



## ICCEE in short, Energy efficiency in the value chain

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UNIVERSITY  
OF BRESCIA



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# The project and the partners

## Improving Cold Chain Energy Efficiency in the food and beverage sector



### Facilitation

- Promote the dissemination of energy efficiency measures within the cold chains in the food and beverage sector with a focus on SMEs through the provision of tools and interactive formats



### Holistic perspective

- Holistic project approach that goes beyond an individual company perspective to entire supply chains, whereby overarching potentials for action are to be identified and better leveraged



### Accelerate investments

- Using the developed formats, the project aims to accelerate the implementation of energy efficiency opportunities through actual investments.

European Commission | Horizon 2020  
European Union Funding for Research & Innovation

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION

**HORIZON 2020**

**ICCEE**  
Grant agreement ID: 847040

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10.3030/847040

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€ 1 997 068,75

EU contribution  
€ 1 997 066

Coordinated by  
UNIVERSITÀ DEGLI STUDI DI BRESCIA  
Italy



## Business case: Refrigeration

- Refrigeration is vital for preserving the quality of food and beverage.
- Currently only 10% of the food produced is properly refrigerated and up to 30% is lost before it reaches the home refrigerator
- Wastes in the cold chain can occur at different stages of the value chain:
  - storage of raw materials
  - packaging and processing
  - distribution and transport
  - refrigerated or frozen storage and display at the point of sale.



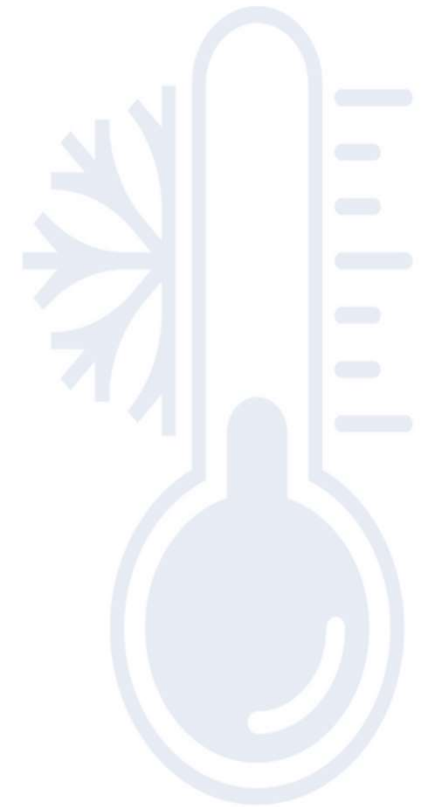
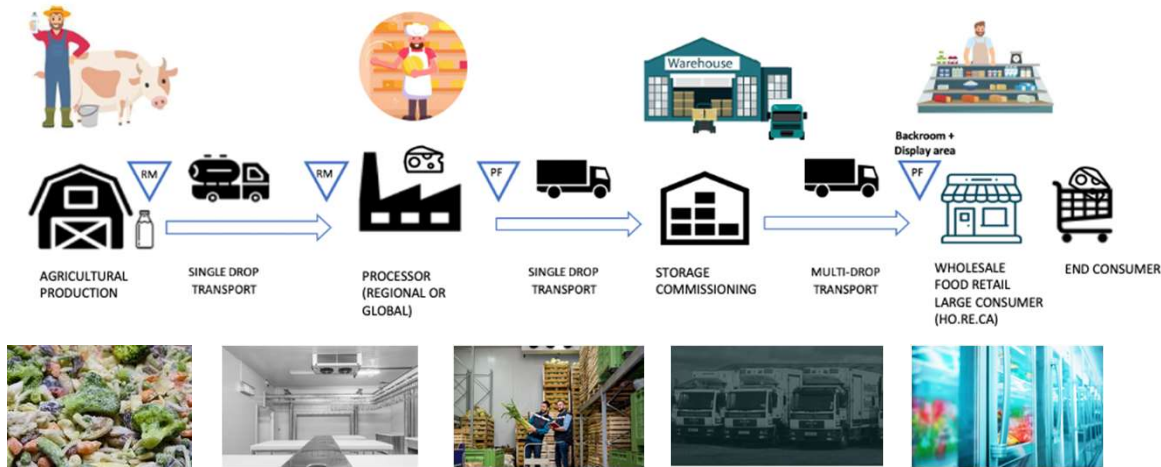
*“An improved global cold chain would allow a reduction of almost 50% of the CO2 emissions of the current cold chain.”*



# Food & Beverage Cold Supply Chains



Cold chains consist of environmentally controlled logistics chains aiming at preserving the quality of perishable goods, connecting processing, storage, and distribution activities from farm to fork.



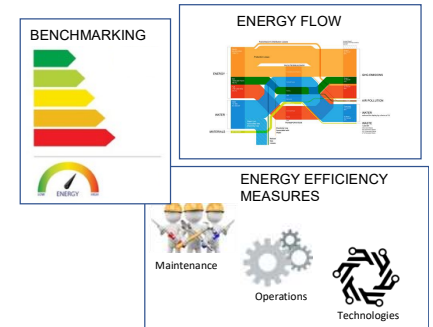
# Two-pillar Approach

TOOL

DEVELOP AND  
APPLY AN  
ANALYTICAL ENERGY  
EFFICIENCY TOOL  
TO SUPPORT AND  
FACILITATE  
INVESTMENT  
DECISION-MAKING

Allow users to estimate the energy & environmental performances of a **cold chain** and its actors and provide:

- suggestions for specific EEM investment
- benchmarking
- what-if analysis



CAPACITY BUILDING  
PROGRAMME

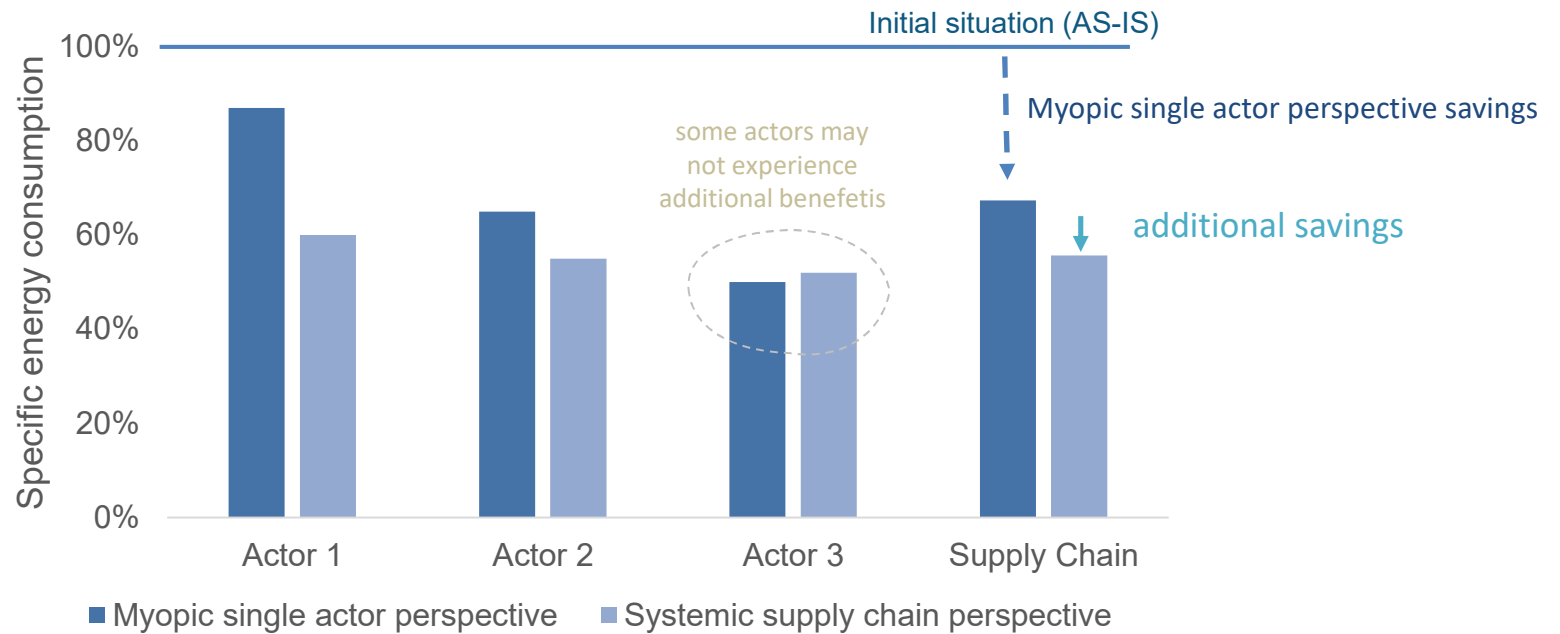
A CAPACITY BUILDING  
PROGRAMME AND  
CREATING A  
COMMUNITY TO  
ACCELERATE CHANGE  
IN THE ENERGY  
CULTURE OF THE  
FOOD & BEVERAGE  
SECTOR

4 main themes:

- Supply chain
- LCA and LCC
- NEBs and behavioural aspects
- Financial aspects and funding opportunities



## Cold chain business model



- Additional energy efficiency measures
- Harmonise interventions
- Increased energy efficiency implementation rate due to lower barriers

# ICCEE-Toolbox: Coverage from 7 angles

## Tool #0: Guidance

*Do you want to know more about solutions and funding for energy-efficient CSCs?*

### Tool #6: Multi-criteria analysis tool (MCDA)

*Did you already take a look at the CSC and LCA tools and do you want to know more?*

### Tool #5: Non-energy benefit evaluator (NEB)

*Do you wonder how to analyze non-energy benefits in a structured manner?*

### Tool #4: Benchmarking non-energy benefits (BEN)

Are you interested in other factors relevant for decision making on CSC energy performance?



### Tool #1: Cold supply chain tool (CSC)


*Do you want to analyze your CSC's energy consumption and prevent food quality losses?*

### Tool #2: Life cycle assessment tool (LCA)

*Do you want to understand the environmental impact of your CSC?*

### Tool #3: Life cycle costing tool (LCC)

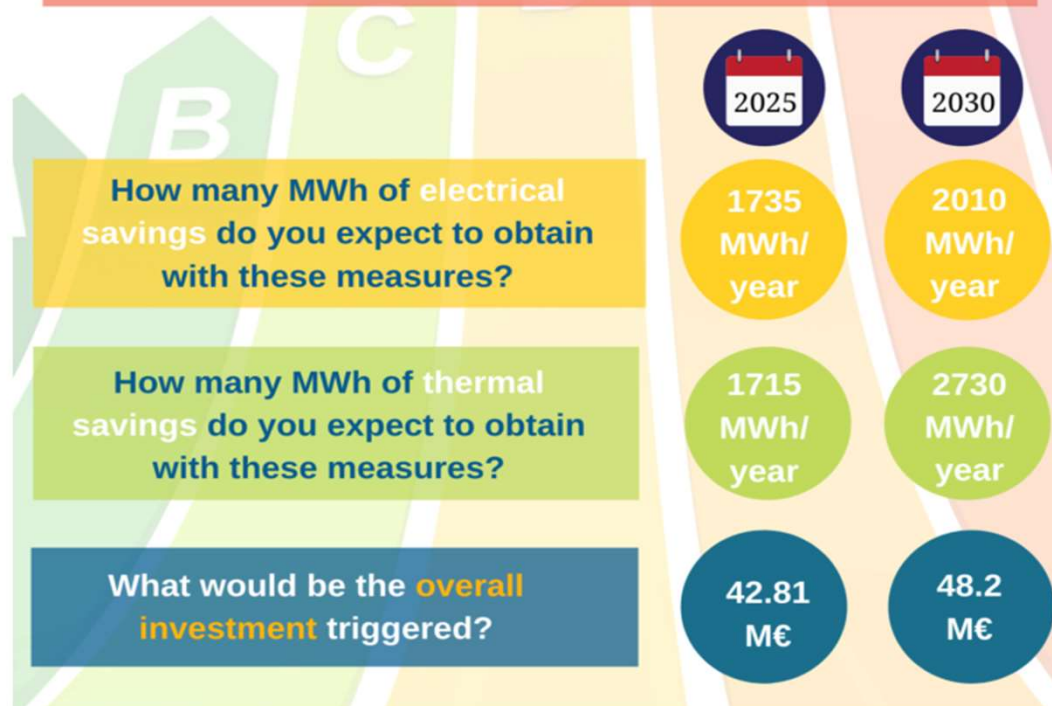
Do you wonder about the economic benefit from energy efficiency measures?

- Printable and available in 8 languages 
- Available for **free** on project website
- Tutorial on  **YouTube**



## Business model validation

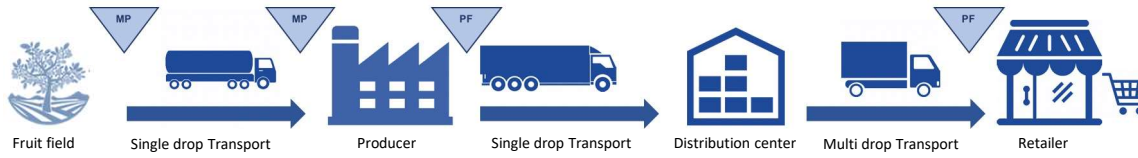
To assess to which extent the ICCEE national trainings supported reaching companies' energy efficiency and sustainability targets, ICCEE asked participants for an estimation. With nearly 100 answers, the total estimated savings and triggered investments are as follows (conservative estimation).



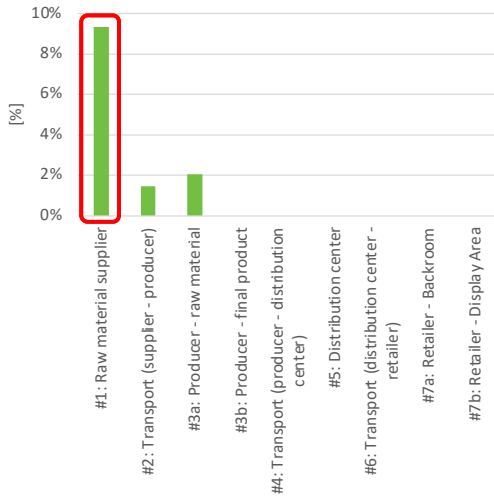


# Fruit & vegetables case study

**FROZEN FRUIT**



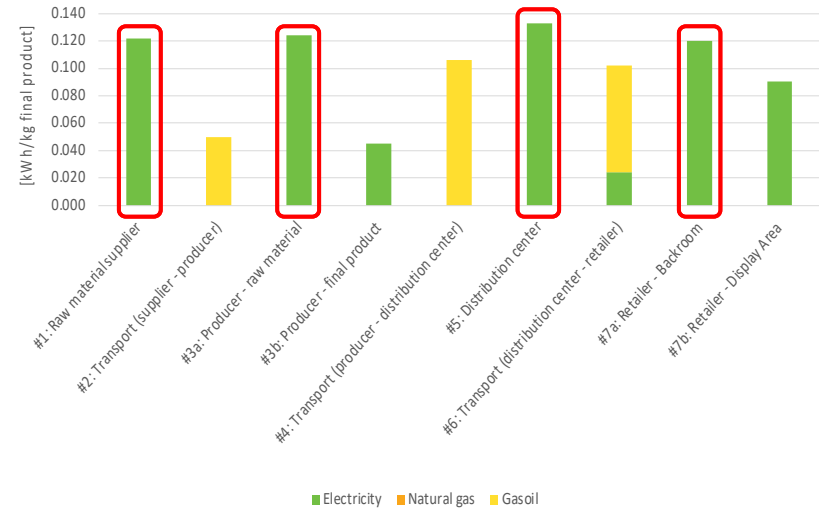
Quality losses



Storage time



Specific energy consumption by energy carriers



## Fruit & vegetables case study - Possible Interventions

Supply chain stage	Energy efficiency measure	Category	Objective
Producer – PF warehouse DC	Faster replenishment (smaller lot size) <u>Use of smart/automatic control system</u>	Management Monitoring and control	↓ refrigeration load requirement and energy consumption
Raw material supplier	Faster replenishment (smaller lot size)	Management	↓ quality losses, refrigeration load requirement and energy consumption
Retailer – Display Area & Backroom	<u>Separated compartments warehouse</u> <u>Improved insulation (reduction of air infiltration of rooms and display area, e.g., by ensuring that door can be closed)</u>	Building	↓ refrigeration load requirement, air infiltration, and energy consumption
Transport Producer – DC DC – Retailer	<u>Alternate means of transport (e.g. portable refrigerated units for LTL)</u> <u>Improved insulation of trucks (e.g., air curtain)</u>	Transport  Transport	↓ fuel consumption (↓ air infiltration → ↓ refrigeration load)
Cold chain	<u>Adjustment of cooling temperature</u> (e.g., -18°C all over the chain instead of -24°C and -20°C)	Management	↓ temperature abuses and energy consumption



# Industry Informative Network & e-learning platform



8 LANGUAGES COURSE  
free available



# Peer-reviewed papers and scientific publications

**Energy efficiency from farm to fork? On the relevance of non-energy benefits and behavioural aspects along the cold supply chain**

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**Keywords:** cold supply, supply chain, food and drink, refrigeration, non-energy benefits (NEB), behaviour

**Abstract:** Though cooling is an ancient concept to preserve food, only modern artificial cooling and freezing make 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 that are responsible for about 30 % of electricity consumption. Energy efficiency could thus be of remarkable importance for companies operating in this field. Energy efficiency measures can extend, additionally to the evident energy savings, non-energy related benefits, e.g. enhanced competitiveness, reduced maintenance requirements or an improved working environment. Such factors have been identified as important for affecting the assessment of energy efficiency measures. When it comes to which cold supply chains, behavioural and organisational aspects seem to be important for decision making about energy efficiency, it was found that factors affecting decision in individual organisations may also occur as cross-organisational issues. Existing analyses on both non-energy benefits and behavioural aspects related to energy efficiency mainly focus on individual companies and hardly touch whole supply chains, in particular from food industry. In conclusion to this research, this paper investigates both aspects more in-depth along the cold supply chain of the food sector, thereby moving from the single company perspective to a full supply chain assessment. For this purpose, 40 semi-structured interviews with company active in cold supply chains were carried out across various member states of the European Union.

1922 INDUSTRIAL NUMBER THEORY PROCEEDINGS 188

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DOI: 10.1186/2161-2287/292878

**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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6-124-21 + Sebastian Leopoldus

**Comparison of Cooling Technologies for Transport Logistics**

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**Abstract:** Despite efforts to increase energy efficiency, the final energy consumption for freight transport in Europe has increased during the last years. Food, beverages, and tobacco accounts for the largest share of tonne-kilometers in road freight transport, while about one-third of the transported products require refrigeration or cooling. Standard technology today are vapour-compression refrigeration (VCR) systems operated either via the vehicle engine or with a dedicated diesel engine, both increasing the fuel consumption for transportation. To achieve the energy and climate targets of the EU, further research is needed for the transport sector and especially on alternative cooling technologies in transportation applications, which are more efficient, and use less non-renewable energy. This paper will present an evaluation of different alternative refrigeration technologies such as (i) eutectic cooling by the use of phase change materials (PCM), (ii) cryogenic cooling, (iii) solid oxide fuel cell in combination with vapour absorption refrigeration, and (iv) photovoltaic (PV) cells as an energy provider for the vapour compression refrigeration (VCR). The alternative systems are compared to the VCR systems regarding technical feasibility, GHG-emissions, and economic competitiveness (investment and operational cost). Required cooling loads are calculated for different pack sizes and distribution scenarios as well as value potentials in different regions of Europe. Emissions during operation as well as emissions related to the production and losses of the fuels and refrigerants are taken into account. However, emissions related to the production of the required hardware are not considered. The results show that all the alternative technologies are feasible, except for the PV-driven VCR system, which one cannot provide enough energy during some months or transport scenarios. They might need to be implemented by an energy storage device. However, PV-driven VCR and eutectic cooling seem to be the most promising systems in terms of emission reduction potential.

**Introduction:** The most common way to transport food in need of refrigeration on land is to use refrigerated trucks. The trucks connect the different stages of the cold supply chain. Due to demographic changes, the total number of refrigerated vehicles around the world is estimated to reach 15.5 million by 2025, up from 3 million in 2013 (Automotive Fleet 2015). The vapour-compression refrigeration (VCR) system is the most common technology in on-road mobile refrigeration applications and 90% of these systems are operated via a dedicated diesel engine (Rai and Yano 2017b). The diesel engine, with a typical fuel consumption of 0.471/1/h per kW cooling capacity (Liu et al. 2012), emits greenhouse gases (GHG), particulate matter and nitrogen oxides (NOx) which are a negative impact on the environment. Regarding the energy and climate targets of the EU, there is a need for a catchall alternative technologies for mobile cooling applications with low environmental impact. This work presents a comparison of some alternative cooling technologies for transport logistics regarding technical applicability, environmental impact and economic competitiveness.

**Alternative refrigeration systems for transport applications**

In this work the following four refrigeration systems are analysed:

- Eutectic cooling

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https://ojs.aaai.org/

**Effects of Energy Efficiency Measures in the Beef Cold Chain: A Life Cycle-based Study**

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**Abstract:** Circular economy and industrial symbiosis represent a production and consumption model involving sharing, lending, renting, and recycling existing materials and products in the most efficient way to increase sustainability and reduce or eliminate waste. Beef production has a high impact on the environment in different impact categories, especially those activities related to livestock breeding and feeding. In this study, a life cycle assessment and a life cycle cost evaluation are carried out investigating potential energy efficiency measures to promote industrial symbiosis scenarios referring to a proposed baseline scenario. Three main potential measures are evaluated: energy recovery from waste via anaerobic digestion, integration of renewable sources at warehouses, including solar PV panels, and the replacement of auxiliary equipment at the retailer. It was found that energy recovery of food waste through anaerobic digestion and cogeneration provides the most valuable benefits to the supply chain. From the economic perspective, using a conventional life cycle cost assessment, the energy production from the use of wastes for anaerobic digestion proved to be the best potential option.

**Keywords:** LCA; LCC; cold chain; beef; circular economy; industrial symbiosis; sustainability

**Nomenclature:**  
GHG Greenhouse gases  
SDG Sustainable Development Goals  
SETAC Society of Environmental Toxicity and Chemistry  
LCA Life Cycle Assessment  
LCC Life Cycle Cost  
ISO International Standard Organization  
FU Functional Unit  
LCI Life Cycle Inventory  
EEM Energy Efficiency Measure

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https://ojs.aaai.org/

**The ICCEE Toolbox. A Holistic Instrument Supporting Energy Efficiency of Cold Food and Beverage Supply Chains**

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**Abstract:** Supply chains of food and beverage sectors represent one of the main drivers of energy consumption. Within this context, food quality issues, changes in energy use, environmental burdens, and the economic viability of farms are essential aspects to consider for improving cold supply chains. This paper presents a dedicated toolbox, developed within the Horizon for supporting decision-making and actors to assess energy efficiency type of food cold-supply (i.e., meat, fish, milk and cheese products, ...). More in specific the toolbox offers support for decision-makers to analyze the specific energy consumption, to decrease the overall (it even including non-energy benefit evaluation many times) separated tools merged within a unique toolbox consider different factors such as assessment of the whole energy requirements in stock by the storage impact, the logistics and quality losses over time. Life Cycle Assessment and Life Cycle costs within the environmental and of energy efficiency measures, based on a benchmarking approach, reach implementing Multi Criteria Analysis was developed on selected factors such as specific and cumulated energy consumptions, quality total burdens (i.e., global warming potential and water scarcity), the ICCEE toolbox is available as free downloadable package on the

energy efficiency; LCA; multi criteria analysis; non-energy

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Thank You!

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