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Proposal title: Supporting the Clean Energy Transition of the HORECA value chain

Deliverable 3.4 Report on the untapped potential of energy efficiency and renewables

Co-funded by the European Union

Summary

INTRODUCTION

The EE4HORECA project brings together 12 partners from 7 countries and focuses on the value chain approach to test and validate the economic viability of collaborative models in greening value chains and to propose benchmarks and standards inputting regulatory and policy improvements. All the activities are focused on supporting companies and staff in the implementation of energy efficiency measures, business models, and benchmarks for greening the HORECA value chain.

The project focuses its activities in the following NACE sectors: accommodation and food service activities (NACE Code: I55 to I56.3.0)

The present work is part of the WP3 that will propose business models and benchmarking for improving the sustainability of the value chain of the HORECA sector.

The overall objectives of the present WP aim to:

- Assess the relevant resource flows of the supply chain and define best practices to improve their sustainability.
- Develop an integrated economic model through a life cycle perspective with considerations of the non-energy benefits.
- Evaluate the untapped potential of energy efficiency and renewable at each step of the value chain once gathered data directly from the supply chain investigated.
- Create a benchmarking tool focused on energy use at the value chain level.

The present report investigates some case studies from the HORECA sector analyzing the energy performance of the current value chains, proposing key sustainable and energy-efficient solutions, and evaluating their impact on the specific value chain considered. Furthermore, challenges and recommendations will be discussed.

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METHODOLOGY

The methodological process used for assessing the untapped potential of energy efficiency and renewable energy in the HORECA sector has been defined in the D3.2 “Report on the integrated economic model with NEBs”. Specifically, one case study per key value chain of the sector (i.e., hotel, restaurant, catering service provider) is investigated.

To obtain comprehensive data and information regarding operational practices and energy consumption, a total of 19 companies were interviewed across the case studies (Table 1). The composition of the participating entities within each value chain is detailed below:

- Hotel Value Chain (Latvia): This chain included one hotel, one food and beverage supplier, one laundry service provider, and two transportation providers.
- Restaurant Value Chain (Spain): This chain comprised one restaurant, five food and beverage suppliers, one laundry service provider, and two transportation providers.
- Catering Service Value Chain (France): This chain consisted of one catering service, one food and beverage supplier, one laundry service provider, and two transportation providers.

Table 1. Companies interviewed for the proposed case studies

Case study	Food & Beverage Supplier	Laundry Service provider	Transportation provider	HORECA company
HOTEL Value Chain	1	1	2	1
RESTAURANT Value Chain	5	1	2	1
Catering Service Value Chain	1	1	2	1

The process consists of three steps to comprehensively assess and implement energy efficiency measures within a value chain:

Step 1: Value chain energy mapping and hot spot identification

Step 2: Economic feasibility assessment

Step 3: Strategic assessment of non-energy benefits

SUSTAINABILITY ASSESSMENT OF THE CURRENT SCENARIO ("AS-IS" SCENARIO)

Hotel value chain

The value chain of a 4-star hotel with cleaning, bar, restaurant, pool, spa, and gym services was analyzed (Figure 1). This hotel typically experiences 30,000 guest nights annually, with 60% occupancy during the low season and 90% during the high season. Key external suppliers include a laundry service and a food and beverage provider supplying dairy, vegetables, fruit, meat, ice cream, and canned goods. Transportation services are also outsourced. These external relationships significantly impact the hotel's overall energy performance.

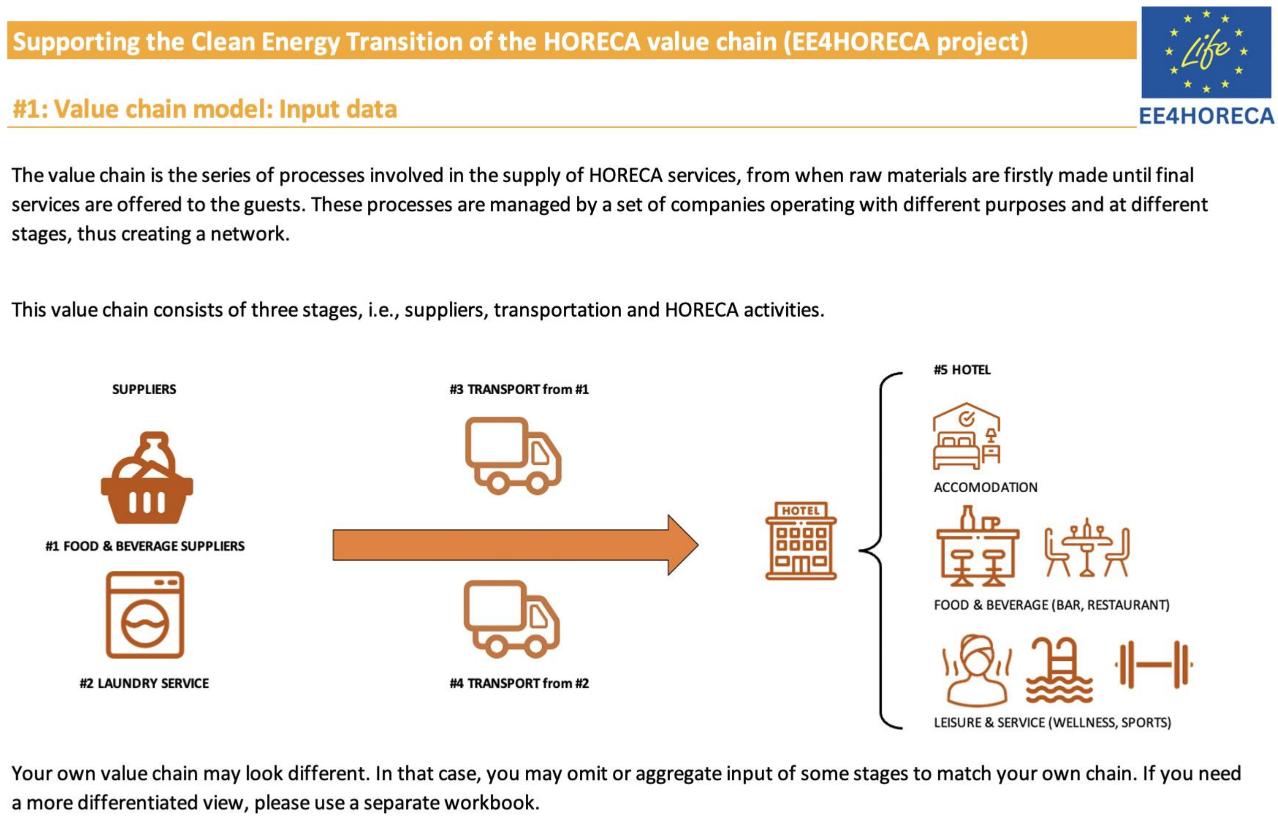


Figure 1. Boundaries of the Hotel Value Chain

The value chain under consideration exhibited a specific energy consumption of 52 kilowatt-hours per guest night. From an economic standpoint, the energy consumption of each guest night contributed €14.97 to the overall costs. In terms of environmental impact, the value chain emitted 13.83 kilograms of carbon dioxide per guest night. Table 2 and Figure 2 present the specific energy consumption per stage and per energy carrier.

Table 2. Performance of the Hotel Value Chain in the current scenario

Specific energy consumption per stage	Specific energy consumption by energy carriers [kWh/guest nights]					
	Electricity	Natural gas	Gas/Diesel oil	Liquified Petroleum Gas (LPG)	Motor spirit (petrol)	Total
#1: Food and Beverage supplier	5,333	1,078	2,725			**9,136**
#2: Laundry service	2,667	1,724	0,727	-	-	**5,117**
#3: Transport from stage #1	0,173	0,000	1,039	0,000	0,000	**1,212**
#4: Transport from stage #2	0,000	0,000	0,270	0,000	0,000	**0,270**
#5: Hotel	26,667	5,747	3,633	-	-	**36,047**
Total	**34,840**	**8,549**	**8,394**	**0,000**	**0,000**	**51,783**

Specific economic impact (EU-mix)	**14,965**	**€/guest night**
Specific environmental impact (EU-mix)	**13,828**	**kg CO2/guest night**

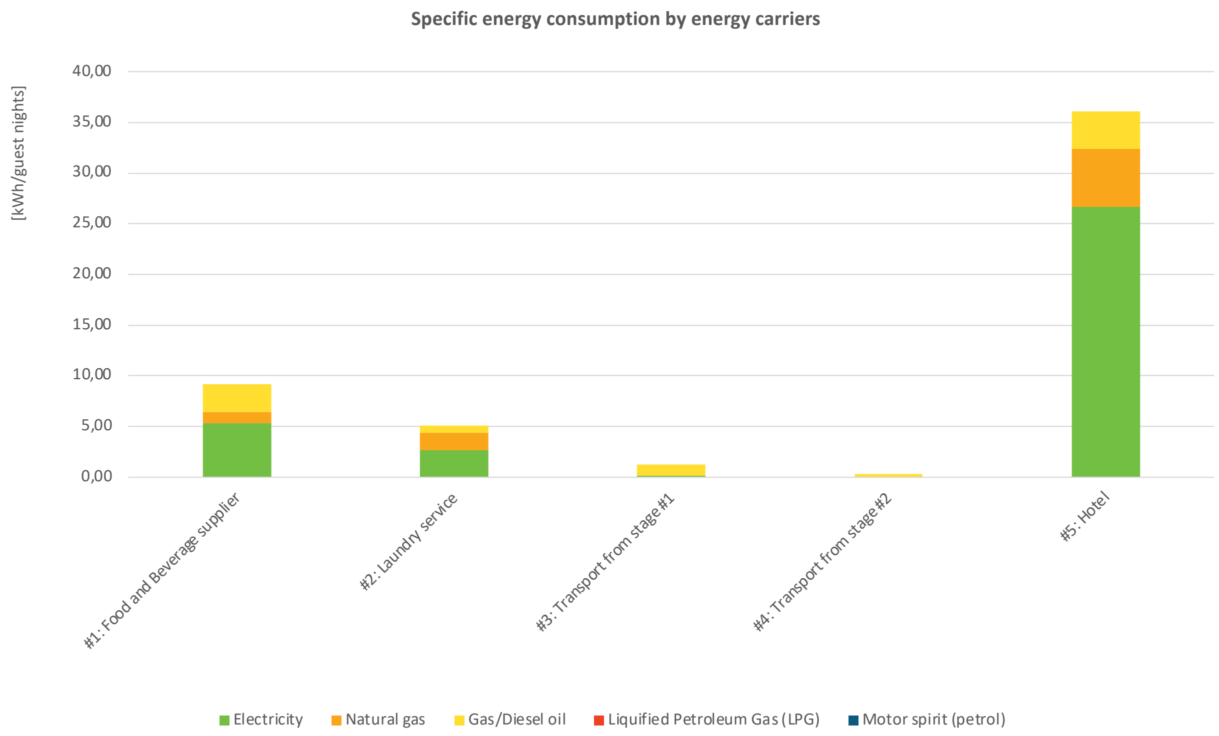


Figure 2. Specific energy consumption per stage and per energy carrier for the hotel value chain

The hotel itself emerged as the primary contributor to the overall energy consumption, accounting for a substantial 70%. Food and beverage suppliers followed, contributing 18% to the total energy usage. Lastly, the laundry service provider was responsible for 10% of the energy consumption.

Within the hotel, energy consumption is distributed across various operational areas (Figure 3a). Room loads, including lighting, heating, and cooling, constitute 30% of the hotel's energy use. Hot water generation, essential for laundry, cleaning, and guest amenities, accounts for 20% of the total energy consumption. Finally, HVAC systems, responsible for maintaining comfortable indoor temperatures, consume the remaining 20% of the hotel's energy.

Food and beverage suppliers allocate a significant portion of their energy consumption to refrigeration, accounting for 40% of their total energy use (Figure 3b). Processing activities, such as cooking, preparation, and packaging, consume an additional 30% of their energy.

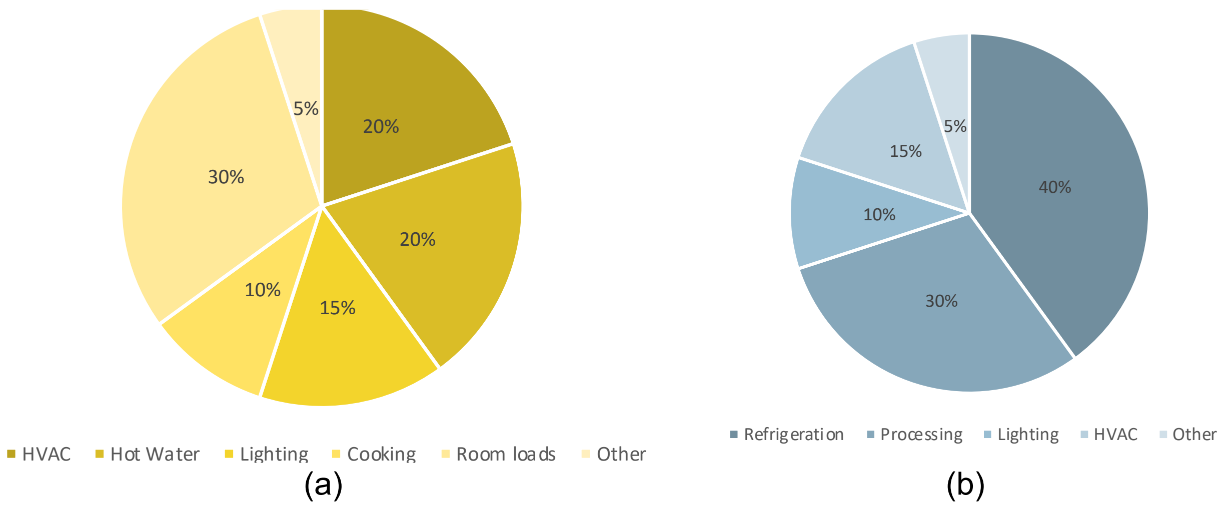


Figure 3. Energy usage for a) the hotel and b) the food and beverage supplier stages

After the analysis of the results, potential avenues for enhancing energy efficiency within the value chain were identified and prioritized. Given that, the focus was initially directed towards the supply chain stage which contributed the most significantly to overall energy consumption. Three specific measures were proposed, as outlined in Table 3.

Table 3. Energy efficiency measures for the hotel value chain

#	Supply chain stage	Energy efficiency measure	Category	Objective
1	Hotel	Installation of pool covers ad optimal management of pool and SPA operations	Internal equipment and services	↓ lower energy consumption for heat and electricity
2	Food and beverage supplier	Food waste reduction policy	Virtous behaviour	↓ energy for processing and transportation
3	Laundry service	Towel re-use programme	Management	↓energy load for cleaning towels

Restaurant value chain

The value chain of a restaurant with cleaning and bar internal services was analyzed (Figure 4). This restaurant typically experiences about 31,000 food covers annually, with an average 87% occupancy rate. Key external suppliers include a laundry service and some food and beverage providers (i.e., a vegetable and fruit provider, a bakery, two butchers, and a wholesaler). Transportation services are also outsourced. These external relationships significantly impact the restaurant's overall energy performance.

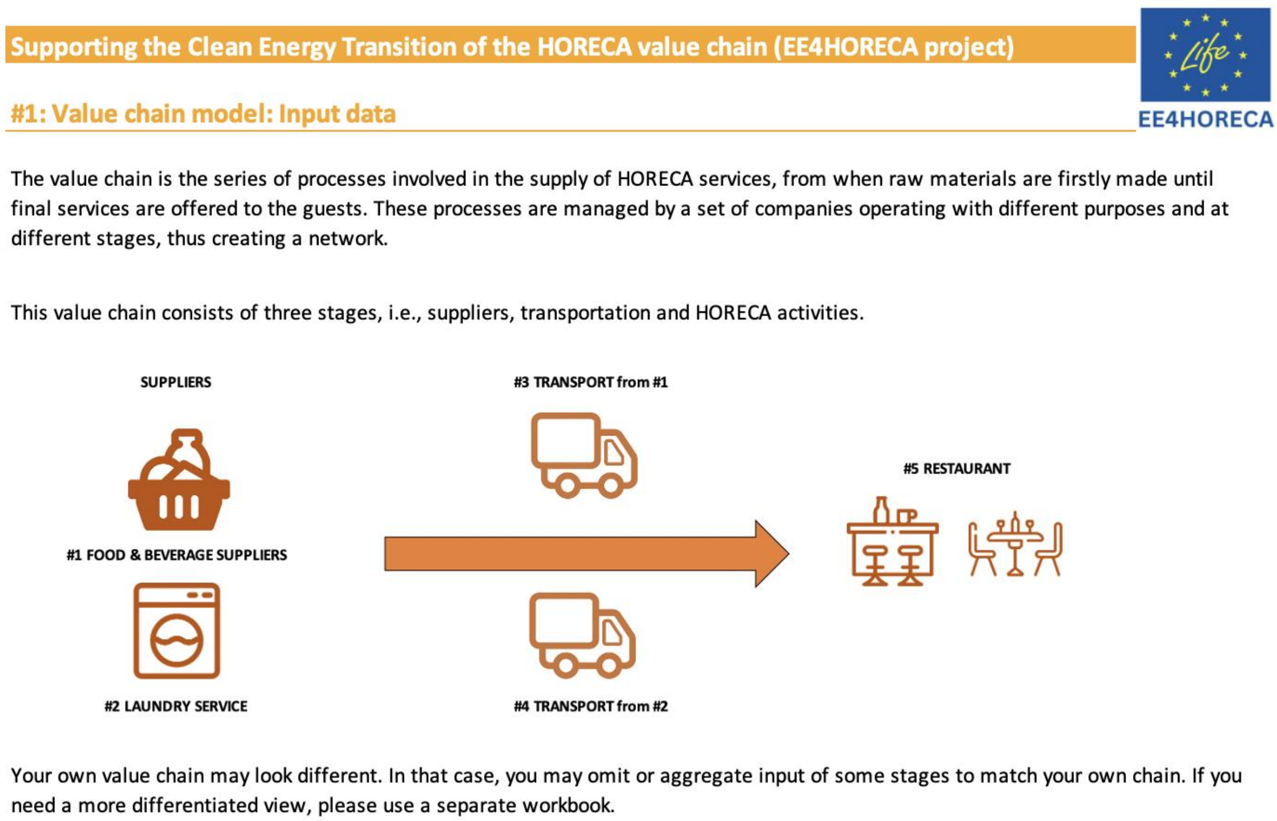


Figure 4. Boundaries of the restaurant value chain

The value chain demonstrates an average specific energy consumption of 12 kilowatt-hours (kWh) per food cover. In terms of economic impact, the energy consumption of each food cover contributes €3.4 to the overall cost of the value chain. From an environmental perspective, every food cover is associated with the emission of 3.2 kilograms (kg) of carbon dioxide (CO_2).

The restaurant emerges as the primary contributor to energy consumption, accounting for 41% of the total. This significant contribution is likely attributed to the energy-intensive processes involved in cooking, refrigeration, and lighting within the restaurant.

Food and beverage suppliers play a substantial role in the value chain's energy consumption, contributing 37%. The energy-intensive nature of food production, transportation, and storage within these suppliers is a major driving factor.

Transportation activities related to the delivery of food and beverages from suppliers to the restaurant account for 20% of the energy consumption. The energy required for transportation, such as fuel consumption for delivery vehicles, is a significant contributor to this portion of the value chain's energy footprint.

Table 4 and Figure 5 present the specific energy consumption per stage and per energy carrier.

Table 4. Performance of the Restaurant Value Chain in the Current Scenario

Specific energy consumption per stage	Specific energy consumption by energy carriers [kWh/food covers]						
	Electricity	Natural gas	Gas/Diesel oil	Liquified Petroleum Gas (LPG)	Motor spirit (petrol)	**Total**	
#1: Food and Beverage supplier	3,019	0,670	0,713			**4,402**	
#2: Laundry service	0,002	0,020	0,000	-	-	**0,022**	
#3: Transport from stage #1	0,691	0,000	1,740	0,000	0,000	**2,430**	
#4: Transport from stage #2	0,000	0,000	0,202	0,000	0,000	**0,202**	
#5: Restaurant	4,538	0,320	0,000	-	-	**4,858**	
Total	**8,250**	**1,009**	**2,655**	**0,000**	**0,000**	**11,914**	
				Specific economic impact (EU-mix)		**3,443**	**€/food cover**
				Specific environmental impact (EU-mix)		**3,218**	**kg CO2/food cover**

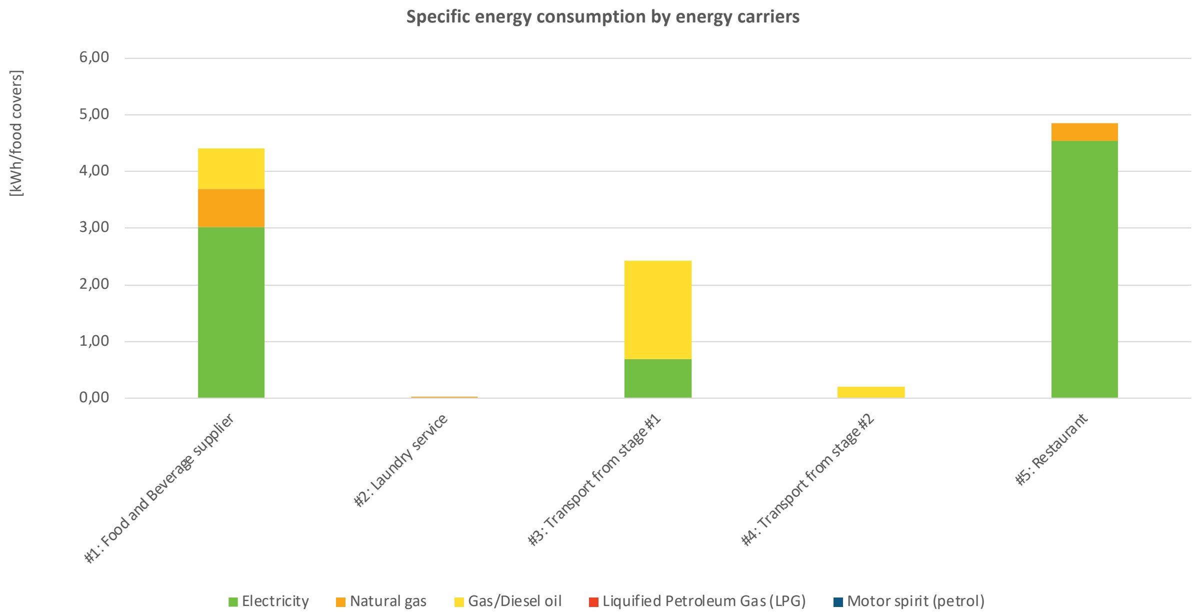
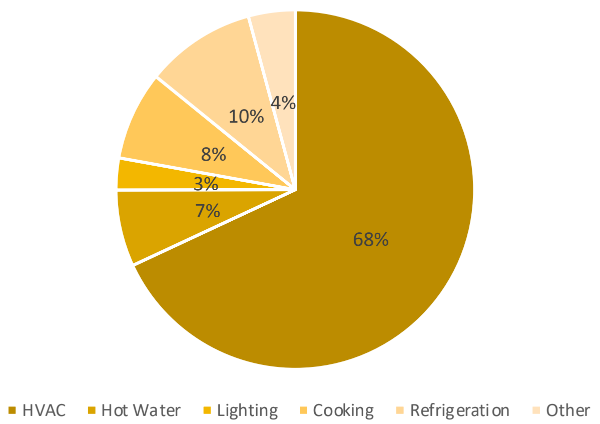
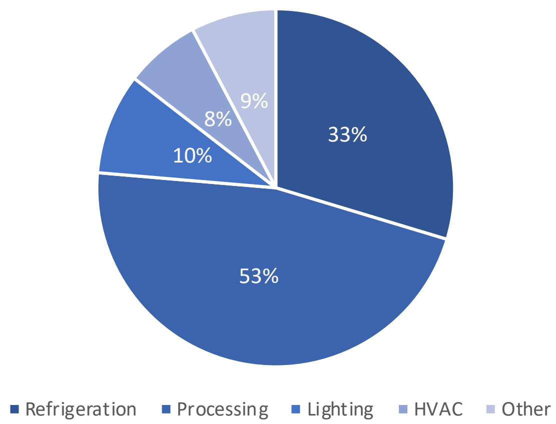


Figure 5. Specific energy consumption per stage and per energy carrier for the hotel value chain

The hotel itself emerged as the primary contributor to the overall energy consumption, accounting for a substantial 70%. Food and beverage suppliers followed, contributing 18% to the total energy usage. Lastly, the laundry service provider was responsible for 10% of the energy consumption. The restaurant's energy consumption is predominantly attributed to heating, ventilation, and air conditioning (HVAC), which accounts for 68% of its total energy usage (Figure 6a). Refrigeration, necessary for preserving food and beverages, constitutes the remaining 10% of the restaurant's energy consumption. Food and beverage suppliers primarily consume energy for processing and refrigeration (Figure 6b). Processing activities, such as food preparation, packaging, and preservation, account for 53% of their energy consumption. Refrigeration, essential for maintaining food quality and safety, constitutes 33% of their energy usage.





(a) (b)

Figure 6. Energy usage for a) the restaurant and b) the food and beverage supplier stages

After the analysis of the results, potential avenues for enhancing energy efficiency within the value chain were identified and prioritized. Given that, the focus was initially directed towards the supply chain stage which contributed the most significantly to overall energy consumption. Three specific measures were proposed, as outlined in Table 5.

Table 5. Energy Efficiency Measures for the Restaurant Value Chain

#	Supply chain stage	Energy efficiency measure	Category	Objective
1	Restaurant	Improved insulation (walls, rooftop, windows, pipes)	Buildings	↓ lower energy consumption for HVAC
2	Food and beverage supplier	Warehouse with separated compartments, with automated glide racks	Refrigeration	↓ refrigeration load requirement, air infiltration, and energy consumption
3	Transport from food and beverage suppliers	Alternate means of transport (e.g. portable refrigerated units for LTL) allowing combined deliveries for fresh, frozen, and ambient temperature products	Tranport	↓ total number of travel → ↓ fuel consumption

Catering service value chain

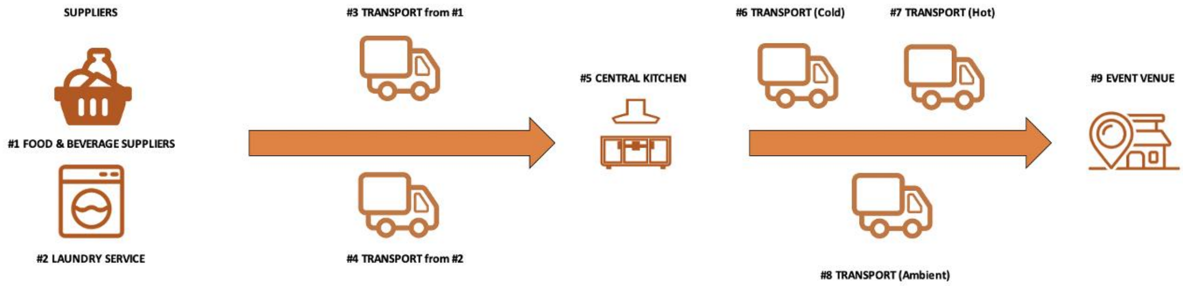
The value chain of a catering service provider which typically experiences 30,000 food covers annually (Figure 7) is analysed. Key external suppliers include a laundry service and a food and beverage provider supplying fresh, frozen and ambient temperature products. Transportation services are also outsourced. These external relationships significantly impact the catering value chain's overall energy performance.

Supporting the Clean Energy Transition of the HORECA value chain (EE4HORECA project)

#1: Value chain model: Input data

The value chain is the series of processes involved in the supply of HORECA services, from when raw materials are firstly made until final services are offered to the guests. These processes are managed by a set of companies operating with different purposes and at different stages, thus creating a network.

This value chain consists of three stages, i.e., suppliers, transportation and HORECA activities.



Your own value chain may look different. In that case, you may omit or aggregate input of some stages to match your own chain. If you need a more differentiated view, please use a separate workbook.

Figure 7. Boundaries of the catering value chain

The value chain under consideration exhibited a specific energy consumption of 39.5 kilowatt-hours per food cover. From an economic standpoint, the energy consumption related to each food cover contributed €11.42 to the overall costs. In terms of environmental impact, the value chain emitted 10.4 kilograms of carbon dioxide per guest night.

Table 6 and Figure 8 present the specific energy consumption per stage and energy carrier.

Table 6. Performance of the Catering Value Chain in the current scenario

Specific energy consumption per stage	Specific energy consumption by energy carriers [kWh/food covers]						
	Electricity	Natural gas	Gas/Diesel oil	Liquified Petroleum Gas (LPG)	Motor spirit (petrol)	**Total**	
#1: Food and Beverage supplier	12,727	1,829	3,468	-	-	**18,024**	
#2: Laundry service	4,267	2,759	1,163	-	-	**8,188**	
#3: Transport from stage #1	0,653	0,000	2,011	0,000	0,000	**2,664**	
#4: Transport from stage #2	0,000	0,000	0,252	0,000	0,000	**0,252**	
#5: Central Kitchen	3,333	0,920	0,727	-	-	**4,980**	
#6-8: Transport from central kitchen to the event venue	0,167	0,000	1,474	0,000	0,000	1,641	
#9: Event Venue	3,3333333	0,3333333	0,083	-	-	**3,750**	
Total	**24,480**	**5,840**	**9,177**	**0,000**	**0,000**	**39,498**	
			Specific economic impact (EU-mix)			**11,415**	**€/food cover**
			Specific environmental impact (EU-mix)			**10,402**	**kg CO2/food cover**

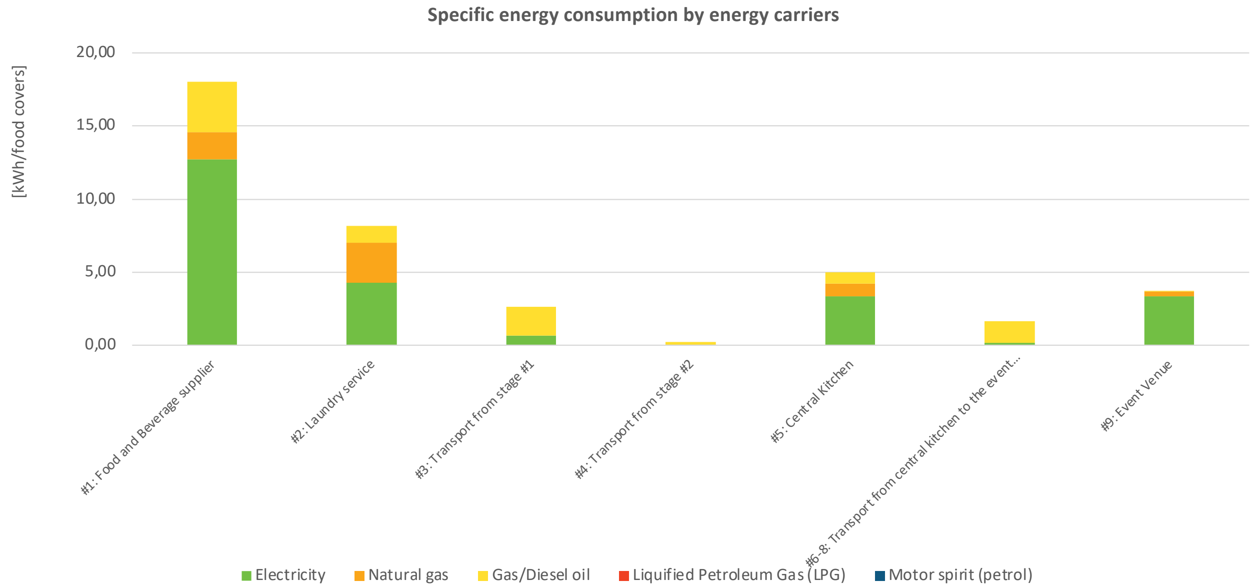


Figure 8. Specific energy consumption per stage and per energy carrier for the hotel value chain

Food and beverage suppliers represent the largest contributor to energy consumption within the value chain, accounting for 46% of the total. The transportation of food and beverages from the central kitchen to the event venue constitutes 26% of the energy consumption. Additionally, the laundry service provider contributes 21% to the overall energy usage. Within the catering service provider, energy consumption is distributed across various operational areas (Figure 9a). Cooking equipment, including stoves, ovens, and grills, consumes 19% of the energy. While lighting in food processing facilities, storage areas, and dining spaces accounts for 15% of the energy usage. Food and beverage suppliers allocate a significant portion of their energy consumption to refrigeration, accounting for 40% of their total energy use (Figure 9b). Processing activities, such as cooking, preparation, and packaging, consume an additional 30% of their energy.

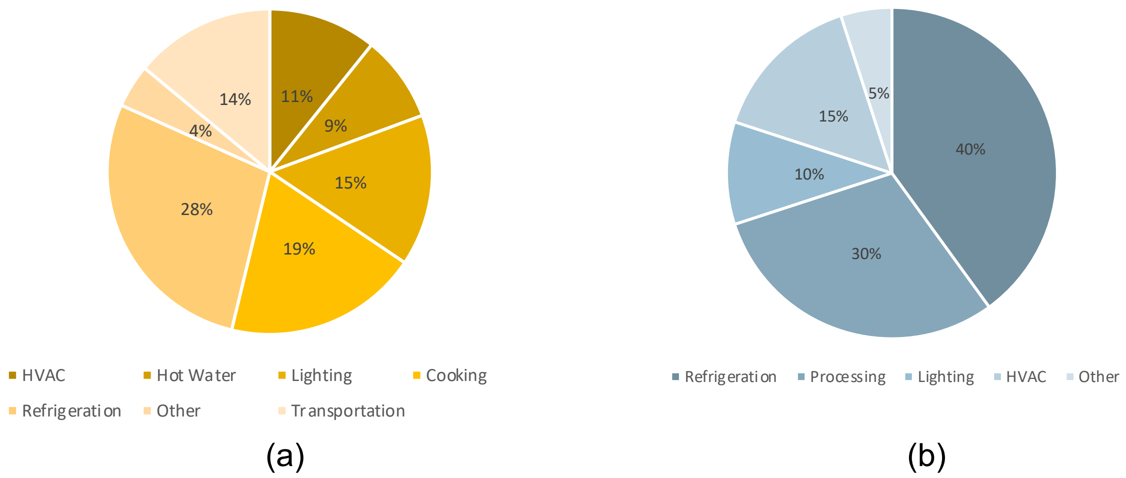


Figure 9. Energy usage for a) the catering service provider and b) the food and beverage supplier stages

After the analysis of the results, potential avenues for enhancing energy efficiency within the value chain were identified and prioritized. Given that, the focus was initially directed towards the supply chain stage which contributed the most significantly to overall energy consumption. Three specific measures were proposed, as outlined in Table 7.

Table 7. Energy efficiency measures for the catering value chain

#	Supply chain stage	Energy efficiency measure	Category	Objective
1	Food and beverage supplier	Retrofitting refrigeration system with natural refrigerant	Internal equipment and services	↓ Energy for refrigeration
2	Central kitchen + event venue	Energy-efficient technologies in food preparation, storage, and service at the central kitchen	Internal equipment and services	↓ Energy for processing and storing
3	Laundry service	Reduced laundry temperature and efficient laundry equipment	Management and equipment	↓ Load requirement and energy consumption

SUSTAINABILITY ASSESSMENT OF THE IMPROVED SCENARIO ("TO-BE" SCENARIO)

Hotel value chain

A comprehensive analysis of the three measures outlined in the preceding sections was conducted to assess their potential energy savings throughout the supply chain. Additionally, the corresponding impacts on costs and emissions were carefully evaluated. Table 8 summarizes the key findings.

If all three measures were implemented, a significant reduction of approximately 22% in specific energy consumption could be achieved. This reduction is calculated based on the energy consumption per guest night, considering all relevant actors within the value chain.

Table 8. Sustainability performance of the hotel value chain after the proposed interventions

Specific energy consumption per stage								
[kWh/guest night]	Intervention 1		Intervention 2		Intervention 3		ALL	
	Total	*Share*	*Total*	*Share*	*Total*	*Share*	*Total*	*Share*
#1: Food and Beverage supplier	9,136	18,7%	6,852	13,8%	9,136	18,6%	6,852	16,9%
#2: Laundry service	5,117	10,5%	5,120	10,3%	2,560	5,2%	2,560	6,3%
#3: Transport from stage #1	1,212	2,5%	1,212	2,4%	1,212	2,5%	1,212	3,0%
#4: Transport from stage #2	0,270	0,6%	0,270	0,5%	0,270	0,5%	0,270	0,7%
#5: Restaurant	29,564	67,8%	36,048	72,8%	36,048	73,2%	29,564	73,1%

KPI	Total	Δ	Total	Δ	Total	Δ	Total	Δ	
Specific energy consumption	**45,300**	-12,5%	**49,502**	-4,4%	**49,226**	-4,9%	**40,458**	-21,9%	**kWh/guest night**
Specific economic impact (EU-mix)	**13,092**	-12,5%	**14,305**	-4,4%	**14,226**	-4,9%	**11,692**	-21,9%	**€/guest night**
Specific environmental impact (EU-mix)	**12,025**	-13,0%	**13,232**	-4,3%	**13,183**	-4,7%	**10,835**	-21,6%	**kg CO2/guest night**

A comprehensive life cycle cost analysis was conducted on the three proposed energy efficiency measures. This analysis considered not only the potential energy savings but also the associated profit generation, investment requirements, and ongoing energy costs.

As illustrated in Table 9, the installation of pool covers in conjunction with optimized management of pool and spa operations emerged as the most financially viable measure. This measure exhibited the highest net present value, indicating a favorable return on investment over the long term.

While the food waste reduction policy and towel reuse program may have demonstrated higher internal rates of return and profit indices due to their relatively low investment costs, the overall economic benefits of the pool cover, and optimized pool/spa management were more substantial over the 20 years of analysis.

Table 9. Life cycle cost analysis of the proposed interventions for the hotel value chain

	Without measure	EEM1	EEM2	EEM3	
Unit operation costs	14,97	13,09	14,31	14,23	[Euro/unit]
Net present value	25.137.826 €	25.431.065 €	25.245.406 €	25.259.335 €	[Euro]
Internal rate of return		7473%	27144%	27159%	[%]
Profit index		366,87	1333,27	1334,01	[-]

While energy efficiency is a cornerstone of optimizing pool and spa operations, it is important to recognize the numerous non-energy benefits that can significantly enhance the overall guest experience and facility performance, mainly related to improved water quality, enhanced guest comfort, environmental benefits, and financial benefits (see Table 10).

Table 10. Non-energy benefits of optimizing pool and spa operations in the hotel

IMPROVED WATER QUALITY	• Reduced Chemical Usage: Optimized filtration systems can effectively remove contaminants, minimizing the need for excessive chemical treatments. This results in cleaner, healthier water for guests and a more pleasant swimming environment. • Enhanced Water Clarity: Efficient filtration ensures clear, inviting pool and spa water, enhancing the facility's aesthetic appeal.
ENHANCED GUEST COMFORT	• Consistent Water Temperature: Optimized heating schedules maintain comfortable water temperatures throughout the day, ensuring a pleasurable swimming experience for guests. • Reduced Maintenance Disruptions: Minimizing equipment breakdowns and maintenance issues through optimized operations reduces disruptions to guest enjoyment and improves overall satisfaction.
ENVIRONME NTAL BENEFITS	• Reduced Water Waste: Efficient filtration systems help minimize water loss due to evaporation or leaks,contributing to water conservation efforts. • Improved Air Quality: Well-maintained pools and spas can enhance indoor air quality by reducing mold and mildew growth.
FINANCIAL BENEFITS	• Increased Guest Satisfaction: A more enjoyable and comfortable swimming experience can lead to increased guest satisfaction, repeat business, and ultimately, higher revenue. • Reduced Maintenance Costs: Efficient equipment and reduced chemical usage can result in lower maintenance expenses over time

Beyond the environmental and economic advantages associated with reducing food waste, implementing such a policy can offer several additional benefits:

- Enhanced Food Safety: Minimizing food waste reduces the risk of foodborne illnesses by ensuring proper food storage and handling.
- Improved Brand Reputation: Consumers increasingly value sustainability and ethical practices. A hotel that actively reduces food waste demonstrates a commitment to environmental responsibility, enhancing its brand image and attracting environmentally conscious guests.
- Increased Customer Satisfaction: Reduced food waste ensures guests consistently receive high-quality, fresh food, leading to increased satisfaction and positive reviews.
- Strengthened Community Ties: Participating in initiatives to donate excess food to local food banks or charities can contribute to the community and strengthen the hotel's social impact.
- Employee Engagement: A food waste reduction policy can foster teamwork and employee engagement, creating a positive work environment and encouraging employees to take pride in their contributions to sustainability.

A towel reuse program offers several non-energy benefits that can significantly impact a hotel's operations and sustainability:

- Environmental Impact: Reduced water and chemical usage can minimize the environmental impact of laundry operations, particularly in regions with water scarcity or high water costs.
- Operational Efficiency: Fewer laundry loads reduce the workload for laundry staff, leading to increased efficiency and potentially lower labor costs. Reduced wear and tear on towels can also extend their lifespan, reducing the need for frequent replacements.
- Guest Satisfaction: Many guests appreciate hotels that take steps to reduce their environmental impact. A towel reuse program demonstrates a commitment to sustainability and can provide a more personalized service by offering guests the option to reuse towels.
- Cost Savings: Decreased water, energy, and chemical usage can lead to substantial cost savings for the hotel,ultimately contributing to increased profitability.

Restaurant value chain

A comprehensive analysis of the three measures outlined in the preceding sections was conducted to assess their potential energy savings throughout the supply chain. Additionally, the corresponding impacts on costs and emissions were carefully evaluated. Table 11 summarizes the key findings.

If all three measures were implemented, a significant reduction of approximately 18% in specific energy consumption could be achieved. This reduction is calculated based on the energy consumption per guest night, considering all relevant actors within the value chain.

Table 11. Sustainability performance of the restaurant value chain after the proposed interventions

Specific energy consumption per stage									
[kWh/food cover]	Intervention 1		Intervention 2		Intervention 3		ALL		
	Total	*Share*	*Total*	*Share*	*Total*	*Share*	*Total*	*Share*	
#1: Food and Beverage supplier	4,402	40,2%	3,647	32,7%	4,402	38,3%	3,647	37,3%	
#2: Laundry service	0,022	0,2%	0,022	0,2%	0,022	0,2%	0,022	0,2%	
#3: Transport from stage #1	2,430	22,2%	2,430	21,8%	2,019	17,6%	2,019	20,7%	
#4: Transport from stage #2	0,202	1,8%	0,202	1,8%	0,202	1,8%	0,202	2,1%	
#5: Restaurant	3,886	35,5%	4,858	43,5%	4,858	42,2%	3,886	39,8%	
KPI	**Total**	**Δ**	**Total**	**Δ**	**Total**	**Δ**	**Total**	**Δ**	
Specific energy consumption	**10,943**	-8,2%	**7,513**	-36,9%	**11,503**	-3,5%	**9,776**	-17,9%	**kWh/food cover**
Specific economic impact (EU-mix)	**3,162**	-8,2%	**3,225**	-6,3%	**3,324**	-3,5%	**2,825**	-17,9%	**€/food cover**
Specific environmental impact (EU-mix)	**2,937**	-8,7%	**2,995**	-6,9%	**3,075**	-4,4%	**2,572**	-20,1%	**kg CO2/food cover**

A comprehensive life cycle cost analysis was conducted on the three proposed energy efficiency measures. This analysis considered not only the potential energy savings but also the associated profit generation, investment requirements, and ongoing energy costs.

As illustrated in Table 12, the use of a portable refrigerated unit during transportation emerged as the most financially viable measure. This measure exhibited the highest net present value, internal rate of return, and profit index, indicating a favorable return on investment over the long term.

Table12. Life cycle cost analysis of the proposed interventions for the restaurant value chain

	Without measure	**EEM1**	**EEM2**	**EEM3**	
Unit operation costs	3,44	3,16	3,23	3,32	[Euro/unit]
Net present value	5.285.545 €	5.257.835 €	5.031.877 €	5.285.730 €	[Euro]
Internal rate of return		1151%	301%	4280%	[%]
Profit index		56,29	14,53	210,03	[-]

Beyond their energy efficiency advantages, active refrigerated containers offer a multitude of non-energy benefits that can significantly enhance supply chain efficiency, reduce costs, and improve overall operations.

- Enhanced Product Quality: By maintaining optimal temperature and humidity levels, active refrigerated containers help preserve the freshness and quality of perishable goods, ensuring that they arrive at their destination in excellent condition. This can lead to increased customer satisfaction and reduced product returns.
- Reduced Food Waste: By minimizing temperature fluctuations and preventing spoilage, active refrigerated containers can help reduce food waste, leading to cost savings and environmental benefits.
- Improved Supply Chain Visibility: Many active refrigerated containers are equipped with advanced tracking and monitoring systems that provide real-time data on temperature, humidity, and location. This enhanced visibility allows for better supply chain management, proactive issue resolution, and improved customer service.
- Reduced Environmental Impact: By optimizing transportation routes and minimizing the need for multiple handling and transfers, active refrigerated containers can help reduce the overall environmental footprint of the supply chain. This includes reduced fuel consumption, emissions, and waste generation.
- Increased Operational Efficiency: The versatility and efficiency of active refrigerated containers can streamline operations, reduce labor costs, and improve overall productivity. This can lead to increased profitability and a competitive advantage.

In addition to these benefits, active refrigerated containers can also contribute to:

- Improved food safety: By maintaining strict temperature controls, these containers can help prevent foodborne illnesses and ensure the safety of perishable products.
- Enhanced brand reputation: A reliable and efficient supply chain, supported by active refrigerated containers, can strengthen a company's brand reputation and customer trust.
- Increased market access: The ability to transport perishable goods safely and efficiently over long distances can open up new markets and expand business opportunities.

Beyond the significant energy savings associated with improved insulation, several other non-energy benefits can enhance the overall performance and sustainability of restaurant buildings. Details are provided in Table 13.

Table 13. Non-energy benefits of improved insulation in the restaurant

IMPROVE D INDOOR COMFOR	• Temperature Control: Effective insulation helps maintain a comfortable indoor temperature throughout the year, reducing the need for excessive heating or cooling. This ensures that guests and staff are always comfortable, leading to a more enjoyable dining experience.

INCREASED OPERATION EFFICIENCY	• Reduced Maintenance Costs: Improved insulation can help to prevent moisture buildup and mold growth, reducing the need for costly maintenance and repairs. • Enhanced Durability: Well-insulated buildings can be more resistant to the elements, helping to prolong their lifespan and reduce the need for costly renovations.
ENVIRONMENTAL BENEFITS	• Reduced Carbon Footprint: By reducing energy consumption, improved insulation can help to reduce a restaurant's carbon footprint and contribute to environmental sustainability. • Improved Resource Efficiency: By reducing the need for excessive heating and cooling, improved insulation can help to conserve resources such as water and electricity.
FINANCIAL BENEFITS	• Increased Property Value: A well-insulated restaurant building can be more valuable and attractive to potential buyers or tenants. • Improved ROI: The long-term cost savings associated with improved insulation can lead to a higher return on investment for restaurant owners.

Non-energy benefits of a Warehouse with Separated Compartments and Automated Glide Racks are mainly improved inventory management, enhanced efficiency and productivity, improved product quality and safety, and environmental benefits. Details are provided in Table 14.

Table 14. Non-energy benefits of warehouse with separated compartments and automated glide racks at the food and beverage suppliers

IMPROVED INVENTORY MANAGEMENT	• Enhanced Organization: Separated compartments provide a clear and organized storage system, facilitating easy identification and retrieval of products. • Reduced Product Mixing: Automated glide racks minimize the risk of product mixing, preventing cross-contamination and ensuring accurate inventory records. • Accurate Stock Levels: The automated system can provide real-time inventory data, enabling precise stock level management and avoiding stockouts or overstocking.

ENHANCED EFFICIENCY AND PRODUCTIVITY	• Faster Order Fulfillment: Automated glide racks allow for quick and efficient retrieval of products, speeding up order fulfillment processes and improving customer satisfaction. • Reduced Labor Costs: The automated system can reduce the need for manual labor, leading to cost savings and increased productivity. • Improved Space Utilization: Separated compartments and automated glide racks optimize storage space,maximizing the warehouse's capacity and minimizing the need for additional facilities.
IMPROVED PRODUCT QUALITY AND SAFETY	• Reduced Product Damage: Automated glide racks handle products gently, minimizing damage and spoilage. • Enhanced Food Safety: Separated compartments help prevent cross-contamination between different food items, ensuring food safety and compliance with regulatory standards. • Improved Product Traceability: The automated system can track product movements and history, facilitating product recalls and ensuring traceability in case of quality issues.
ENVIRONMEN TAL BENEFITS	• Reduced Waste: Efficient inventory management and reduced product damage can minimize waste and reduce the environmental impact of the warehouse operations. • Improved Sustainability: By optimizing storage and reducing energy consumption, the warehouse can contribute to a more sustainable supply chain.

Catering service value chain

A comprehensive analysis of the three measures outlined in the preceding sections was conducted to assess their potential energy savings throughout the supply chain. Additionally, the corresponding impacts on costs and emissions were carefully evaluated. Table 15 summarizes the key findings.

If all three measures were implemented, a significant reduction of approximately 22.3% in specific energy consumption could be achieved. This reduction is calculated based on the energy consumption per guest night, considering all relevant actors within the value chain.

Table 15. Sustainability performance of the catering service value chain after the proposed interventions

Specific energy consumption per stage									
[kWh/food cover]	Intervention 1		Intervention 2		Intervention 3		ALL		
	Total	Share	Total	Share	Total	Share	Total	Share	
#1: Food and Beverage supplier	12,617	44,0%	18,024	47,2%	18,024	48,2%	12,617	41,1%	
#2: Laundry service	8,188	28,5%	8,188	21,4%	6,080	16,3%	6,080	19,8%	
#3: Transport from stage #1	2,664	9,3%	2,664	7,0%	2,664	7,1%	2,664	8,7%	
#4: Transport from stage #2	0,252	0,9%	0,252	0,7%	0,252	0,7%	0,252	0,8%	
#5: Central Kitchen	4,980	17,4%	3,704	9,7%	4,980	13,3%	3,704	12,1%	
#6: Transport to the event venue (Fresh proc	0,503	1,8%	0,503	1,3%	0,503	1,3%	0,503	1,6%	
#7: Transport to the event venue (Hot produ	0,827	2,9%	0,827	2,2%	0,827	2,2%	0,827	2,7%	
#8: Transport to the event venue (Pproduct	0,311	1,1%	0,311	0,8%	0,311	0,8%	0,311	1,0%	
#6-8: Transport from central kitchen to the	1,641	5,7%	1,641	4,3%	1,641	4,4%	1,641	5,3%	
#9: Event Venue	3,750	13,1%	3,750	9,8%	3,750	10,0%	3,750	12,2%	
KPI	**Total**	**Δ**	**Total**	**Δ**	**Total**	**Δ**	**Total**	**Δ**	
Specific energy consumption	**34,091**	-13,7%	**38,222**	-3,2%	**37,390**	-5,3%	**30,707**	-22,3%	**kWh/food cover**
Specific economic impact (EU-mix)	**10,113**	-11,4%	**11,046**	-3,2%	**10,806**	-5,3%	**8,874**	-22,3%	**€food cover**
Specific environmental impact (EU-mix)	**9,182**	-11,7%	**10,052**	-3,4%	**9,859**	-5,2%	**8,076**	-22,4%	**kg CO2/food cover**

A comprehensive life cycle cost analysis was conducted on the three proposed energy efficiency measures. This analysis considered not only the potential energy savings but also the associated profit generation, investment requirements, and ongoing energy costs.

As illustrated in Table 16, the retrofitting of the refrigeration system at the food and beverage supplier with natural refrigerant emerged as the most financially viable measure. This measure exhibited the highest net present value, indicating a favorable return on investment over the long term.

While installing energy-efficient technologies in food preparation, storage, and service at the central kitchen and reduced laundry temperature and efficient laundry equipment at the laundry service provider may have demonstrated higher internal rates of return and profit indices due to their relatively lower investment costs, the overall economic benefits of the refrigeration system were more substantial over the 20 years of analysis.

Table 16. Life cycle cost analysis of the proposed interventions for the catering service value chain

	Without measure	**EEM1**	**EEM2**	**EEM3**	
Unit operation costs	11,41	10,11	11,05	10,81	[Euro/unit]
Net present value	7.182.931 €	7.380.178 €	7.225.930 €	7.285.555 €	[Euro]
Internal rate of return		2664%	4679%	11762%	[%]
Profit index		130,64	229,63	577,60	[-]

Beyond the energy consumption and cost savings associated with using a natural refrigerant, retrofitting a refrigeration system can offer several additional benefits, as defined in Table 17.

Table 17. Non-energy benefits of retrofitting the refrigeration system with natural refrigerant

ENVIRONMENTAL BENEFITS	• Reduced Greenhouse Gas Emissions: Natural refrigerants have a significantly lower global warming potential (GWP) compared to traditional synthetic refrigerants, contributing to reduced greenhouse gas emissions and mitigating climate change. • Improved Air Quality: Natural refrigerants are often non-toxic and do not contribute to ozone depletion,improving air quality and reducing the risk of respiratory problems.
OPERATIONAL BENEFITS	• Increased System Reliability: Natural refrigerants can often lead to improved system reliability and efficiency due to their physical properties and compatibility with existing refrigeration equipment. • Reduced Maintenance Costs: Natural refrigerants may require less frequent maintenance and repairs compared to synthetic refrigerants, leading to long-term cost savings.
REGULATORY COMPLIANCE	• Adherence to Environmental Regulations: Retrofitting to a natural refrigerant can help businesses comply with increasingly stringent environmental regulations regarding refrigerant use.
BRAND REPUTATION AND CUSTOMER PERCEPTION	• **Enhanced Corporate Image:** Adopting a natural refrigerant can improve a company's brand reputation and demonstrate a commitment to sustainability and environmental responsibility. • **Attracting Eco-Conscious Customers:** Many consumers are increasingly aware of environmental issues and prefer to support businesses that prioritize sustainability. By retrofitting to a natural refrigerant, a company can appeal to this growing market segment.

When combined with a photovoltaic (PV) system, retrofitting to a natural refrigerant can offer even greater benefits:

- **Energy Independence:** A PV system can generate renewable energy on-site, reducing reliance on the grid and potentially achieving energy independence.
- **Cost Savings:** By generating electricity, a business can reduce its energy costs and increase profitability.
- **Enhanced Sustainability:** Combining renewable energy with natural refrigerant further strengthens a company's commitment to sustainability and environmental responsibility.

While energy efficiency is a significant advantage of adopting these technologies, numerous non-energy benefits can enhance the overall operations of a central kitchen (Table 18).

Table 18. Non-energy benefits of energy-efficient technologies in the central kitchen of a catering service provider

IMPROVED FOOD QUALITY	• Preservation of Nutrients: Energy-efficient refrigeration and storage systems can help preserve the nutritional value and freshness of food, ensuring that meals delivered to customers are of the highest quality. • Reduced Food Waste: Efficient equipment can minimize food spoilage, leading to less waste and reduced costs.
ENHANCED FOOD SAFETY	• Improved Hygiene: Energy-efficient cooking and cleaning equipment can help maintain a clean and hygienic kitchen environment, reducing the risk of foodborne illnesses. • Accurate Temperature Control: Precise temperature control in refrigeration and cooking equipment is essential for food safety. Energy-efficient technologies can ensure accurate temperature maintenance.
OPERATIONAL EFFICIENCY AND PRODUCTIVITY	• Reduced Maintenance: Energy-efficient equipment often requires less maintenance, reducing downtime and improving operational efficiency. • Improved Workflow: Efficient equipment can streamline processes and improve workflow, leading to increased productivity and faster order fulfillment. • Cost Savings: While energy efficiency is a significant factor, reduced maintenance, less food waste, and improved operational efficiency can also contribute to overall cost savings.
ENHANCED CUSTOMER SATISFAC	• Consistent Quality: Energy-efficient technologies can help ensure consistent food quality, leading to satisfied customers and repeat business. • Faster Service: Efficient operations can result in faster order fulfillment and delivery times, improving customer satisfaction.
ENVIRONMENTAL BENEFITS	• Reduced Carbon Footprint: Beyond energy savings, energy-efficient technologies can contribute to a reduced carbon footprint for the catering provider. • Improved Sustainability: By adopting sustainable practices, catering providers can enhance their reputation and attract environmentally conscious customers.

Also implementing reduced laundry temperatures and efficient laundry equipment can offer several additional benefits beyond energy savings:

- Preservation of Fabric Integrity: Lower water temperatures can help maintain the integrity of fabrics, reducing shrinkage, fading, and wear and tear. This can extend the lifespan of textiles and reduce the need for frequent replacements.
- Improved Fabric Quality: Lower temperatures can prevent fabrics from becoming rough or stiff, ensuring that they remain soft and comfortable to wear.

- Reduced Chemical Exposure: Using lower water temperatures and energy-efficient equipment can reduce the amount of detergent and other chemicals needed for cleaning, minimizing the risk of skin irritation and allergies.
- Improved Water Conservation: By using less hot water, businesses can reduce their overall water consumption,contributing to water conservation efforts and reducing water bills.
- Enhanced Sustainability: Implementing these measures demonstrates a commitment to sustainability and environmental responsibility, which can improve a company's brand image and attract environmentally conscious customers.
- Reduced Noise Pollution: Modern, energy-efficient laundry equipment often incorporates noise reduction features,minimizing noise pollution and creating a more pleasant working environment.
- Improved Employee Morale: A more efficient and sustainable laundry operation can contribute to a positive work environment, boosting employee morale and productivity.

DISCUSSION

This section presents a comparative analysis of the findings from living labs and working groups conducted with French, German, Italian, Latvian, and Spanish companies, focusing on the challenges and opportunities for enhancing energy efficiency within the HORECA value chain.

Collaboration and Value Chain Optimization

The establishment of collaborative relationships among value chain actors emerged as a critical factor in addressing energy efficiency challenges. By fostering collaboration through shared expertise, resources, and best practices, achieving cost efficiencies via group purchasing, and enhancing market visibility through unified marketing efforts, HORECA businesses could collectively achieve greater energy savings. However, building trust and overcoming logistical hurdles were identified as key challenges to effective collaboration.

Successful business models were characterized by a strong emphasis on shared value creation, such as group purchasing platforms, platforms for sustainable product selection, energy service companies, joint ventures, energy communities, shared logistics, and joint investments in energy efficiency projects.

These models demonstrate the value of collaboration in achieving sustainability and cost reductions.

Challenges Across Regions

Across all regions, a consistent challenge was identified in the lack of time, internal expertise, and resources (e.g., internal energy monitoring and data analysis) dedicated to energy management within HORECA establishments. This limitation hindered the implementation of effective energy efficiency measures. Furthermore, financial constraints and the complexity of regulatory frameworks posed significant obstacles to investment in energy-saving technologies.

Other challenges included the intense price competition, the high upfront costs for energy-efficient technologies, the shortage of skilled labor, the lack of information and infrastructure, the lack of knowledge sharing and peer feedback to find partners, and the seasonality.

Furthermore, the diverse scale of the companies participating in the collaboration creates significant challenges. This is particularly evident in sectors like transportation and food and beverage suppliers, where accommodating the needs of smaller businesses can be problematic.

Best Practices and Transferability

While varying challenges were encountered, several promising practices have also been identified that could be replicated elsewhere. Adopting energy-efficient technologies, such as LED lighting, water-saving fixtures, and advanced heating and cooling systems, demonstrated tangible benefits. Additionally, the importance of staff training and guest awareness programs in influencing energy consumption patterns was evident. Other identified areas of potential are flow reduction devices, intelligent window controls, circuit breaker enhancements, efficient water heating systems, partial vacancy-based energy management (i.e., during periods of partial vacancy, group customers should be put together on the same floor or in the same zone and heat only the occupied areas), voltage optimization technologies, ventilation monitoring systems, water-saving showerheads, AI-driven organic waste management, advanced room automation, and electric delivery vehicles.

The transferability of these practices was contingent upon factors such as the specific characteristics of the local market, the technical compatibility, the upfront costs, the availability of financial incentives, and the regulatory environment. The successful replication of energy-efficient practices across the HORECA sector is influenced by several key factors, among which:

- Contextual Factors: Local market conditions, building characteristics, climate, and regional energy prices can significantly impact the feasibility of transferring specific practices.
- Technological Compatibility: The integration of new technologies with existing infrastructure and systems is crucial for successful implementation.
- Financial Considerations: Upfront investment costs, the availability of financial incentives, and ongoing operational expenses can influence the adoption of energy-efficient measures.
- Regulatory Environment: Supportive policies and regulations can facilitate the adoption of good practices, while restrictive frameworks may hinder implementation.
- Organizational Capacity: The availability of skilled personnel, access to knowledge and information, and organizational readiness are essential for successful transfer.
- Guest Behavior: The willingness of guests to adopt energy-saving behaviors can impact the effectiveness of certain practices, such as reducing water consumption or optimizing room temperature.

Examples of potential strategies to enhance transferability are:

- Knowledge Sharing: Facilitating the exchange of best practices and lessons learned through industry networks, conferences, and online platforms.
- Pilot Projects: Implementing pilot projects to test the feasibility and effectiveness of new practices in different contexts.
- Financial Incentives: Providing financial support, such as grants or low-interest loans, to encourage the adoption of energy-efficient technologies.
- Capacity Building: Offering training and technical assistance to HORECA establishments to enhance their capabilities in energy management.
- Standardization: Developing standardized methodologies and performance indicators for assessing energy efficiency.

- Policy Alignment: Advocating for supportive policies and regulations that create a favorable environment for energy-efficient investments.

Recommendations

To significantly reduce the environmental footprint and operational costs of the HORECA sector, a comprehensive approach incorporating human capital development, financial incentives, collaboration, knowledge sharing, technology, sustainable practices, and supportive policies is essential.

The main strategic recommendations are:

- Invest in Human Capital: Equip HORECA staff with the necessary skills and knowledge to manage energy consumption effectively through targeted training programs, certifications, and on-the-job coaching.
- Facilitate Financial Support: Expand access to a variety of financial incentives, such as grants, loans, and tax breaks, to encourage investments in energy-efficient equipment, technologies, and building retrofits.
- Foster Industry Collaboration: Create platforms for collaboration among HORECA businesses, suppliers, distributors, and energy service providers to share best practices, develop joint energy efficiency projects, and leverage economies of scale.
- Promote Knowledge Sharing: Establish knowledge-sharing networks and platforms to disseminate information about innovative energy-saving technologies, case studies, and policy developments.
- Leverage Technology: Utilize advanced digital tools and technologies to monitor energy consumption, identify inefficiencies, optimize operations, and enable data-driven decision-making.
- Implement Sustainable Practices: Integrate sustainable practices throughout the value chain, including waste reduction, recycling, procurement of eco-friendly products, and responsible sourcing.
- Support Policy Development: Advocate for supportive policies and regulations that create a favorable environment for energy efficiency investments, such as energy performance standards, feed-in tariffs, and carbon pricing.

Hereafter, some specific action areas for improving the energy efficiency of the HORECA value chains are reported:

- Optimize Energy Consumption: Implement advanced energy monitoring systems, conduct regular energy audits, and identify opportunities for reducing energy waste in areas such as lighting, heating, ventilation, and air conditioning.
- Enhance Cold Chain Efficiency: Improve energy efficiency in food and beverage transportation by adopting electric vehicles, optimizing delivery routes, and investing in high-performance refrigeration equipment.
- Promote Sustainable Laundry Practices: Upgrade to high-efficiency laundry equipment, implement water and energy-saving washing cycles, and optimize laundry schedules.

- Strengthen Supplier Partnerships: Develop strategic collaborations with suppliers to source renewable energy, eco-friendly products, and packaging materials that minimize environmental impact.
- Access Financing and Incentives: Facilitate access to financing options and government incentives to support energy efficiency projects and investments.
- Optimize Heating and Cooling Systems: Install high-efficiency heating and cooling systems, such as heat pumps, and explore renewable energy sources like solar and geothermal for heating and cooling needs.
- Build Energy Awareness: Launch comprehensive staff and customer awareness campaigns to promote energy-saving behaviors and practices.
- Reduce Waste and Packaging: Implement waste reduction strategies, optimize packaging materials, and collaborate with suppliers to minimize waste throughout the supply chain.
- Harness Renewable Energy: Explore opportunities for on-site renewable energy generation, such as solar panels, and purchase renewable energy certificates to offset carbon emissions.
- Participate in Energy Communities: Encourage participation in energy communities to share resources, implement collective energy efficiency measures, and benefit from shared savings.

In Table 19, the main challenges, recommendations, transferability of good practices, collaborative value chain relationships, and value chain business models based on collaboration are summarized.

Table 19. Main challenges, recommendations, transferability of good practices, collaborative value chain relationships, and value chain business models based on collaboration for the HORECA value chains

Category	Summary
Challenges	• Limited internal capabilities for energy monitoring • Seasonal variations in energy demand • Challenges in integrating new solutions with existing infrastructure • Price volatility and competitiveness pressures • Insufficient transparency regarding sustainability performance • Lack of qualified personnel and expertise • Difficulty accessing necessary funding • Insufficient information about energy efficiency opportunities • Supply chain complexities and logistical challenges • High upfront costs for energy-saving investments • Knowledge gaps within the organization
Recommendations	• Talent development: Energy specialist training programs • Knowledge exchange: Shared learning platforms • Community engagement: Partnerships with local authorities for CSR initiatives • Sustainable procurement: Platforms for evaluating eco-friendly products • Guest education: Programs to raise guest awareness • Expert collaboration: Partnerships with energy service companies • Performance measurement: Benchmarking and footprinting tools for hotels

	• Industry networks: Development of collaborative partnerships • Collective action: Energy communities • Information hub: Centralized data platforms • Supply chain efficiency: Partnerships with logistics companies and bulk delivery options • Financial support: Access to funding
Transferability of Good Practices	The successful transfer of energy-efficient practices in the HORECA sector depends on various factors including local conditions, technology, finances, organizational capabilities, and customer behavior. Collaborative efforts, knowledge sharing, and financial support are crucial for widespread adoption.
Collaborative Value Chain Relationships	Key factors enabling collaboration include geographical proximity, clear regulations, and mutually beneficial partnerships. A networking platform and a corporate social responsibility (CSR) approach are suggested to facilitate collaboration. Companies expressed a need for knowledge sharing, peer feedback, and assistance in finding partners.
Value Chain Business Models based on Collaboration	Successful business models leverage economies of scale achieved through group purchasing and stakeholder expectations that prioritize environmental responsibility. Collective up-marketing efforts and the use of shared platforms are also beneficial.

CONCLUSIONS

This report's findings emphasize the significant, yet frequently untapped, potential for enhancing energy efficiency and integrating renewable energy solutions throughout the HORECA sector's intricate value chains. Through in-depth analyses of case studies spanning hotels, restaurants, and catering services, the research demonstrates that well-designed interventions can lead to substantial energy savings—ranging from 18% to 22.3%—while simultaneously boosting both economic performance and environmental sustainability.

A core insight of this study is the critical importance of a holistic approach, one that extends beyond simply reducing direct energy costs. The integrated economic model developed within the EE4HORECA project reflects this, incorporating not only Life Cycle Cost (LCC) assessments but also a comprehensive evaluation of Non-Energy Benefits (NEBs). These NEBs, which include enhanced operational efficiency, improved quality of products and services, decreased resource consumption, better working conditions for employees, and enhanced brand reputation, are often difficult to quantify in purely financial terms. Nevertheless, they play a vital role in strengthening the overall business justification for investments in energy efficiency.

Furthermore, the report emphasizes that enhancing energy performance is not solely about adopting new technologies. It also necessitates strong organizational commitment, collaboration across different sectors, and supportive policies. Achieving success is closely linked to the availability of qualified personnel, access to appropriate financial mechanisms, and a regulatory environment that fosters sustainability. Collaboration throughout the value chain—among suppliers, service providers, and HORECA establishments—is identified as a crucial factor in achieving greater energy savings and creating operational synergies.

Despite the considerable potential, the sector faces persistent challenges, including limited internal expertise, complex regulations, and financial barriers. However, the identified best practices are transferable across the sector, and the report offers targeted recommendations for capacity building, financial incentives, digitalization, and knowledge sharing, providing a clear pathway to overcome these obstacles.

Ultimately, the transition of the HORECA sector towards a future characterized by energy efficiency and renewable energy requires systemic change. This encompasses not only technological innovation but also a fundamental shift in mindset towards integrating sustainability into all decision-making processes. The EE4HORECA framework offers a strong foundation for enabling this transformation, creating an alignment between economic viability, environmental responsibility, and long-term resilience.