lisa Neusel, Simon Hirzel	13.07.2020	Francisco Puente	21.07.2020

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About the project

The project Improving Cold Chain Energy Efficiency (ICCEE) will accelerate turning energy efficiency opportunities in small and medium sized enterprises (SMEs) of the food and beverage sector into actual investments and create a clear understanding of the opportunities offered by improving energy efficiency for companies' staff.

The specific objectives of ICCEE are:

1) Implement and apply an analytical energy efficiency tool to support and facilitate the decision-making processes of the companies in the supply chains in assessing their current energy performance of the supply chain.

2) Identify the energy saving potential of companies and support investments in viable energy efficiency improvement measures.

3) Create a capacity building programme and a community dedicated to support the change in the energy culture of organizations improving their energy performance through direct training and the development of an e-learning module.

ICCEE will make it easier for SMEs in the cold chains of the food and beverage sector to undertake to understand the relevance of their supply chains for energy efficiency.

The focus on the cold chains was chosen because of the sector's substantial energy requirements (refrigerated transport, processing and storage) and considerable potential for energy savings. The cold supply chain is among the most energy-intensive systems within the food and beverage sector whilst there is limited understanding of its large energy efficiency potential and the economic advantages that can be obtained from energy saving measures.

The implementation of a holistic approach, shifting from the single company perspective to the chain assessment, leads to increased opportunities for EEMs.

ICCEE is coordinated by the University of Brescia with 12 partners: IEECP, FIRE (Federazione Italiana per l'uso razionale dell'energia), Adelphi Research, ATEE (Association Technique Energie Environnement), Fraunhofer ISI, Riga Technical University, ESCAN, SPES GEIE, ECSLA, Chamber of Korinthia, University of Stuttgart, and Romalimenta.

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Project partners

ECSLA
European Cold Storage and Logistics Association

SPES GEIE
Spread European Safety

RA
ROMALIMENTA

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the energy consulting

IEECP
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Legal Notice

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Executive Summary

While cooling is an ancient concept to preserve food, only modern artificial industrial cooling and freezing made it possible to offer high quality food worldwide and independently of the season. This makes cooling and freezing important energy end-uses in the food industry: they are responsible for about 30% of electricity consumption of the sector. Energy efficiency could thus be of remarkable importance for companies operating in this field.

In addition to evident energy savings, energy efficiency measures can also entail non-energy related benefits, e.g. enhanced competitiveness, emissions mitigation, reduced maintenance requirements or an improved working environment. Such factors have been identified as important for affecting the assessment of energy efficiency measures in other areas of activities and could also be relevant for cold supply chains. Since members of various organizations interact in these chains, behavioural and organizational aspects in the supply chain could also be an important factor affecting decisions on energy efficiency measures.

Existing analyses on both non-energy benefits and behavioural aspects related to energy efficiency mainly focus on individual companies and hardly touch cold supply chains from the food and beverage industry. To address this gap, this report investigates both aspects more closely along the whole cold supply chain of the food sector, thereby moving from the single company perspective to a full cold supply chain assessment, which constitutes an innovation compared to previous studies. For this purpose, 61 semi-structured interviews and a supplementary online-survey with 175 participants with companies active in cold supply chains were carried out across various member states of the European Union.

The report first introduces the relevance of thinking energy efficiency beyond individual company boundaries along entire cold supply chains and the underlying literature (section 1). It then presents the chosen methodology for the interviews and the survey (section 2) and describes the detailed results of the survey (section 3). Finally, it provides the key observations from the survey (section 4) and uses those to derive strategic conclusions for the remainder of the ICCEE project (section 5).

The findings suggest that energy efficiency is presently considered more strongly in individual companies than along entire cold supply chains. While non-energy benefits appear to be relevant for both individual companies and the cold supply chain as a whole, awareness along the chain seems to be lower in comparison. Further complexity along the cold supply chain seem added by the prevalence of behavioural aspects such as a different priorities of the various actors, a lack of know-how and skilled personnel or a lack of communication and a person coordinating exchanges along the chain which may impede an easy implementation of energy efficiency measures.

Conclusions from these findings concern three areas of an intervention strategy for the further course of the project. Firstly, these conclusions relate to the target group of the ICCEE project and the successful involvement of this group into the project and its trainings. Based on the findings, a country-based approach for capacity building involving companies from various stages of the supply chain seems adequate since many supply chains appear to be mainly active in countries/larger regions. Furthermore, the involvement of stakeholders from storage and logistics seems to be promising starting point for initiating an exchange on energy-related issues as they seem to be particularly active in this field. Secondly, follow conclusions concerning the ICCEE tools. The results show on the one hand that the ICCEE tools can only provide simplified and generalized models of cold supply chains due to their real-world complexity. On the other hand, the variety of chains calls for adaptable and scalable models which can be adjusted to user needs. Furthermore, with regard to non-energy benefits, companies seem to need assistance to discover such effects from the implementation of energy efficiency measures - especially when it comes to entire cold supply chains. Direct economic benefits of efficiency measures seem to be important and thus, an attempt in determining the monetary value of non-energy benefits should be made. In addition, the tools should cover funding opportunities and offer companies the opportunity to process their energy data as decision-making support in the implementation phase of efficiency measures. Thirdly, conclusions concern how ICCEE can help its participants to overcome behavioural barriers. Among others, establishing a communication channel on the ICCEE platform can help to strengthen the exchange along the chain and networks between the participants can be promoted. This should help to raise awareness of energy efficiency in addition to the planned training and workshops.

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1. Introduction

On their way from "farm-to-fork", food products pass through many hands under cooling. The activities of various organizations and actors that deal with transporting, processing and offering food under temperature-controlled conditions can be termed as a "cold supply chain "(CSC) (Figure 1). The setup of a CSC can be characterized by a considerable complexity, also due to strict hygiene and refrigeration requirements that affect the energy consumption and product quality offered to final consumers.

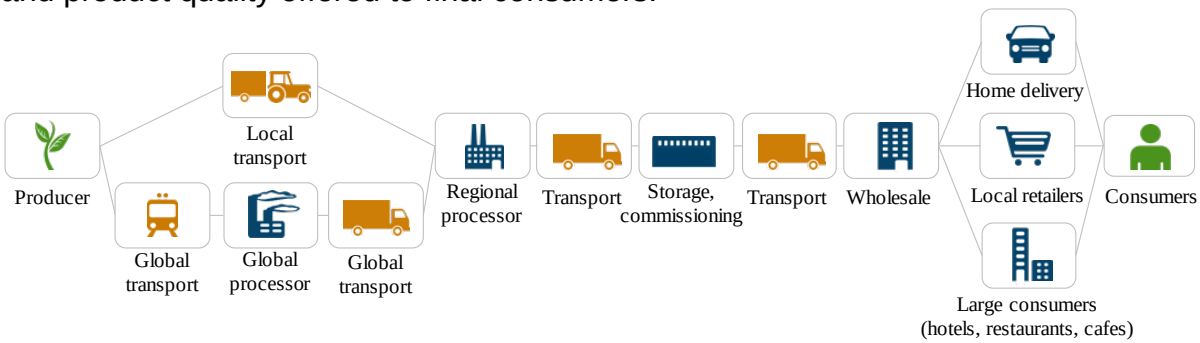

Figure 1. Simplified illustration of a cold supply chain from farm-to-fork (loosely based on Deutsches Tiefkühlinstitut e. V. 2016).

While the relevance of energy demand and energy saving potentials have been pointed out on the level of individual companies, thinking energy efficiency beyond individual company boundaries along entire CSCs could offer additional opportunities to reduce energy demand (Marchi und Zanoni 2017). On the one hand, this could open up the possibility to focus on the most cost-effective "energy efficiency measures" (EEMs) across all stages of CSCs, e.g. by pooling resources. On the other hand, such cross-company activities could also offer new opportunities for energy savings, e.g. by thinking about joint deliveries or by harmonizing maximum temperature levels along the chain while ensuring a high-quality and safe product. Though these potentials are appealing, their realization requires a close cooperation of companies along the chain.

In literature, it has been pointed out that non-energy benefits (NEBs) may have a substantial impact on the value of EEMs in some sectors (e.g. Worrell et al. 2003), but potential non-energy related losses have also been pointed out at (e.g. Cagno et al. 2019). Furthermore, the adoption of EEMs is subject to various economic, but also "behavioural and organizational aspects" (BOAs) which can act as barriers to the implementation of energy efficiency measures (e.g. Sorrell et al. 2000; Trianni et al. 2013). Since literature on energy efficiency, NEBs and BOAs mainly focuses on the energy performance of individual firms, the approach described in this report aims to make an attempt to close this gap by extending the view from a single-company to a CSC perspective at the example of the food sector (Figure 2).

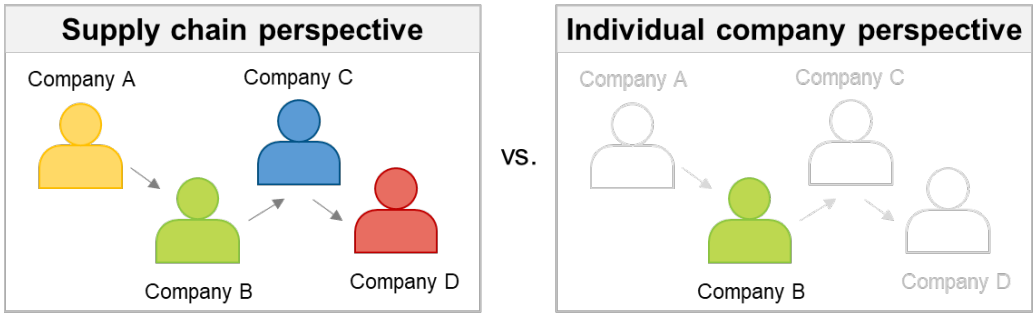

Figure 2. Schematic illustration of cold supply chain perspective vs. individual company perspective.

In particular, the following **research questions** are addressed:

- What does the setup of a cold supply chain generally look like?
- To what degree do companies cooperate along the cold supply chain with regard to energy efficiency?
- What is the relevance of NEBs along the supply chain as compared to the individual perspective?
  What are particular behavioural/organizational challenges with regard to energy efficiency improvements along the cold supply chains?

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2. Methodological Approach

The adoption of EEMs obvious is a multi-faceted issue. The framework of the present analysis is shown in Figure 3. The core aspect of this investigation is the role of energy efficiency (#1) in the CSCs. For the investigation, we assume that the role of energy efficiency is affected by the perception of NEBs (#2), but also by the view on BOAs (#3).

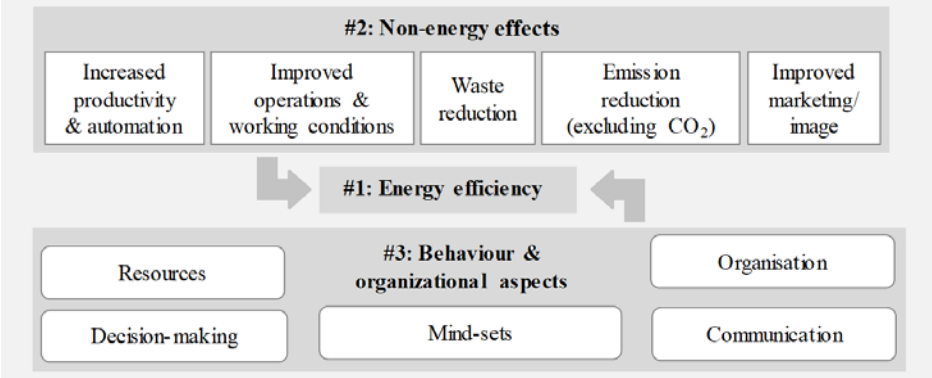

Figure 3. Illustration of the framework of investigation.

2.1. Qualitative analysis: Interviews

As a first step in the investigation, we used semi-structured in-depth stakeholder interviews to gain first insights on energy efficiency of different actors active in the cold chain. The target group were companies from the food industry operating in different stages of the CSC (production and processing, storage and logistics, wholesale and retail). The interviews were conducted with representatives from the organizations with a good knowledge about or responsible for energy and sustainability related topics (e.g. energy, operations or production managers) and/or who are familiar with the CSC of the food sector.

The interviews had an explorative character combining both open and closed questions. A guideline was used to facilitate and harmonize the interviews. This format was chosen to ensure comparability between the interviews and to allow for exploring relevant new aspects not explicitly foreseen in the guideline which followed the topics covered by the research questions. Regarding NEBs, the interviews sought to both gain insights on the single-company as well as the CSC perspective. BOAs focused on the interaction along the CSC only.

The interviews were conducted via telephone or face-to-face in December 2019 and January 2020 and took between 15 and 85 minutes with an average of 45 minutes. Within the study a total number of 61 interviews was conducted in 11 different countries (10 of them EU-countries). The majority of interviews was conducted in the three countries Germany (n = 16), Italy (n = 15) and Spain (n = 9). The majority of interviewees work in a private company (n = 59); others are from associations related to the food industry (n = 2). 36 companies are active in production and processing, 11 work in the storage and logistics sector and 10 belong to wholesale and retail (others: n = 4, e.g. refrigeration systems suppliers and

associations). A broader range of different sectors was covered (Figure 4). Concerning company size, an almost homogeneous distribution amongst small, medium and large companies is achieved (small and micro: n = 17, medium: n = 21, large: n = 21). About one third of the companies/organizations have a formal energy management system (according to ISO 50001) and about two thirds of the companies are following up on energy-related matters with a formalized energy management system.

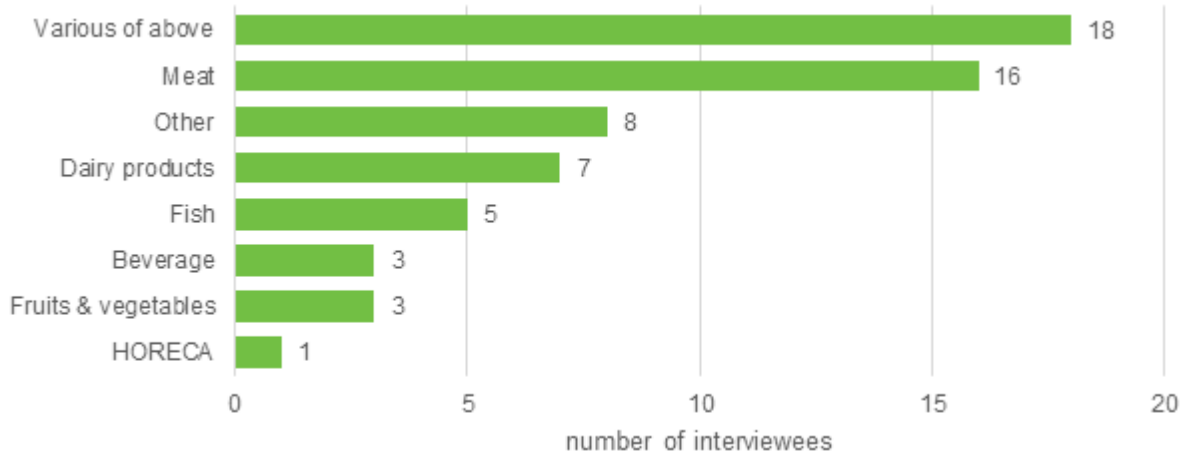

Figure 4. Split of interviewee numbers by sector of origin.

With regard to the interpretation of the findings, typical **limitations of interview approaches** apply (Yin 2009). First, they include a potential bias in the selection of interviewees since only those interested in the topic tend to take part. Second, the quality of interviews could vary due to different interviewers and translations. Emphasis has been given to ensure a common understanding of questions by the guideline with formalized questions to interviewees and additional separate instructions and examples for the interviewers. Third, interviewees could feel the need to provide socially desirable answers in an interview situation. To minimize this, the focus is set to factual information on existing processes rather than desirable situations. Fourth, the interview design, e.g. the order of questions, might affect responses. Finally, the interviewees work in different areas of the CSCs, they have different cultural and technological backgrounds and they operate under sometimes varying conditions, e.g. with regard to climate, energy prices and/or national policy measures. The survey solves some of these problems, although it must be remembered that there is obviously less control over the participants or the tracking of those who actually participate. Yet, with reoccurring trends across the interviews and surveys carried out in different contexts, the authors assume that the results tend to have some degree of robustness. This is reflected in the broad range of companies and actors across all stages of the food industry cold supply chains covered within the study.

2.2. Quantitative analysis: Survey

Based on the insights from the interviews, a broader online multi-language survey was carried out. The target group were again companies from the food sector operating in different stages of the CSC across the EU. The aim of the anonymous survey was to validate and enhance the preliminary results obtained from the interviews and to increase the sample size for reasons of representativeness. The survey consisted of four parts including the general setup of the cold supply chain, the role of energy-efficiency, NEBs and BOAs. Items were asked for as closed questions this time (partly multiple answers). Depending on the user's answers, some questions were automatically skipped if relevant knowledge was not provided. Some questions were asked first for the individual company and then for the CSC to obtain a reference for understating the results of the CSC.

After the implementation of the survey in 8 languages more than 1000 potential survey participants from food industry were contacted by the project team, either directly or with the support of associations. Within the two months from April to June 2020 during which the survey was open for participation, 175 evaluable results were obtained despite the pandemic situation affecting activity levels in the target sector.

A first scan of the survey results indicated that a part of the participants only answered questions on the setup of the cold supply chain and left the survey when energy-related questions were asked. Since these partial answers provide interesting insights in the cold supply chain it was to chosen to include these partial answers in the evaluation of results. The criterion for inclusion were that at least three meaningful answers were to be given in the first block of questions and that the participant had stayed a minimum amount of time in the survey to enhance the change that participants properly reflected on the questions.

Within the study a total number of 175 surveys filled out in the 8 different languages were evaluated. The majority of surveys were filled out in the three languages Italian (n = 50), Spanish (n = 48) and German (n = 26). The majority of participants work in a private company (n = 122); others are from associations related to the food industry (n = 9) or other not further specified organizations (n = 17) (no answer: n=2). Figure 5 shows the countries the participating organization are mainly operating from.

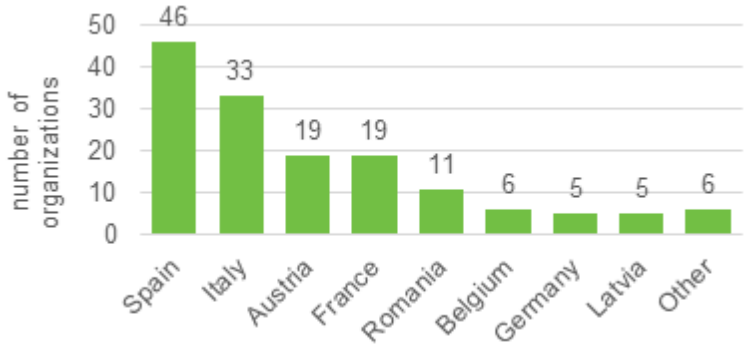

Figure 5. Countries from which the companies and organizations participating in the survey are mainly operating from.

80 participants are active in production and processing, 29 work in the storage and logistics sector and 23 belong to wholesale and retail (others: n = 17). Again a broad range of different sectors was covered with a larger share of participants from the meat industry. Concerning company size, an almost homogeneous distribution amongst small, medium and large companies is achieved (small and micro: n = 59, medium: n = 47, large: n = 52).

2.3. Presentation of the analysis

In the following sections, the results of the investigation are given. While the interviews were used to generate an understanding on the operation of cold supply chains in the food industry to enhance the framing of the survey, the descriptive presentation of results in section 3 deals with the detailed answers to the survey. In the following section 4, the key observations from the survey are stated. Interview results which differed strongly from the survey results are pointed out, as well. In the following section 5, the results from the observations are then used to derive strategic conclusions for the remainder of the ICCEE project.

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3. Descriptive overview of the results

The description of the survey results follows the topics addressed in the survey:

- the structure of the cold supply chains of the food sector
- the role of energy efficiency in these chains
- non-energy benefits from energy efficiency measures
- behavioural and organizational aspects

For each item, the number n of valid answers is provided. Note that some questions allowed for multiple answers. Furthermore, some questions were only shown to participants if they answered previous questions in a certain manner. Question on BOAs were for example only asked to those participants that were actively involved in exchange on energy-related topics along the CSC to avoid reporting of hearsay. Thus the number of responses concerning BOAs are considerably lower than for the first questions.

3.1. Structure of the cold supply chain

The aim of this first part is to gain insights into the structure of the CSCs of the food industry, In particular, the question how many links and companies CSCs typically consist of is addressed, i.e. how many SMEs are usually involved and how the companies are linked to each other. E.g. if companies from all over the globe or rather locally distributed companies are involved in such chains, if the involved companies all know each other and how often the chains' composition changes.

#1: Structure of the cold supply chain I

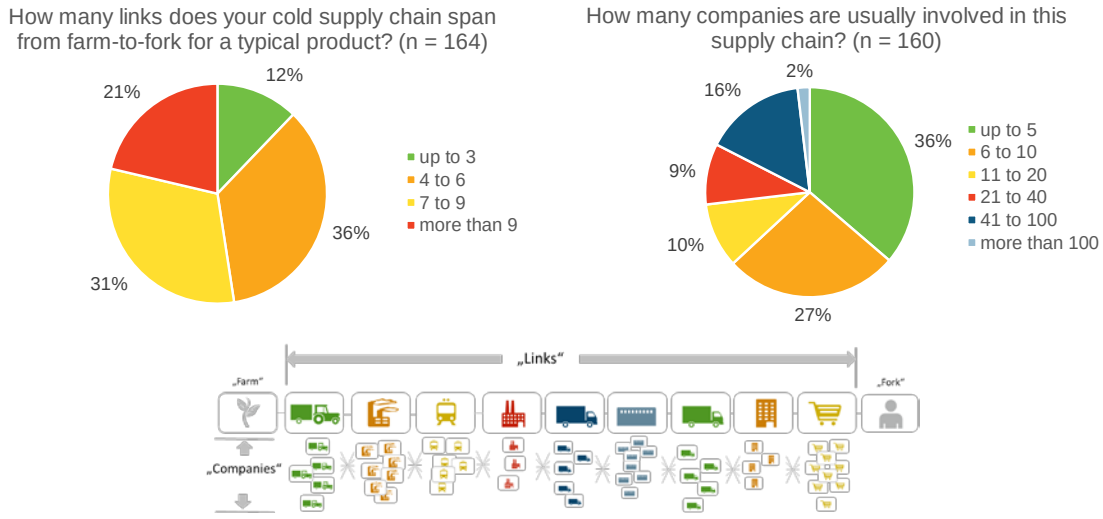

Figure 6. Survey: Size of cold supply chains

#1: Structure of the cold supply chain II

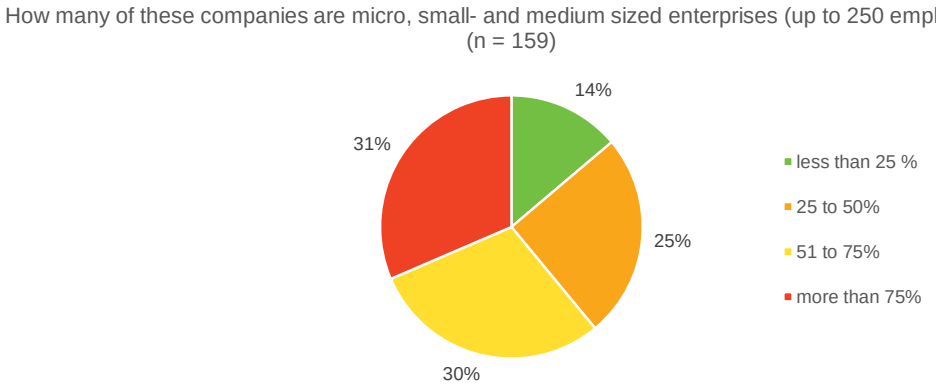

Figure 7. Survey: Composition of cold supply chains in terms of company size

#1: Structure of the cold supply chain III

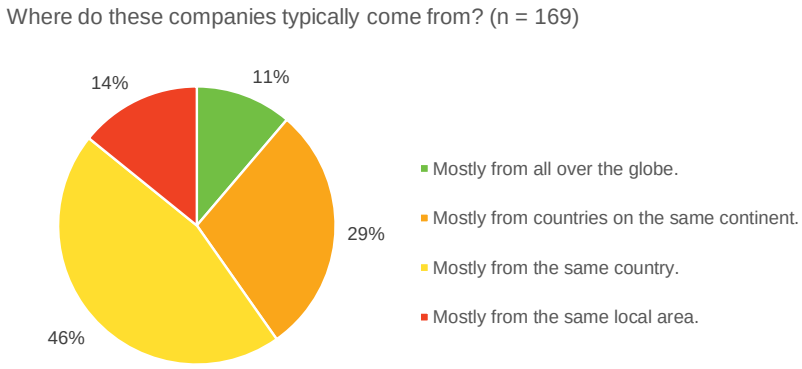

Figure 8. Survey: Composition of cold supply chains in terms of origin

#1: Structure of the cold supply chain IV

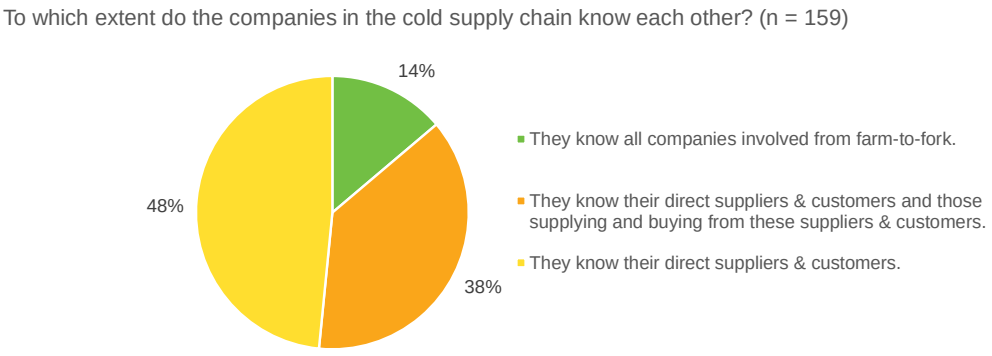

Figure 9. Survey: Knowledge of others in cold supply chains

#1: Structure of the cold supply chain V

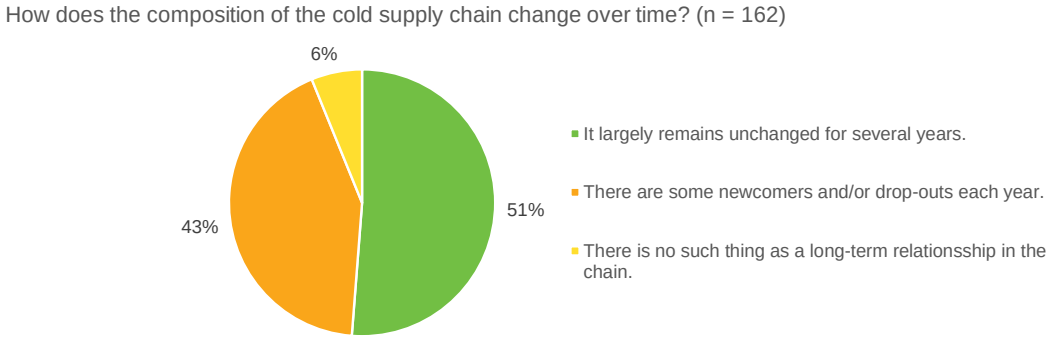

Figure 10. Survey: Evolution of cold supply chains

#1: Structure of the cold supply chain VI

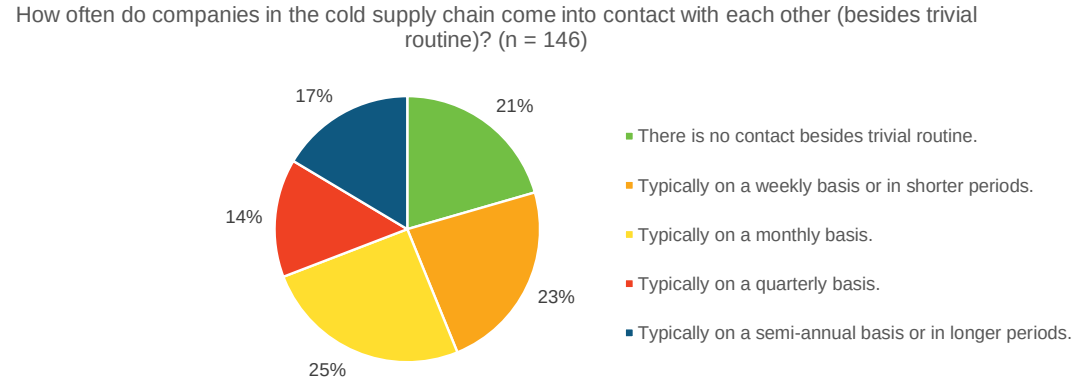

Figure 11. Survey: Frequency of interactions within cold supply chains

3.2. The role of energy efficiency in the cold supply chain

The aim of this part is to learn about the relevance of energy efficiency in the CSC and to understand who affects the topic. Therefore the participants assess the relevance of energy efficiency in decision-making processes from the perspective of their individual company as well as their whole supply chain. Additionally they are asked which link in the CSC mainly drives energy-efficiency forward along the chain.

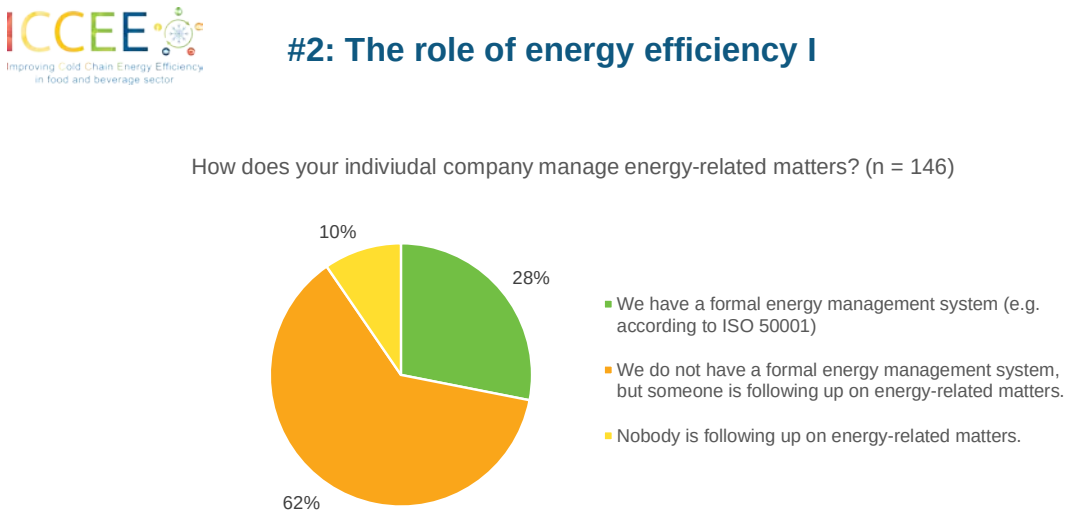

Figure 12. Survey: Management of energy-related matters

#2: The role of energy efficiency II

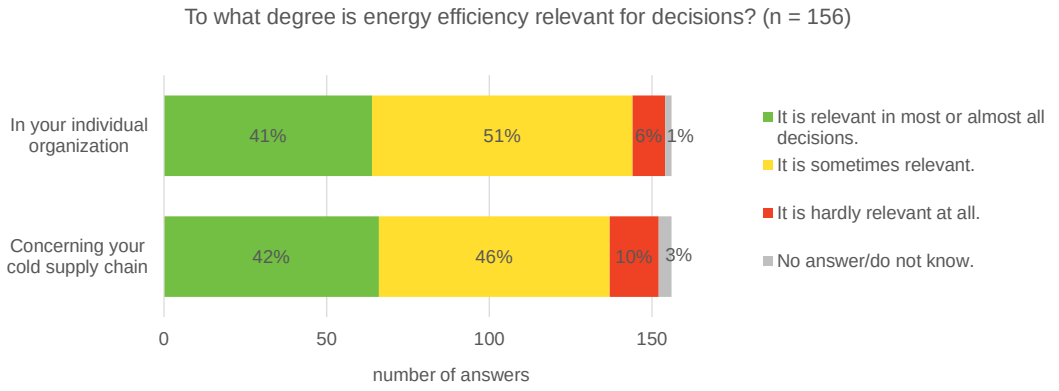

Figure 13. Survey: Relevance of energy efficiency for decisions

#2: The role of energy efficiency III

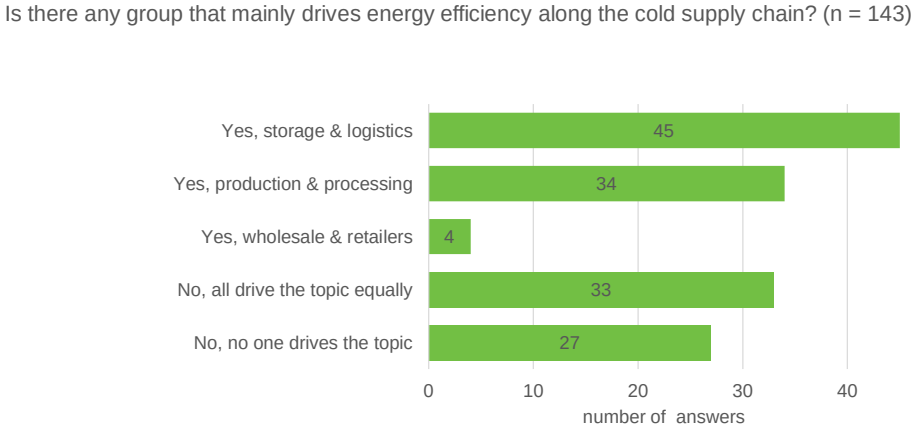

Figure 14. Survey: Driver of energy efficiency along supply chains

3.3. The relevance of non-energy benefits in the cold supply chain

The aim of this part is to understand the relevance of benefits from energy-efficiency measure besides energy and CO_2 savings. The participants were invited to reflect on positive or negative effects of recently implemented EEMs. Examples for positive effects could be reduction of waste or non-CO_2 emissions, increased productivity or improved working conditions, better marketing/image. While examples for negative effects could be the need for surplus personnel, frustration with new solutions, decreased process stability or productivity. Again with taking into account the individual company perspective versus the supply chain perspective.

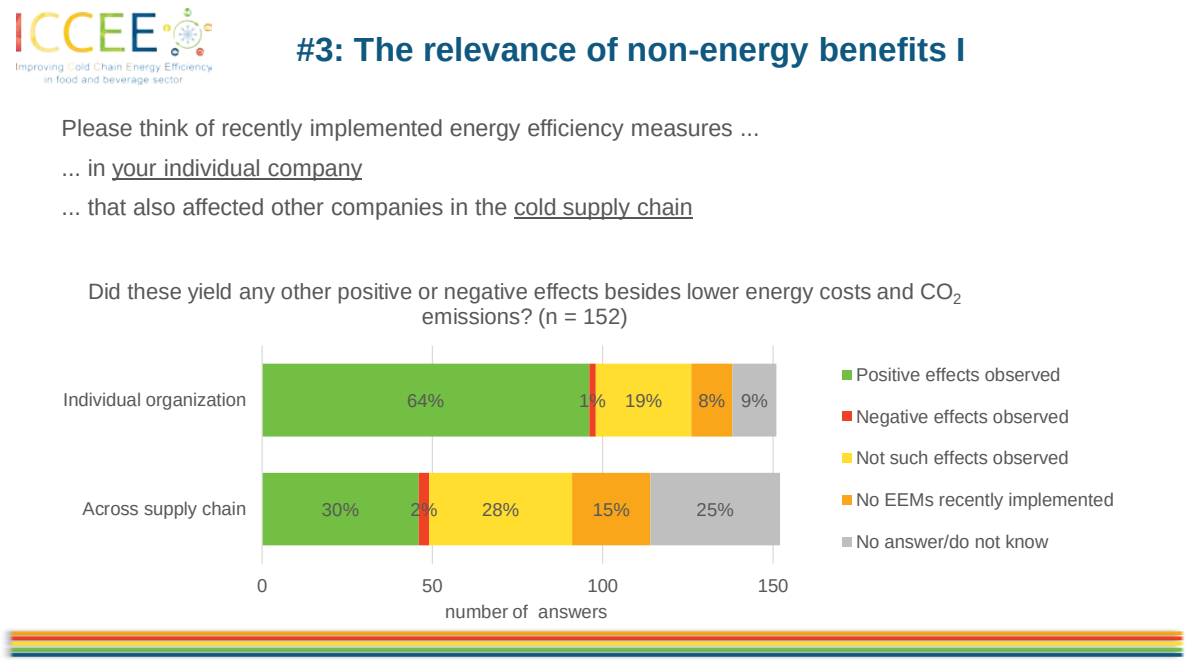

Figure 15. Survey: Effects of energy efficiency measures besides reductions of energy demand and carbon dioxide

#3: The relevance of non-energy benefits II

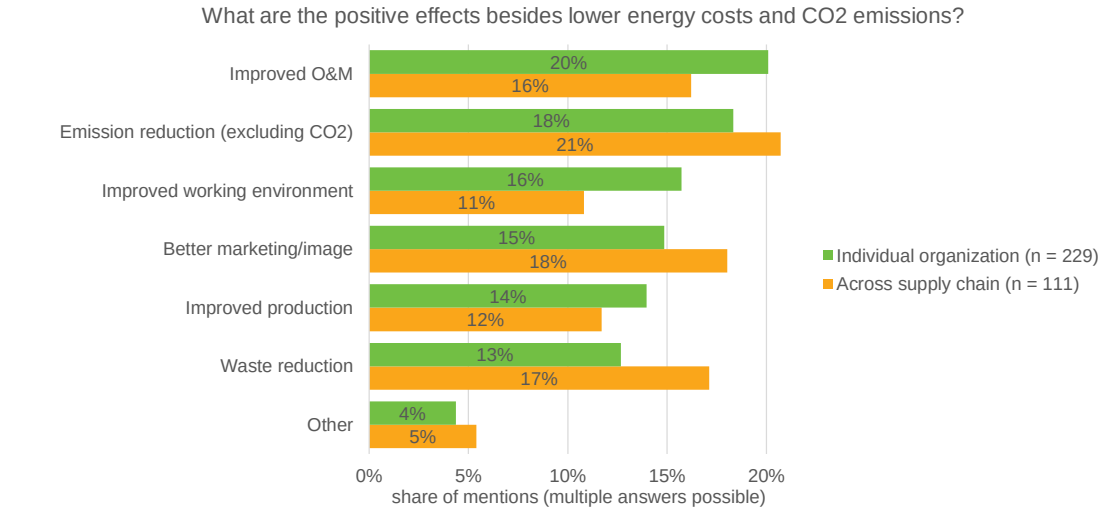

Figure 16. Survey: Positive effects besides energy savings and emission reductions

3.4. Behavioural and organizational aspects influencing energy efficiency measures along the chain

The aim of this part is to learn about the importance of behaviour-related aspects in the CSC, since many aspects influence the implementation of energy efficiency measures along such complex chains. To further understand the particular behavioural/organizational aspects/challenges with regard to energy efficiency improvements along the CSCs, those are queried on five categories, i.e. concerning communication along the chain, decision-making processes, mind-sets/behaviour of companies, the cold chain's organization and resources.

#4: Behavioural and organizational aspects I

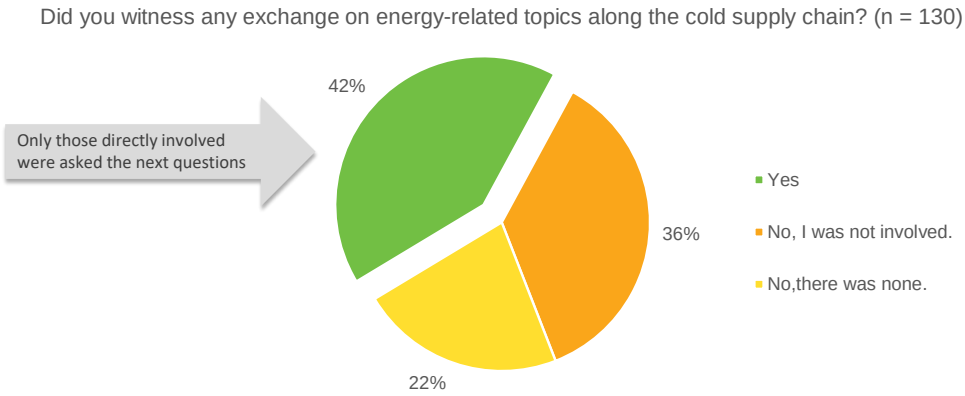

Figure 17. Survey: Witnessing exchanges on energy-related topics along cold supply chains

#4: Behavioural and organizational aspects II

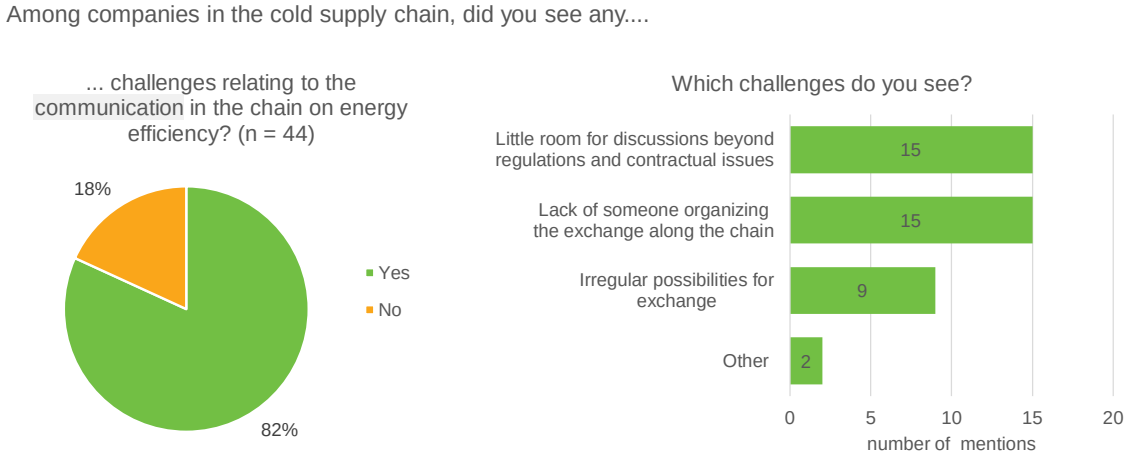

Figure 18. Survey: Relevance of challenges related to communication along cold supply chains

#4: Behavioural and organizational aspects III

Among companies in the cold supply chain, did you see any....

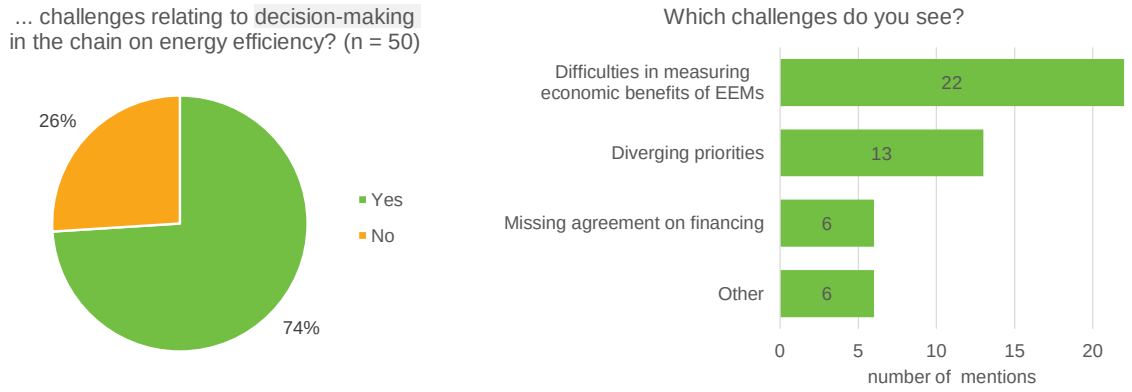

Figure 19. Survey: Relevance of challenges related to decision-making along cold supply chains

#4: Behavioural and organizational aspects IV

Among companies in the cold supply chain, did you see any....

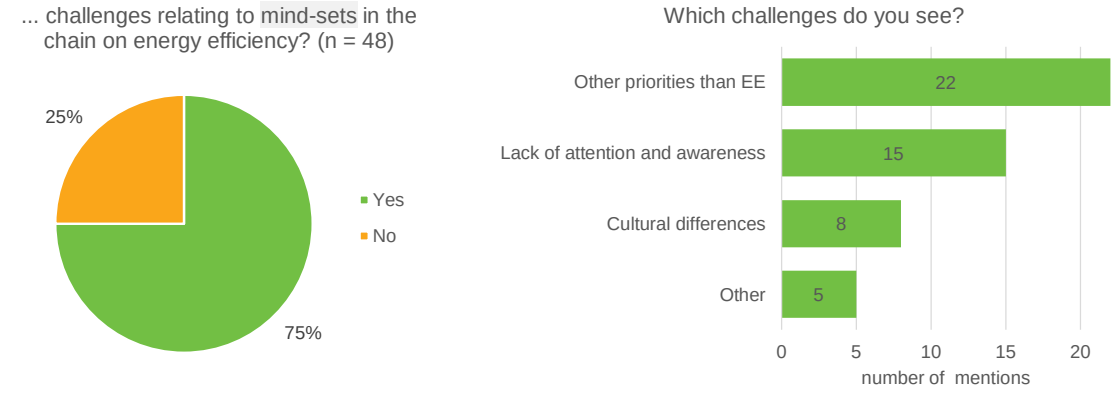

Figure 20. Survey: Relevance of challenges related to mind-sets along cold supply chains

#4: Behavioural and organizational aspects V

Among companies in the cold supply chain, did you see any....

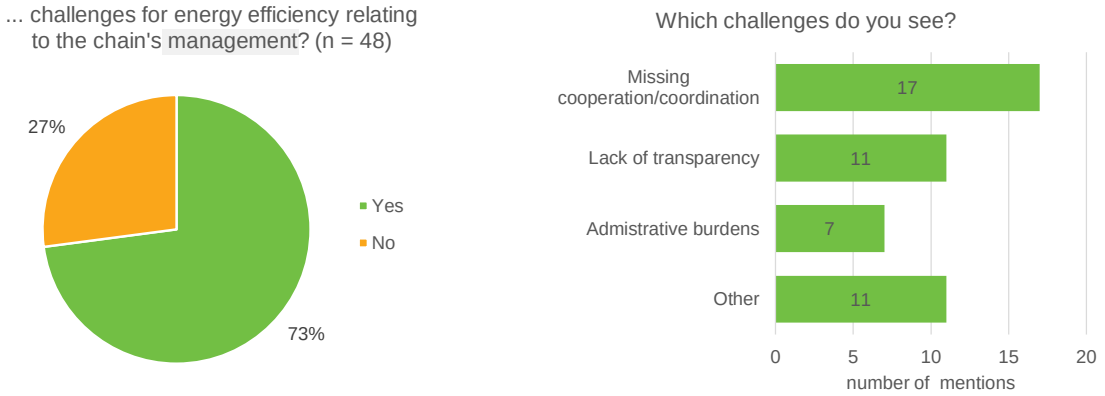

Figure 21. Survey: Relevance of challenges related to chain management on energy efficiency along cold supply chains

#4: Behavioural and organizational aspects VI

Among companies in the cold supply chain, did you see any....

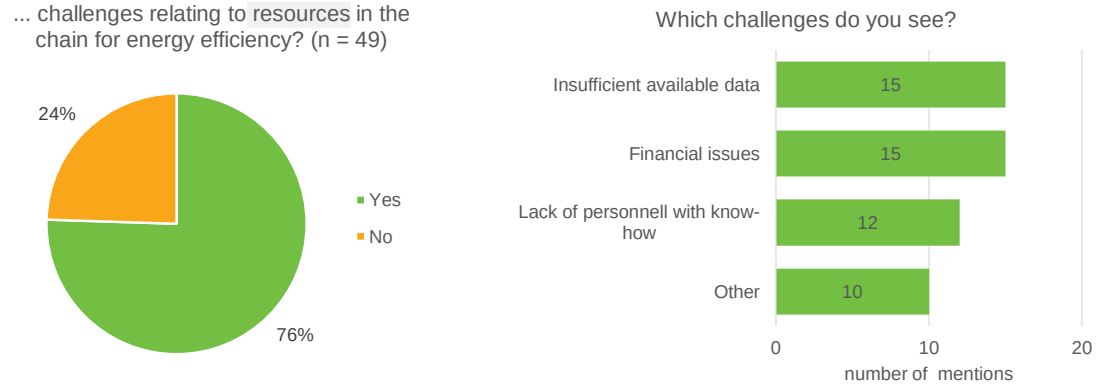

Figure 22. Survey: Relevance of challenges related to resources for energy efficiency along cold supply chains

4. Key observations from the survey

While the interviews serve to gain first insights into the functioning of cold chains in the food industry, the survey allows a more detailed analysis of energy efficiency in the cold chain and the related research questions addressed in the project. As an introduction, the interviews give an insight into why the cold chain is relevant for companies in the food industry. This includes the compliance with food safety regulations, the maintaining of the cold chain during production and the delivery to customers as well as the assurance of product quality from farm-to-fork. Moreover current hot topics of the cold supply chain are identified:

- Assurance of product quality and compliance with cold chain requirements
- Energy efficient equipment and processes
- Cost reduction (energy and production)
- Lack of skilled personnel
- Process optimization

What does the setup of a cold supply chain generally look like?

With regard to the **structure of CSCs** the survey results reveal that both the number of companies and the number of links in a supply chain can vary substantially depending on the individual chain. The same is the case for the proportion of small and medium-sized enterprises in the chains. While about one third of the participants indicate that their chain consists of up to 5 companies, two thirds indicate a larger number of members. This underlines that cold supply chains are quite heterogeneous. With regard to the composition of the supply chains, the majority of involved companies seems to come from the same country or even same local area and work together in long-term relationships with only a few newcomers and dropouts each year. Globally active supply chains seem relatively limited. Despite the local limitations, few cold chain links seem to know all their members (only 15 %). They are more likely to know their direct suppliers and customers and those supplying and buying from these. When it comes to exchanges between members of the CSC apart from trivial routine matters such as contractual issues, the picture is quite heterogeneous: Half of the supply chains exchange information on a fairly regular basis, others exchange information over much longer periods (3+ months) or not at all.

To what degree do companies cooperate along the cold supply chain with regard to energy efficiency?

In accordance with the results of the interviews, companies in the CSC seem to agree that **energy efficiency** is a topic of high relevance especially in refrigeration due to the high energy consumption and energy costs involved. This seems to be both true from the perspective of individual companies as well as entire CSCs where the participants claim that

energy efficiency is a relevant criterion in decision-making. Yet the interviews reveal in addition that economic considerations of food products dominate any exchange between companies and that actual implementation of EEMs also strongly depend on their monetary advantage. Here, high initial investments and long amortization periods are frequently mentioned as impeding the implementation of EEMs.

The interviews furthermore suggest that awareness for EEMs is lower along entire CSCs than within individual companies. For instance, no interviewee could name concrete EEMs implemented and coordinated together with other members of the CSC. Individual organizations seem to focus on their own situation and interests, independence and flexibility. Yet, especially smaller organizations who are reticent to implement EEMs due to high investments might profit from a cooperation along the CSC. In sum, these results suggest that potentials of cross-company activities seem generally agreed upon, yet their realization is far from common practice.

Another observation is that storage and logistics seem particularly inclined to push energy efficiency in CSCs. Yet also production and processing seem to play an important role, while wholesale and retail generally seem to be less active on the topic. Yet one third of the participants does not see any difference in the role of these groups for driving energy efficiency.

What is the relevance of NEBs along the supply chain as compared to the individual perspective?

NEBs besides energy and emission savings seem to be relevant for both individual companies, as well as the CSC as a whole. Based on the results, it can be observed that positive effects seem to far outweigh negative associated aspects. Yet, awareness on NEBs along the CSC seem relatively low compared to individual companies and possible economic impacts difficult to measure for the companies. Furthermore, the survey results indicate that different NEBs are perceived for CSC as compared to the individual companies. For individual companies production related benefits like improved operation and maintenance and improved productivity seem to be in the foreground, while from a supply chain perspective improved image and marketing as well as waste reduction rank high. Emission reduction (excluding CO_2) seems to be an important benefit for both. It should be noted that during the interviews the differentiation between NEBs perceived for the cold chain and for individual companies was not very pronounced.

What are particular behavioural/organizational challenges with regard to energy efficiency improvements along the cold supply chains?

At the **organizational and behavioural** level of the CSC, it is evident from the interviews that some energy is wasted due to a lack of coordination and communication along the chain. Regarding the exchange on energy efficiency along the CSC more than half of the

survey participants points out that there is no communication or exchange or that they are not involved in energy-related communication activities. When filtering those that are engaged in energy-related communication activities the survey results reveal that the complexity of CSC operations seems to be a challenge for implementation of EEMs. Among others, this is due to the statement that there is a lack of someone to organize exchanges along the chain. Due to the complex structure of the different actors in CSCs, challenges arise like different priorities and difficulties in measuring the economic benefits of EEMs as well as a lack of available data and financing issues. Other challenges include the lack of know-how and skilled personnel or the lack of attention for energy-related topics - all barriers which relate to individual companies, as well, but might be more pronounced when looking at the entire CSCs. It follows that behavioural and organizational aspects in their interaction are of particular relevance for the uptake of energy-efficiency measures across the supply chain.

The ICCEE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 847040.

5. Intervention strategy on NEBs and BOAs for further tasks

The final step of this report is to develop an intervention strategy based on three successive steps (Figure 23). Firstly, it should serve as support for the development of approaches for a successful involvement of companies in the capacity building activities. Secondly, the strategy should serve as an input to the capacity building programme activities (WP4) to enhance the perception of NEBs. And finally, it should help to overcome behavioural barriers and lead to an increased energy culture of the stakeholders. This strategy will serve also as key input for the design of the ICCEE tool (WP3) since in the assessment of the energy savings measures also the NEBs will be highlighted.

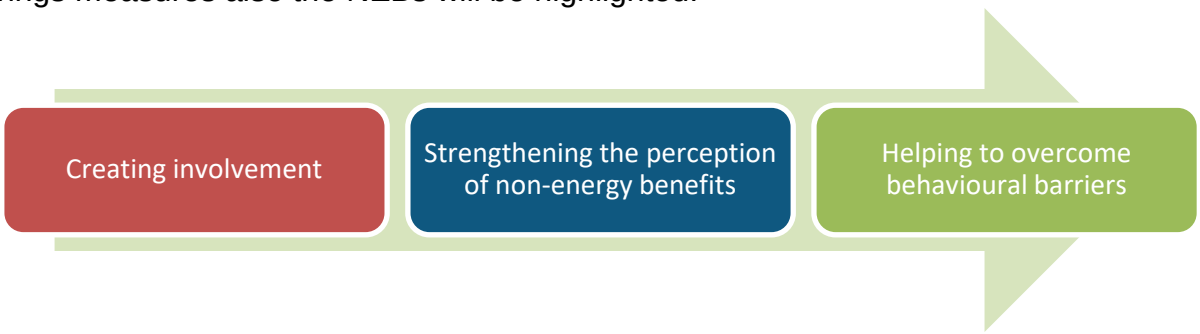

Figure 23. Illustration of the Intervention strategy aims

The following tables give an overview of the key observations as describes in section 4 and the resulting conclusions regarding the intervention strategy. The work packages that could take these into account are indicated in brackets.

Table 1. Intervention strategy - Creating involvement

Observation	Conclusion
Cold supply chains are heterogenous (e.g. number of companies, links, size)	There is no supply chain models that fits them all; adaptable and scalable model needed; simplifications and generalizations difficult to avoid (WP 2 & 3)
Majority of supply chains mostly operate in a local/national environment	Country-based approach for capacity building and communication seems helpful, fully international approach not priority (WP4 & 5)
Only few supply chain companies have a full view of all supply chain members	Companies might not be aware of all energy efficiency opportunities across the CSC; companies from various stages in the supply chain should preferably be involved in training activities / tool validations (WP 3 & 4)
Cold supply chains tend to be rather stable over time	Opportunity for long-term improvement of established supply chains; opportunity for step-wise approach (over longer period) monitoring of progress of supply chains (WP 4)
Half of the supply chains exchange rather regularly, others in longer periods (3+ month)	For having a rather quick involvement, it seems advisable to start with those in the training that exchange more often (WP4)
While various groups are active, storage & logistics seems more active	For initiating an exchange process, involving storage & logistics companies could be a good starting point (WP4)

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Table 2. Intervention strategy - Strengthening the perception of NEBs

Observation	Conclusion
Awareness of NEBs along the CSC falls short compared to individual companies	Companies should be helped to discover NEBs from the implementation of EEMs, especially in CSC (WP 3 & 4); In workshops with actors from different stages of CSC: Elaborate examples where implemented EEMs could offer potential NEBs to various actors. (WP 4)
Companies have difficulties in determining the economic benefits of energy efficiency measures	Companies should be helped in identify both the direct economic benefits of energy efficiency measures and those of NEBs (WP 2 & 3)
Negative effects related to energy efficiency measures seem hardly relevant	Focus on positive messages of energy efficiency; no activities for avoiding negative perceptions needed (WP 3)
Productivity improvements are an important NEB for individual companies	In gaining companies and for the communication of results, this aspect of the NEBs should be stressed (WP4 & 5); greater involvement of wholesale and retail

Table 3. Intervention strategy - Helping to overcome behavioural barriers

Observation	Conclusion
Missing regular exchange on energy-related matters beyond contractual issues across the supply chain members	Fostering communication along the chain; establishing and strengthening networks between ICCEE participants during workshops and trainings; establish a communication channel on the platform (WP 4)
Insufficient available data as challenge relating to resources in the chain for energy efficiency	Giving companies the opportunity to process their (energy) data in a supply chain context using the tools provided (WP2 & WP3)
Financial issues as challenge relating to resources in the chain for energy efficiency	Funding opportunities to be integrated in the tool; introduction of decision support models conveying the additional financial and other benefits of EEMs and bringing quantification of NEBs to the fore (WP 3 & 4)
Missing awareness as challenge regarding energy efficiency along the chain accompanied by diverging priorities	Raising awareness for energy efficiency and their NEBs in trainings and workshop (WP2 & 3 & 4)

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6. Conclusion

The aim of this report is to investigate on the role of energy efficiency, the relevance of NEBs and the influence of BOAs with regard to energy efficiency along cold supply chains. For this purpose, 61 interviews with stakeholders and an online survey with 175 participants from the cold chain of the food sector were realized. As a final step, an intervention strategy on conclusions for the following work packages was derived from these results.

The results from the investigation suggest that energy efficiency is presently considered more strongly in individual companies than along entire CSCs. Though there seems to be a common understanding that energy efficiency must be tackled along the chain, the complexity of CSC operations turns out to be a challenge for implementation. There are various behavioural and organizational challenges related to the organization of the CSC which seem to impede the implementation of EEMs along the chain. The narrative of the interviews suggests that the focus on individual company goals and on regulatory and price matters dominates the exchange in the CSC. Furthermore the survey results reveal that opportunities for a focused exchange on energy efficiency seem to be missing, knowledge and know-how on energy-efficient techniques and operational behaviour could be improved and common resources for cross-company activities enhanced. With regard to the role of non-energy effects, positive effects of EEMs seem to outweigh negative associated aspects by far. Increased productivity in particular seems to play an important role for driving energy efficiency decisions due to its direct economic relevance - especially for the individual companies. From a supply chain perspective improved image and marketing as well as waste reduction also rank high.

Finally, a number of conclusions have been elaborated which will be taken into account in the following work packages (see Table 1 to Table 3). These concern the target group for the forthcoming trainings and workshops, the perception of NEBs in the implementation of EEMs in individual companies as well as along entire supply chains and the relevance of behavioural and organizational aspects within the chains. As such, they shall help guide further steps in the project implementation to maximize its impact.

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