EE4HORECA

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Deliverable 3.2 Report on the integrated economic model with NEBs

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 (EEMs), 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 work proposes an analysis of the sustainable business model Canvas offering a powerful framework for organizations to design and evaluate their value chain through a sustainability lens. Furthermore, an integrated model is developed for assessing the current energy performance of the HORECA value chains, identifying the most promising energy efficiency measures, and evaluating their impact on the value chain.

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SUSTAINABILITY BUSINESS MODEL CANVAS

The Sustainable Business Model Canvas offers a powerful framework for organizations to design and evaluate their value chain through a sustainability lens. Moving beyond traditional profit-first models, it integrates environmental and social considerations into core business strategies. This holistic approach compels businesses to consider the three pillars of sustainability: economic success, environmental impact, and social well-being. The canvas acts as a visual map, highlighting interconnected business components and their impact on sustainability goals. It also considers positive and negative externalities, allowing businesses to strategically minimize negative environmental or social impacts while maximizing positive ones. By fostering clear communication through visualization, the canvas becomes a valuable tool for discussions with investors, partners, and stakeholders increasingly focused on a company's commitment to environmental and social responsibility. In essence, the Sustainable Business Model Canvas empowers businesses to become responsible actors, contributing to a future that benefits not just themselves, but society and the environment as well. Figure 1 provides a detailed structure of this model specific to the HORECA sector, discussed in the following sections.

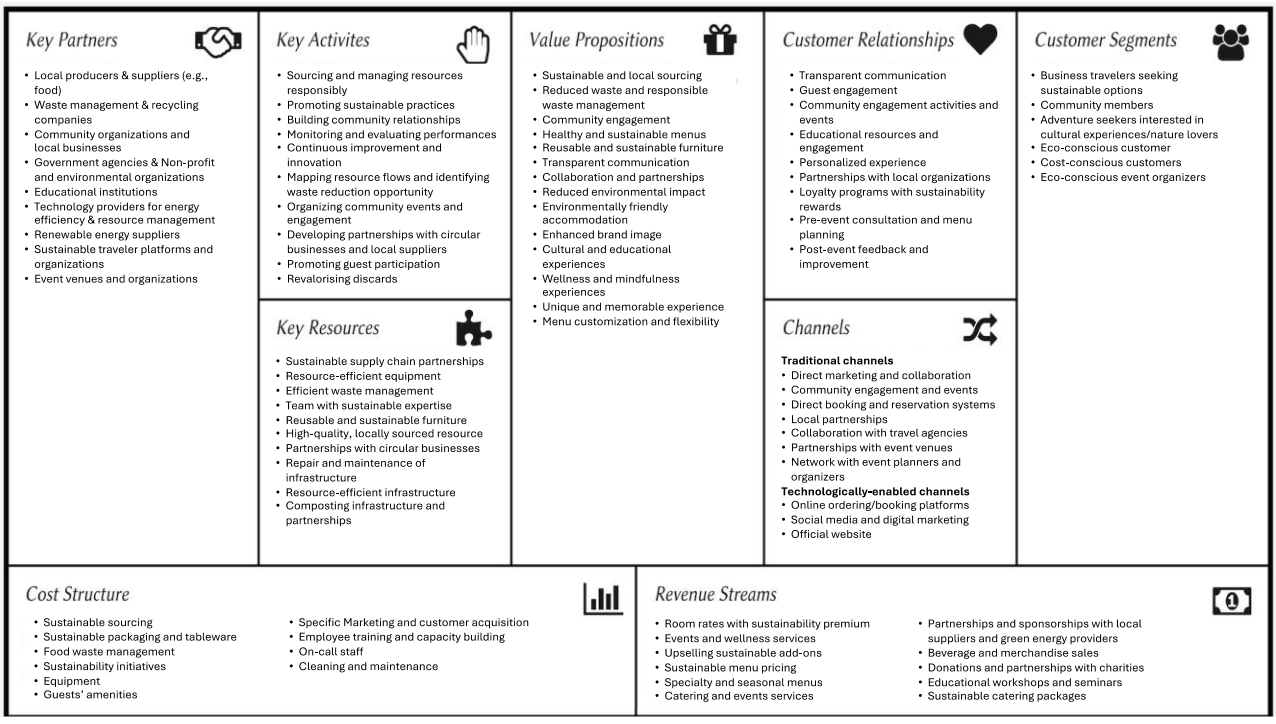


Figure 1: HORECA sustainable business model Canvas.

Key Partners

The Sustainable Business Model Canvas necessitates the establishment of strategic alliances with key partners. These partnerships foster a collaborative ecosystem that reinforces the HORECA's commitment to environmentally sound practices. The hotel cultivates connections with platforms catering to environmentally conscious travelers and organizations promoting sustainable tourism practices. This facilitates reaching a target audience aligned with the hotel's values. Alliances with local farms, businesses, and

suppliers committed to responsible practices establish a sustainable flow of goods and services. This includes partnerships with local organic food producers, ensuring access to fresh, high-quality ingredients while promoting economic and environmental well-being. Sourcing locally minimizes transportation requirements, leading to cost reduction, lower emissions, and support for the local community. Collaboration with companies providing sustainable waste management solutions and responsible recycling options ensures proper waste disposal and minimizes environmental impact. Partnerships with government agencies, non-governmental organizations promoting sustainable tourism, and educational institutions foster knowledge exchange, and collaborative efforts, and equip future hospitality professionals with the necessary skills to implement sustainable practices. Access to renewable energy sources is crucial. Partnering with renewable energy suppliers facilitates cost reduction and propels the hotel towards achieving its sustainability goals. Exploration of diverse clean energy sources like solar, wind, and geothermal allows for alignment with the hotel's specific environmental objectives. The restaurant cultivates similar partnerships to further its commitment to sustainability. Building partnerships with local farms, distributors, and businesses committed to sustainable practices and ethical sourcing ensures transparency and responsibility within the supply chain. Collaborating with companies offering composting and responsible recycling options ensures all waste streams are managed ethically. Partnering with non-profit organizations promoting environmental awareness, food security, or sustainable agriculture broadens the positive impact of the restaurant's initiatives. Collaboration with local businesses, organizations, and social spaces facilitates the co-hosting of events, workshops, or initiatives promoting sustainability within the community. Catering also leverages key partnerships to achieve its sustainability goals. Building partnerships with local farms and producers ensures ethical sourcing and reduces transportation emissions. Partnering with companies offering responsible solutions for managing food waste and other catering-related waste streams minimizes environmental impact. Collaborating with event venues prioritizing sustainability or organizations with similar goals strengthens the collective commitment to a greener future.

Key Activities

The model further outlines key activities that translate resources into sustainable operations. Resource conservation is achieved through regular monitoring and optimization of energy and water consumption, facilitated by technology and operational practices. Sustainable sourcing is prioritized through partnerships with local and sustainable suppliers, minimizing waste generation, and implementing responsible disposal methods. Guest engagement empowers guests to reduce their environmental footprint through towel reuse, water conservation programs, and participation in circular practices. The hotel fosters a collaborative relationship with the local community by supporting local businesses, engaging in local initiatives, and creating opportunities for cultural exchange through responsible tourism practices. Continuous improvement is a cornerstone of the model, with regular review and evaluation of sustainability initiatives identifying opportunities for improvement and adaptation to evolving best practices. The model embraces the circular economy by mapping resource flows within the hotel to identify areas for waste minimization, reuse, and recycling. Partnerships with businesses specializing in upcycling, downcycling, and waste management further this goal. Circular procurement practices prioritize sourcing furniture, amenities, and operational supplies from circular businesses or through responsible product-as-a-service models. Finally, continuous monitoring of waste generation, resource use, and the effectiveness of circular initiatives allows for data-driven adaptation and continuous improvement. Building strong community relationships is central to sustainable

restaurants' mission. Collaboration with local businesses, supporting local farmers' markets, and organizing educational events on sustainable food systems foster connections and promote environmental awareness. The restaurants' commitment should be further demonstrated through continuous monitoring and adaptation of practices based on environmental impact, food waste generation, and resource consumption. Innovation is key, with the restaurant actively seeking new opportunities to enhance sustainability. The restaurant should foster engagement through educational workshops, collaborations with local businesses, and participation in community initiatives promoting sustainability. Catering service providers also leverage a sustainable approach. By analyzing resource flows, the catering service identifies areas for improvement. Developing strong relationships with local producers ensures transparency and minimizes transportation footprints. Food waste reduction strategies like seasonal menus and responsible portion control are key components. Community engagement, participating in local events, supporting community initiatives, and building relationships with organizations that share similar sustainability values, fosters a broader positive impact. Finally, continuously monitoring waste generation, resource use, and the effectiveness of sustainability initiatives, allows adjusting and adapting strategies for continuous improvement.

Key Resources

The eco-businesses in the HORECA sector should prioritize resources that align with their sustainability goals. This means an energy-efficient infrastructure with renewable energy sources, resource-efficient equipment like energy-saving appliances and compostable tableware, and sustainable building materials. Partnerships with environmentally responsible, local suppliers create a sustainable supply chain. Waste reduction is key, achieved through composting systems, recycling programs, and proper disposal procedures. Additionally, sustainable technology empowers management, resource monitoring, and guest engagement related to sustainability initiatives. Finally, a team with expertise in circular practices, sustainable sourcing, responsible food handling, and actively engaged in the restaurant's overall sustainability mission ensures successful implementation and promotion. This ensures comprehensive knowledge and fosters a culture of environmental responsibility within the team. Especially for restaurants, investments in food storage and preservation infrastructure minimize spoilage, with efficient refrigeration, proper storage techniques, and innovative technologies being utilized. Reusable and sustainable tableware for dine-in and compostable or recycled packaging for takeout further demonstrate their commitment. The restaurants should prioritize responsible resource management through various initiatives. Partnering with local farmers, producers, and distributors, minimizing food waste through menu planning and portion control, and implementing responsible water and energy practices are key aspects. They even utilize food-sharing apps and repurpose leftover ingredients for even less waste. Promoting sustainable dining extends to offering reusable takeaway containers, encouraging responsible portion sizes, and allowing guests to opt out of single-use items. Catering also aligns with these practices, building networks with local producers, prioritizing sustainable procurement, utilizing composting and reusable tableware, and leveraging technology for efficient operations.

Value Propositions

The value proposition focuses on a multi-pronged approach to sustainability: guests can expect environmentally friendly accommodations, with the hotel utilizing renewable energy sources, energy-efficient technologies, and sustainable practices throughout its operations. Additionally, the hotel prioritizing locally sourced and seasonal ingredients for its dining

options, can minimize transportation emissions and support nearby communities. Waste reduction and responsible management are also central principles, with practices to minimize waste generation, compost food scraps, and promote responsible recycling and disposal. Beyond the hotel itself, the model fosters community engagement, and cultural experiences. Guests are offered opportunities to connect with the local community and participate in responsible tourism practices. Wellness and mindfulness experiences can also be proposed into the guest experience, providing facilities and activities that promote well-being and connection with nature. Restaurants also by purchasing ingredients meticulously sourced locally and seasonally, minimize the environmental footprint while supporting local farmers having a positive impact on the local economy. Comprehensive strategies should be implemented to minimize food waste, including menu planning optimization, utilization of imperfect produce, and responsible composting practices. Building strong connections within the community should be central to eco-restaurants mission. For instance, it can actively support local producers, host engaging community events, and offer educational experiences that promote mindful consumption. Menus are designed to be both healthy and sustainable, featuring fresh, seasonal dishes and an array of vegetarian and vegan options to cater to various dietary needs. This commitment extends to packaging and tableware, where the use of reusable, compostable, or recycled materials is prioritized. Finally, transparency should be guaranteed by openly communicating sourcing practices, sustainability initiatives, and social impact through menus, websites, and signage. A sustainable catering value chain offers a unique and compelling set of propositions for its clients. This approach goes beyond simply providing food; it fosters environmental responsibility, community engagement, and transparency, all while delivering exceptional culinary experiences. Customers are increasingly seeking to minimize their environmental footprint. A sustainable catering value chain prioritizes local and seasonal ingredients, reducing transportation emissions and supporting local agriculture. Furthermore, it implements strategies to minimize food waste and utilizes sustainable packaging and tableware solutions. Building strong connections within the communities it serves is a core tenet of this approach. This is achieved through forging partnerships with local food producers and collaborating with community organizations. This not only supports local businesses but also fosters social integration and provides an opportunity to learn about and support small-scale farmers and producers. Building trust with its clients is paramount. A sustainable catering value chain accomplishes this by providing clear and comprehensive information about the origin and sustainability practices associated with its ingredients. This transparency empowers clients to make informed decisions about their catering choices, aligning with their values. A multifaceted approach to minimizing food waste is a hallmark of a sustainable catering value chain. This includes implementing pre-order systems, practicing responsible portion control, and donating any surplus food to charities or food banks. This approach not only minimizes environmental impact but also ensures efficient resource utilization. Finally, recognizing that every event is unique, a sustainable catering value chain offers customizable menus featuring seasonal and local options. This caters to diverse dietary preferences and promotes responsible consumption by minimizing unnecessary food options.

Customer Relationships

The Sustainable Business Model Canvas paints a comprehensive picture of how the HORECA businesses should cultivate customer relationships and generate revenue streams while adhering to sustainability principles. Businesses should prioritize transparency, keeping guests informed about their sustainability efforts, certifications, and

progress through various communication channels. Furthermore, engagement programs can be implemented, for instance, by offering guests opportunities to participate in sustainable practices during their stay. This fosters a sense of shared responsibility and empowers guests to contribute to the hotel's sustainability goals. Loyalty programs can also be established, rewarding guests for making eco-conscious choices and participating in environmental initiatives. The hotel should extend its commitment to sustainability beyond its walls by inviting guests to participate in community service activities or cultural experiences that promote social and environmental well-being. Educational workshops and experiences can be offered to further elevate guest awareness about circular economy principles and empower them to adopt sustainable practices in their own lives. Restaurant further cultivates a culture of sustainability through educational experiences. Workshops or seminars can be hosted to educate customers about responsible consumption habits and sustainable food practices. Additionally, community-focused events such as workshops on zero-waste cooking, food preservation techniques, or composting engage the community while promoting education. These efforts are complemented by partnerships with local organizations like food banks or composting companies, ensuring responsible solutions for surplus food or unavoidable waste. Furthermore, catering service providers can collaborate with customers during pre-event consultations to craft menus reflecting sustainable practices, dietary needs, and budget considerations. While post-event feedback from customers about their experience, particularly regarding sustainability aspects, can be used to continuously improve services.

Channels

To reach the target audience, hotels leverage a variety of communication channels. Partnerships with sustainable travel booking platforms ensure visibility among eco-conscious travelers. A clear and informative website can detail the hotel's sustainability initiatives, while social media and digital marketing further amplify its commitment. Collaborations with local tourism agencies promote the hotel as part of a larger sustainable tourism experience. Finally, the hotel can actively engage with the local community through events and partnerships, building relationships and fostering a positive social impact. A multifaceted approach should be utilized to reach restaurants' customers. Online ordering options can include partnerships with sustainable delivery platforms or the restaurant's own dedicated online ordering system. Active engagement on social media platforms showcases sustainable practices and fosters connections with potential customers. Additionally, local partnerships can be cultivated, co-creating events, showcasing local products, and promoting broader community initiatives. The restaurant can further connect with the community by hosting farmers' markets, educational workshops, and farm-to-table dinners. Effective communication strategies are instrumental also for a sustainable catering value chain to thrive. These channels serve a dual purpose: fostering strong client relationships and amplifying the company's commitment to environmental responsibility. A cornerstone of client interaction is a user-friendly online booking platform. This central hub serves as a gateway to the company's sustainable practices. It provides comprehensive information about the company's mission and values, alongside enticing menus, client testimonials, and seamless booking functionalities. Collaboration with event venues committed to sustainability fosters a spirit of mutual promotion. This strategic partnership creates a win-win situation for both parties, extending the reach of each brand and offering clients the convenience of bundled packages that combine venue rental with sustainable catering services. A vibrant social media presence allows the company to cultivate a strong online community. This interactive space serves multiple purposes. It showcases the company's

culinary creativity through food photography, inspires potential clients with unique and visually captivating event setups, and keeps existing clients informed about ongoing community engagement initiatives. Actively participating in relevant conferences and industry events is a strategic approach to building strong relationships with event planners and organizations who share similar sustainability values. This collaborative approach fosters the exchange of ideas and best practices, ensuring the company remains at the forefront of sustainable catering practices. Participation in farmers markets, local food festivals, and community gatherings allows the company to connect with potential clients on a deeper level. These interactions provide a platform to not only promote the company's services but also to strengthen the bonds within the communities it serves. This fosters a sense of shared purpose and reinforces the company's commitment to local sourcing and social responsibility.

Customer Segments

The Sustainable Business Model Canvas for the HORECA value chain prioritizes a clientele that embraces eco-conscious practices. This includes tourists seeking minimal environmental impact during their travels, business travelers representing companies with sustainability goals, and even the local community itself, who can utilize the hotel's facilities for events, dining, or wellness services. Eco-restaurants welcome patrons who value eco-conscious practices, health-focused cuisine utilizing fresh, local ingredients, and convenient, sustainable dining options. These restaurants foster strong connections with residents, particularly those who appreciate local sourcing and community engagement. Furthermore, they recognize the importance of affordability, ensuring that its commitment to sustainability does not preclude value-conscious diners. A range of vegetarian and vegan options caters to plant-based preferences. The key customer segments that contribute to a thriving sustainable catering value chain are eco-conscious event organizers, cost-conscious customers, and locally-focused communities. The first segment comprises forward-thinking individuals who prioritize environmental responsibility throughout their events. They actively seek catering options that align with their values and minimize environmental impact. For these clients, showcasing sustainable practices and a commitment to reducing the environmental footprint is paramount. Understanding the importance of value, sustainable catering services must cater to budget-minded customers. This segment appreciates competitive pricing alongside a commitment to sustainability. Striking a balance between affordability and eco-friendly practices is crucial to attracting this customer base. Finally, groups seeking to support local producers and contribute to the development of their communities are a vital segment within the sustainable catering market. These clients choose catering services that source locally and promote social integration. Highlighting partnerships with local farms and producers resonates strongly with this segment.

Cost structure

The cost structure associated with this model reflects the investments required for sustainability. Upfront investments in sustainable infrastructure, such as renewable energy sources, energy-efficient appliances, water-efficient equipment, waste management strategies (e.g., on-site composting systems), and sustainable building materials, are necessary for long-term environmental and economic benefits. Costs related to sourcing from responsible and sustainable suppliers may be higher than traditional methods but contribute to a more ethical and environmentally friendly operation. Local and/or ethically sourced ingredients may have a higher initial cost than conventional options, although reduced transportation and storage needs can offset these. Prioritizing local sourcing may

require more frequent, shorter-distance deliveries compared to consolidated deliveries from larger suppliers. This can potentially increase transportation costs. Sustainable packaging materials like biodegradable, compostable, or reusable options come at a premium compared to traditional packaging. Similarly, fair trade certifications verifying ethical and sustainable practices throughout the supply chain may incur additional costs. Maintaining a sustainable operation requires ongoing investment. Employees receive training on sustainable practices in food preparation, waste management, and resource conservation. Sustainable equipment and infrastructure require ongoing maintenance. Costs are also associated with implementing and maintaining sustainable practices, including compliance with waste management regulations and reporting requirements. Additionally, marketing specific to eco-tourism initiatives, including printed advertisements, online marketing, social media campaigns, publicity, and promotion, are factored in. Costs associated with providing awareness and education sessions, such as printing materials, speakers, refreshments, and equipment rental, should also be considered. However, the model prioritizes sustainable cost-reduction strategies. Investing in energy-efficient appliances, lighting, and building features reduces utility costs and environmental impact. Implementing water-saving measures, minimizing waste generation, and utilizing waste-to-energy solutions contribute to cost reduction and environmental responsibility. Sourcing food, supplies, and services from local vendors reduces transportation costs and supports local communities, fostering both economic and environmental benefits. Utilizing technology for smart building management, automated energy control, and data analysis optimizes resource usage and minimizes operational costs. Finally, collaborating with local businesses for services like laundry or linen cleaning can offer cost-effective and sustainable alternatives.

Revenue Streams

The hotel's room rates reflect its investment in sustainability, offering competitive pricing with a slight premium. Guests are presented with the opportunity to further contribute to sustainability through upselling eco-friendly add-ons, such as in-room carbon offset programs or locally sourced toiletries. The food and beverage offerings are designed to be also environmentally responsible, focusing on locally sourced and seasonal ingredients. A focus on catering to diverse dietary preferences, including vegetarian and vegan options, further aligns with sustainability goals. An on-site restaurant, coffee bar, and room service provide additional revenue streams while adhering to the hotel's commitment to fresh, local ingredients. To amplify its impact and generate additional revenue, the hotel can foster partnerships and sponsorships with brands and organizations that share its commitment to sustainability. This includes collaborating with local suppliers to support the community and promote sustainable practices, partnering with green energy providers to offer renewable energy options to guests, and collaborating with local tour operators to curate eco-friendly experiences. These partnerships generate revenue streams while reinforcing the hotel's commitment to a holistic approach to sustainability. Also, restaurants can employ a variety of strategies to generate income. Competitive menu pricing reflects the investment in sustainable practices and high-quality, locally sourced ingredients. A slight premium may be applied to further support these efforts. Customers can also make informed choices that contribute to sustainability by opting for premium menu items featuring local specialty ingredients or ethically sourced food. Revenue is further generated through sustainable beverage options and branded merchandise, potentially made from recycled materials. Seasonal menus showcase fresh, local ingredients, highlighting responsible sourcing practices, and may be priced slightly higher to reflect their value. Finally, collaborations with local businesses or organizations aligned with sustainability goals generate awareness and

revenue through co-branded promotions or events. Clients seeking environmentally responsible catering may be willing to pay a slight premium for the value proposition offered. This premium reflects the company's commitment to local sourcing, sustainable packaging, and reduced food waste practices. By offering a diverse range of customizable menus featuring seasonal and local options, the company can cater to a wider range of clients and potentially generate additional revenue through upselling premium ingredients or specialty dishes. Partnerships with event venues committed to sustainability can create bundled packages that offer clients convenience and potentially generate higher revenue through combined service offerings. Finally, the company's expertise in sustainable catering practices can be leveraged to offer educational workshops or resources to clients or the broader community. This knowledge sharing can generate additional revenue streams.

INTEGRATED MODEL

This methodological process leverages three analytical tools to comprehensively assess and implement energy efficiency measures within a value chain:

Step 1: Value Chain Energy Mapping and Hot Spot Identification

The value chain model serves as the foundation for this approach. It facilitates a detailed analysis of energy consumption across each stage of the value chain, disaggregated by energy vector (e.g., electricity, natural gas). This granular breakdown enables the identification of "hotspots" – stages with the highest energy consumption. By pinpointing these hotspots, stakeholders can prioritize the implementation of energy efficiency measures (EEMs) identified in the previously developed checklist (WP2).

Step 2: Economic Feasibility Assessment using the Life Cycle Cost (LCC) Model

Once the most relevant EEMs are selected based on their potential impact on hotspots, the Life Cycle Cost (LCC) model comes into play. This tool allows for a rigorous evaluation of the economic viability of each shortlisted EEM. By considering the initial investment costs, operational savings, and project lifespan, the LCC model provides crucial insights for prioritizing EEM implementation based on their financial attractiveness.

Step 3: Strategic Assessment of Non-Energy Benefits (NEBs)

The final step incorporates the NEBs model. This tool goes beyond just economic considerations to evaluate the associated non-energy benefits of the shortlisted EEMs. These benefits can encompass a wide range of factors, such as improved product quality, reduced maintenance requirements, or enhanced worker safety. By quantifying these NEBs and assessing their strategic relevance, stakeholders gain a more holistic understanding of the value proposition associated with each EEM.

Figure 2 defines the framework of the integrated model developed under this project exploiting also already existing tools developed in other EU-funded projects (i.e., LCC and NEBs tools have been developed under the H2020 project “Improving Cold Chain Energy Efficiency, ICCEE – [1]).

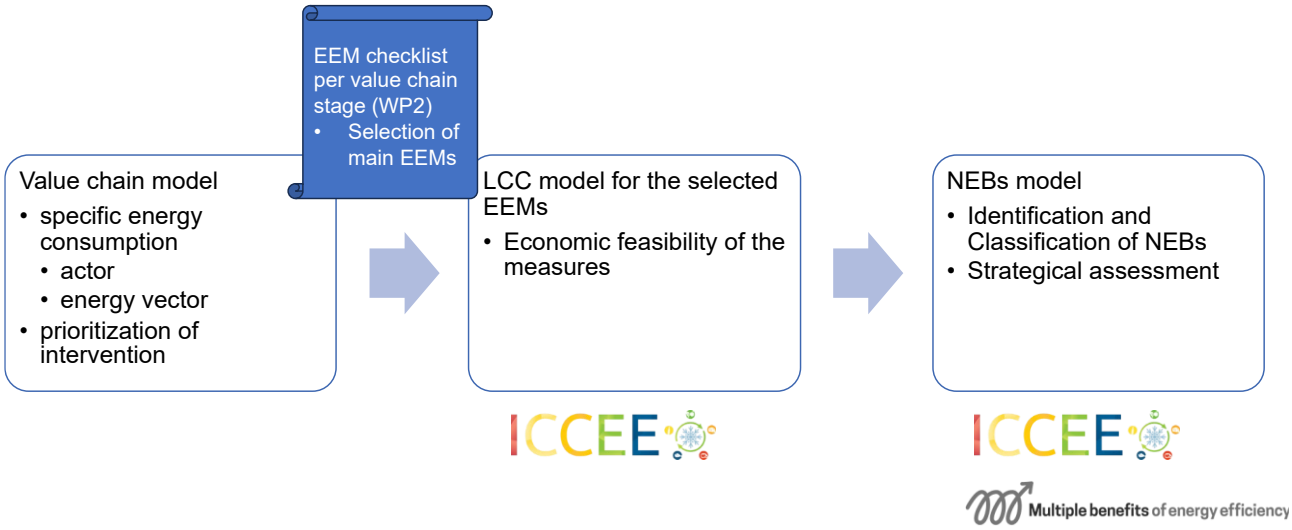


Figure 2: Framework of the integrated model.

Step 1: Value Chain Energy Mapping and Hot Spot Identification

While traditional approaches to energy efficiency have focused on individual companies within a Supply Chain, a more comprehensive perspective that considers the entire value chain offers significant potential for further reductions in energy demand [2]. This value chain approach presents two key advantages:

- Optimizing Energy Efficiency Measures (EEMs) Across Stages: By collaborating and sharing resources, stakeholders throughout the supply chain can identify and implement the most cost-effective EEMs at each stage of the chain. This collaborative effort can lead to significant cost savings compared to individual company initiatives.
- Unlocking Synergistic Opportunities: Cross-company collaboration opens doors to innovative energy-saving strategies. Examples include implementing joint deliveries to optimize transportation logistics or harmonizing maximum temperature levels across the chain while maintaining product safety and quality.

Despite the attractiveness of these potential benefits, realizing them requires fostering a spirit of close cooperation among all participants within the supply chain.

This model analyzes the energy requirement along the value chains of the HORECA sector. This model aims to understand and help minimize the overall specific energy consumption along value chains. For this purpose, it allows the users to analyze (i) energy requirements in HORECA activities, (ii) energy requirements in transport activities, and (iii) energy requirements of the main suppliers.
Specifically, the hotel and the restaurant value chains consist of three stages: i.e., suppliers, transportation of goods from the suppliers to the hotel, and the hotel activities. The catering value chain is characterized by additional stages to transport meals from the central kitchen to the event venue. Figure 3 shows the general structure of the value chains considered in the energy analysis model.

Of course, value chains may look different. In that case, it is possible to omit or aggregate the input of some stages to match the specific chain.

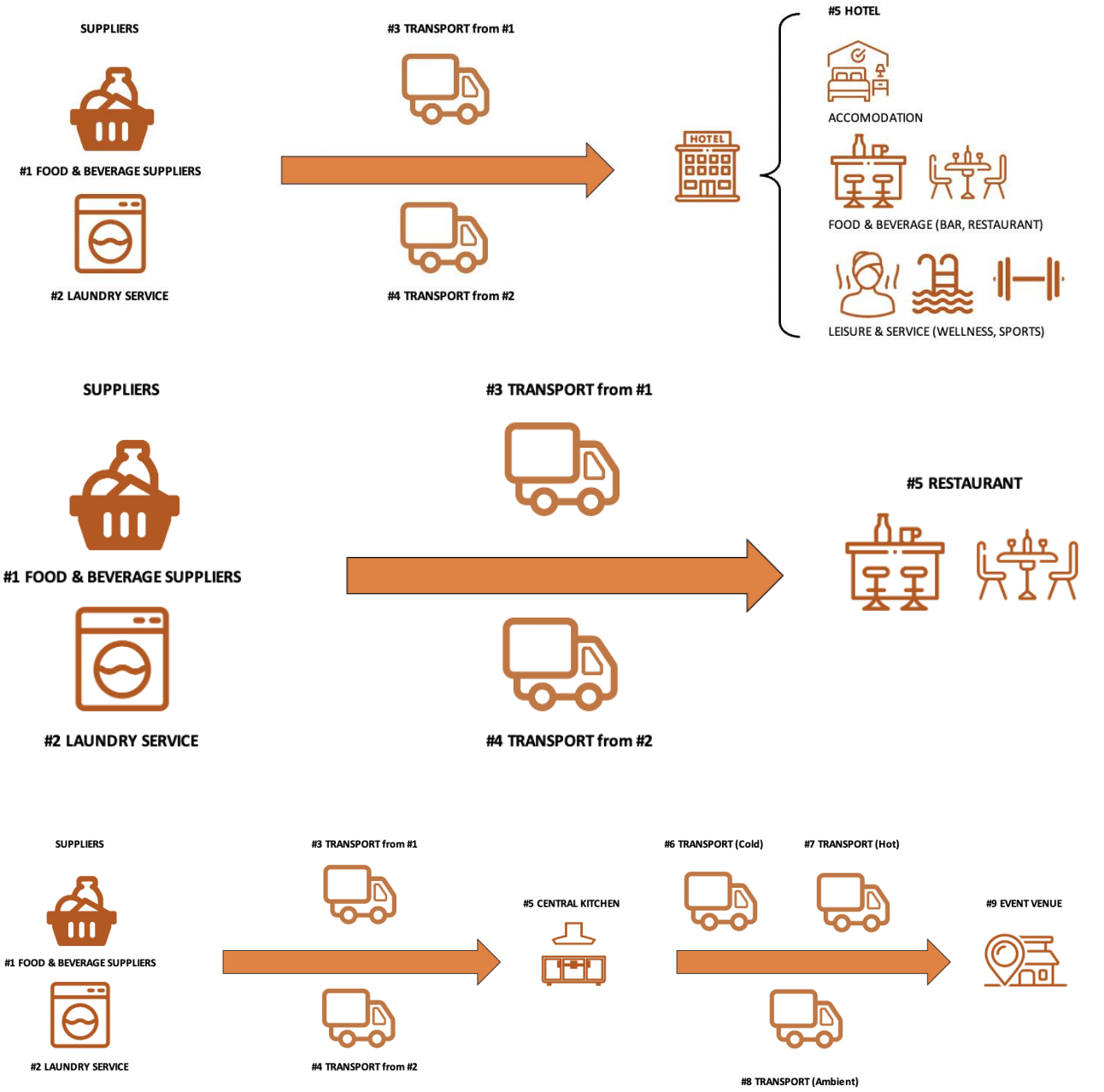


Figure 3: Structure of the HORECA value chains considered in the models.

The results of the value chain energy analysis model applied to input data gathered from all the stages, are reported in terms of specific energy consumption (SEC, kWh/guest night or kWh/food cover) per energy carrier. The results are provided also for each stage of the chain allowing the identification of the hotspot of the value chain (i.e., the stage responsible for the highest share of the overall energy consumption). This information can serve as a basis to support decision-makers in the prioritization of energy efficiency measures to reduce overall energy consumption.

The specific energy consumption is also translated into specific economic impact (€/guest night or €/food cover, considering the EU-mix energy price) and into specific environmental

impact (kg_{CO2}/guest night or kg_{CO2}/food cover, considering the EU-mix CO_2 emission per energy generation).
Figure 4 provides an illustrative example of the results provided with the value chain energy analysis model, in the hotel industry.

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	0,992	2,348	0,000			3,340
#2: Laundry service	0,267	2,299	0,000	-	-	2,566
#3: Transport from stage #1	4,160	0,000	18,461	0,000	0,000	22,621
#4: Transport from stage #2	0,000	0,000	10,381	0,000	0,000	10,381
#5: Hotel	5,000	6,897	0,000	-	-	11,897
Total	**10,419**	**11,543**	**28,842**	**0,000**	**0,000**	**50,804**
			Specific economic impact (EU-mix)			**14,682** **€/guest night**
			Specific environmental impact (EU-mix)			**11,706** **kg CO2/guest night**

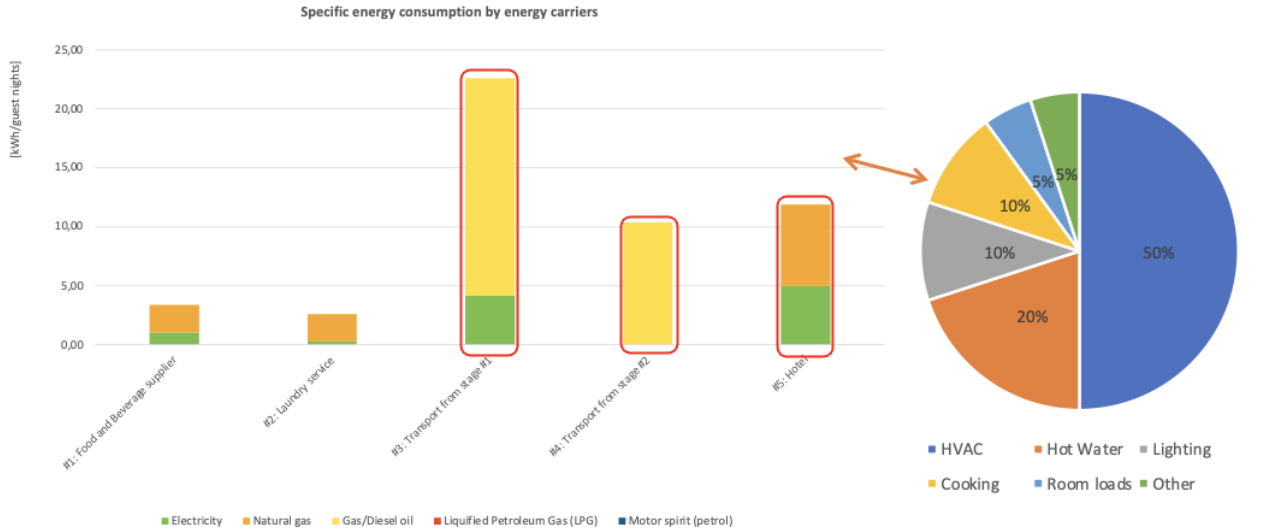


Figure 4: Illustrative example of the results provided with the value chain energy analysis model in the hotel industry.

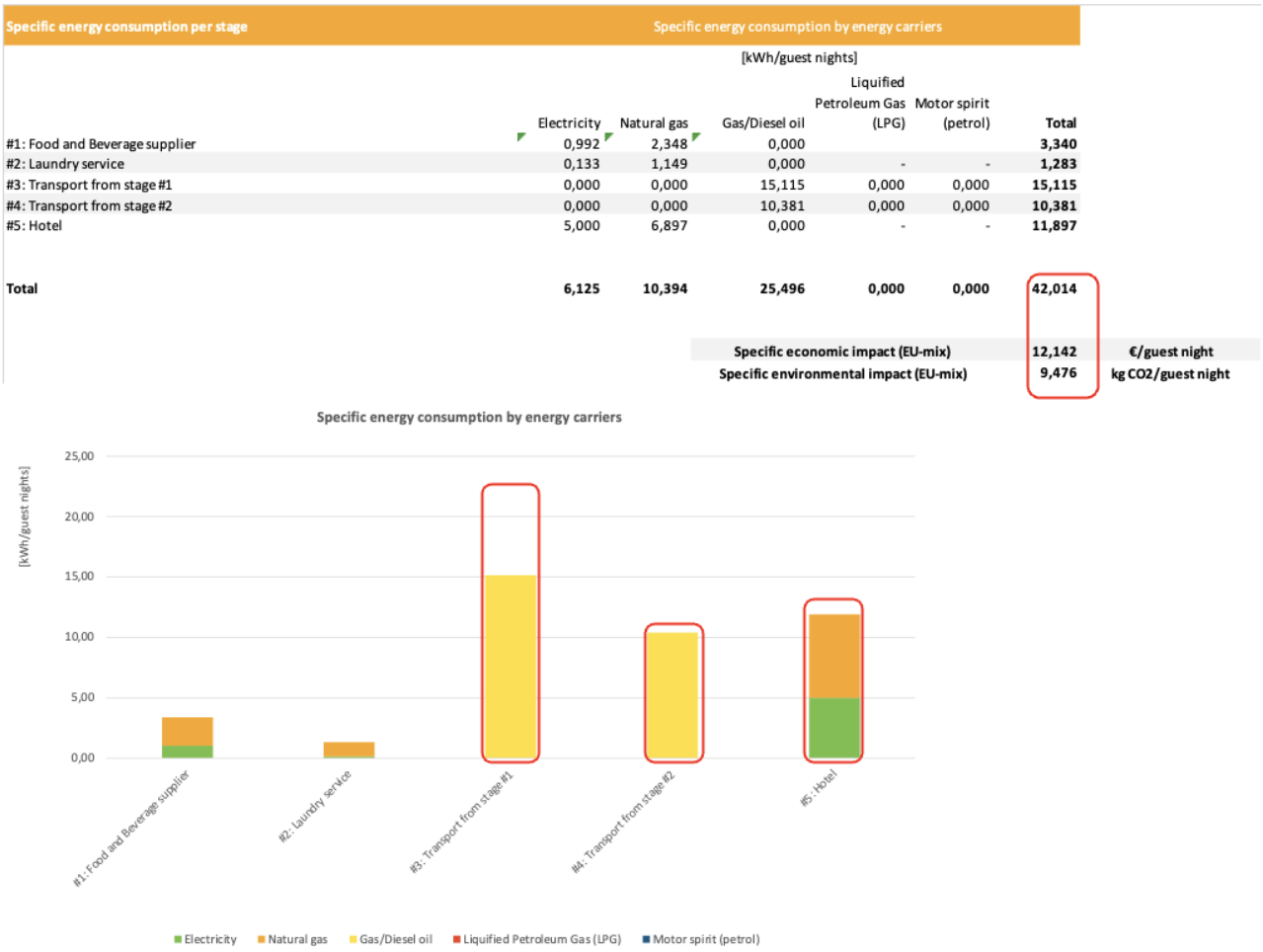
The highest SEC contributions are the transport activities from food and beverage suppliers (45%), the hotel activities (23%), and the transport activities from the external laundry service provider (20%). Specifically, the hotel energy consumptions are mainly related to the HVAC systems. From the obtained results, priority energy efficiency measures can be identified for the hotspot. Some examples are reported in Table 1.

Supply chain stage	Energy efficiency measure	Category	Objective
Transport (#3 and #4)	• Alternate means of transport (e.g. portable refrigerated units for LTL) • Improved insulation of trucks (e.g., air curtain) • Lower replenishment (larger lot size, towel re-use programme)	• Transport • Transport • Management	↓ fuel consumption (↓ air infiltration → ↓ refrigeration load)

Hotel (#5)	• Improved insulation (walls, rooftop, windows, pipes) • Building Management Systems and Guest Room Management System • Inverters	• Building • Monitoring and control • Control	↓ load requirement and energy consumption

Table 1: Illustrative example of the results provided with the value chain energy analysis model.

For instance, if alternate means of transport through portable refrigerated units and a towel reuse program are implemented, the specific energy consumption of the value chain can be reduced by about 17%. The results of the value chain energy performance after the intervention are reported in Figure 5.



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	0,992	2,348	0,000			3,340
#2: Laundry service	0,133	1,149	0,000	-	-	1,283
#3: Transport from stage #1	0,000	0,000	15,115	0,000	0,000	15,115
#4: Transport from stage #2	0,000	0,000	10,381	0,000	0,000	10,381
#5: Hotel	5,000	6,897	0,000	-	-	11,897
Total	6,125	10,394	25,496	0,000	0,000	42,014
				Specific economic impact (EU-mix)		12,142 €/guest night
				Specific environmental impact (EU-mix)		9,476 kg CO2/guest night

Figure 5: Illustrative example of the results provided with the value chain energy analysis model (after interventions).

Step 2: Economic Feasibility Assessment using the Life Cycle Cost (LCC) Model

While energy efficiency measures (EEMs) often necessitate upfront investments, they demonstrably reduce energy consumption and associated costs over time. The H2020 ICCEE project's Life Cycle Cost (LCC) tool facilitates a streamlined analysis of these cost-benefit trade-offs compared to the baseline scenario.

The tool offers two distinct LCC approaches [3]:

- **Conventional Economic Analysis (C-LCC)**: This perspective analyzes costs and benefits from a company's standpoint. It focuses on direct financial implications, including investment expenditures and future operational cost savings. However, it may neglect external environmental and societal impacts.
- **Societal Life Cycle Cost Analysis (S-LCC)**: This broader approach adopts a macroeconomic perspective, encompassing a wider range of costs borne by various stakeholders throughout the entire value chain. It incorporates potential environmental consequences, often monetized based on complementary Life Cycle Assessment (LCA) data.

Due to their differing methodologies, C-LCC and S-LCC utilize distinct output indicators. However, they share some core economic indicators:

- Net Present Value (NPV): This represents the difference between the initial investment and the discounted sum of future net cash flows.
- Internal Rate of Return (IRR): An index reflecting the expected profitability relative to the project's investment cost. It essentially signifies the maximum acceptable loan interest rate for the project to remain profitable.
- Profitability Index (PI): A ratio between the total present value of future income and the initial investment.

S-LCC builds upon these indicators by incorporating additional "damage costs" associated with the project's environmental impact. These costs reflect society's "willingness to pay" for mitigating environmental damage. Consequently, S-LCC utilizes additional output indicators:

- Social Net Present Value (SNPV): Like NPV but incorporates the additional damage costs.

Social Cost-Benefit Analysis (SCBA): Calculated by dividing the future scenario SNPV by the baseline scenario SNPV. An SCBA value greater than 1.0 indicates a positive social return on investment, while a value less than 1.0 suggests a potential social drawback.

Key financial elements – such as public funding opportunities (e.g., grants, tax incentives, subsidies), third-party financing from banks (including interest rates and repayment terms), and performance-based contracts from Energy Service Companies (ESCOs) – can significantly influence the economic viability of a project. Considering these variables when defining LCC inputs allows users to assess the real cost-benefit of sustainability options and to identify financing structures that reduce capital barriers.

Moreover, these financial inputs enable a comparative analysis of multiple investment scenarios, helping decision-makers to identify the most advantageous solutions. For instance, factoring in ESCO contracts with guaranteed savings or grants that offset capital expenditures provides a more accurate and context-sensitive evaluation. Sensitivity analysis on these inputs, such as fluctuating energy prices or changes in financing conditions, can further strengthen the reliability of the tool for strategic planning.

Ultimately, ensuring that such financial aspects are integrated from the outset, when defining the LCC tool’s input parameters, enhances its value as a practical, decision-support

instrument. It equips stakeholders with a realistic understanding of both the costs and funding pathways involved, thereby improving access to capital and the prioritization of sustainable investments.

The required input spans four sections: 0) a definition of the EEMs, 1) the cost associated, 2) their impact, and 3) the framework conditions for the analysis.

While energy reduction is a primary benefit of EEMs, the LCC tool empowers users to evaluate broader impacts beyond just energy consumption. This includes potential reductions in water use and even improvements in product quality, ultimately influencing the final output of the supply chain process.

Figure 6 provides the LCC results for the interventions suggested in the previous section for the illustrative example in the hotel industry.

Conventional life cycle costing

The conventional LCC results take a purely economic perspective and include the conventional costs associated with a product in the current situation and with the energy efficiency measures. This type of LCC usually presents the perspective of one entity or organization.

Unit costs (UC): The UC indicate the operating costs to produce a specific unit of the investigated product. The lower these cost, the more favourable is the situation. Please note that these costs do not include investments in the case of energy efficiency measures.

Net present value (NPV): The NPV is the discounted value of the income minus expenditures. The higher its value, the more favourable is the situation. The calculation considers only those cash flows that are within the scope specified earlier.

Internal rate of return (IRR): The IRR is evaluating the profitability of an investment required for a certain EEM. It is calculated for the organization that implements the specific EEM. It shows the maximum interest rate of a loan that can be tolerated by the project and if it exceeds the capital costs, the implementation of the measure can be accepted. The higher the value, the more preferable is the situation. Any IRR higher than the average cost of capital can be considered as valid.

Profit index (PI): The PI is a ratio between of the present value of future income as compared to the initial investment. Any value higher than 1.0 can be considered as valid.

	Without measure	EEM1	EEM2	
Unit operation costs	14,68	12,48	14,39	[Euro/unit]
Net present value	251.517 €	243.009 €	251.383 €	[Euro]
Internal rate of return		439%	6423%	[%]
Profit index		17,20	252,38	[-]

Societal life cycle costing

Societal life cycle costs use an expanded macroeconomic system and includes a larger set of costs, including those that will be, or could be, relevant in the long term for all stakeholders directly affected and for all indirectly affected through externalities (direct and indirect cost covered by society).

In this case, the costs from emitting carbon dioxide are considered as additional costs while the inflows from selling products are not considered here. This means that the societal cost-benefit (SCB) only evaluates the relationship between the investment (cost) and the benefits it delivers (reduction in production costs and savings to the environment).

An energy efficiency measure is preferable from a societal perspective if it reaches a SCB larger then 1.0. It is more preferable, the earlier this ratio is achieved. If 'xxx' is displayed, then no favourable cost benefit ratio is achieved within 20 years respectively after the duration of the scope defined on the input sheet.

	EEM1	EEM2	
Cost benefit ratio	1	1	[a]
Cost benefit ratio after 5 years	1,32	1,15	[-]

Figure 6: Illustrative example of the LCC results considering the following interventions: EEM1- portable refrigerated units and EEM2 - the towel reuse program.

Step 3: Strategic Assessment of Non-Energy Benefits (NEBs)

The integration of energy efficiency measures (EEMs) within value chains presents a multifaceted challenge. This investigation focuses on the influence of EEMs throughout the value chain. As depicted in Figure 7, the proposed framework posits that the effectiveness of EEMs is contingent upon both the perception of Non-Energy Benefits (NEBs) and the prevailing organizational and behavioral aspects (BOAs) [4,5].

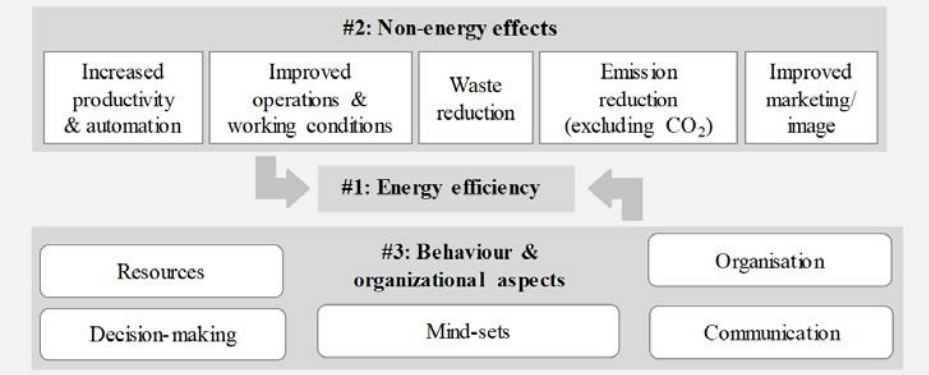
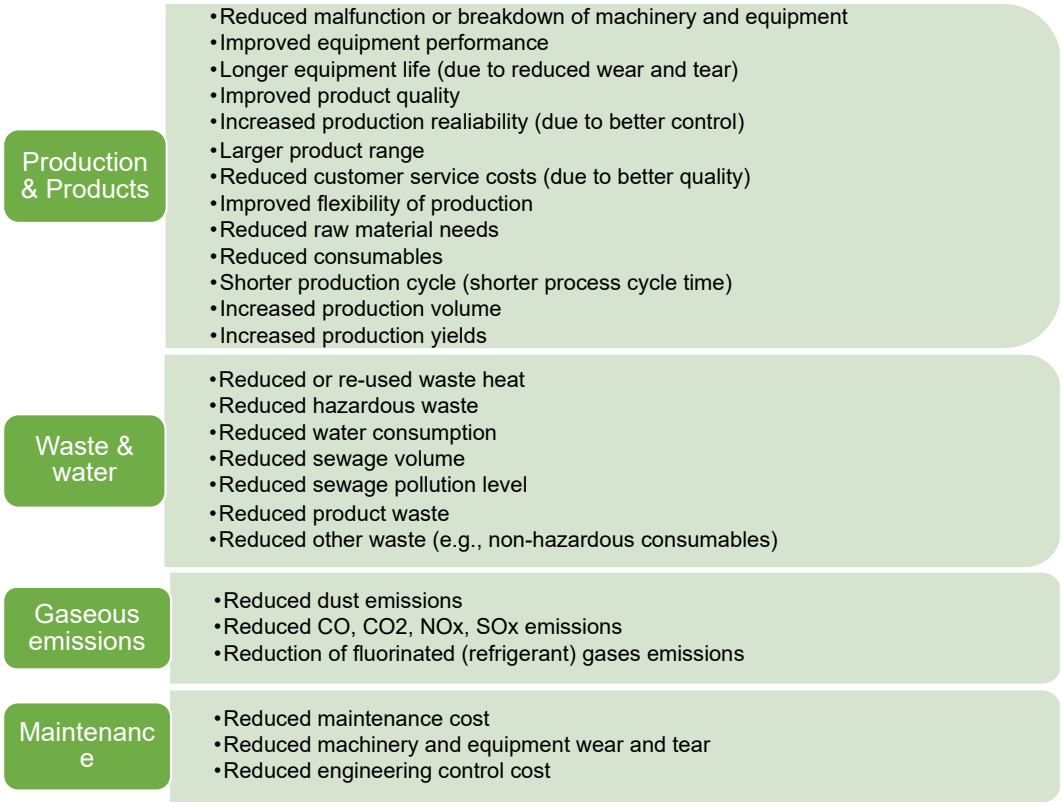


Figure 7: Illustration of the framework of investigation.

While energy savings are the primary focus of EEMs, they can also generate significant collateral advantages, such as enhanced competitiveness, reduced maintenance needs, and improved working environments. However, these NEBs are often overlooked or

undervalued during the evaluation process of energy-saving projects. The ICCEE tool addresses this gap by providing a structured approach to identifying, classifying, and strategically assessing NEBs within the decision-making framework for EEM implementation. Notably, the tool extends its analysis beyond the individual company perspective to encompass the entire value chain. As depicted in Figure 8, the user should evaluate the presented areas and their associated NEBs based on their relevance, importance, and strategic implications for the specific EEM under consideration. This strategic analysis should encompass potential impacts on costs, value propositions, and associated risks.



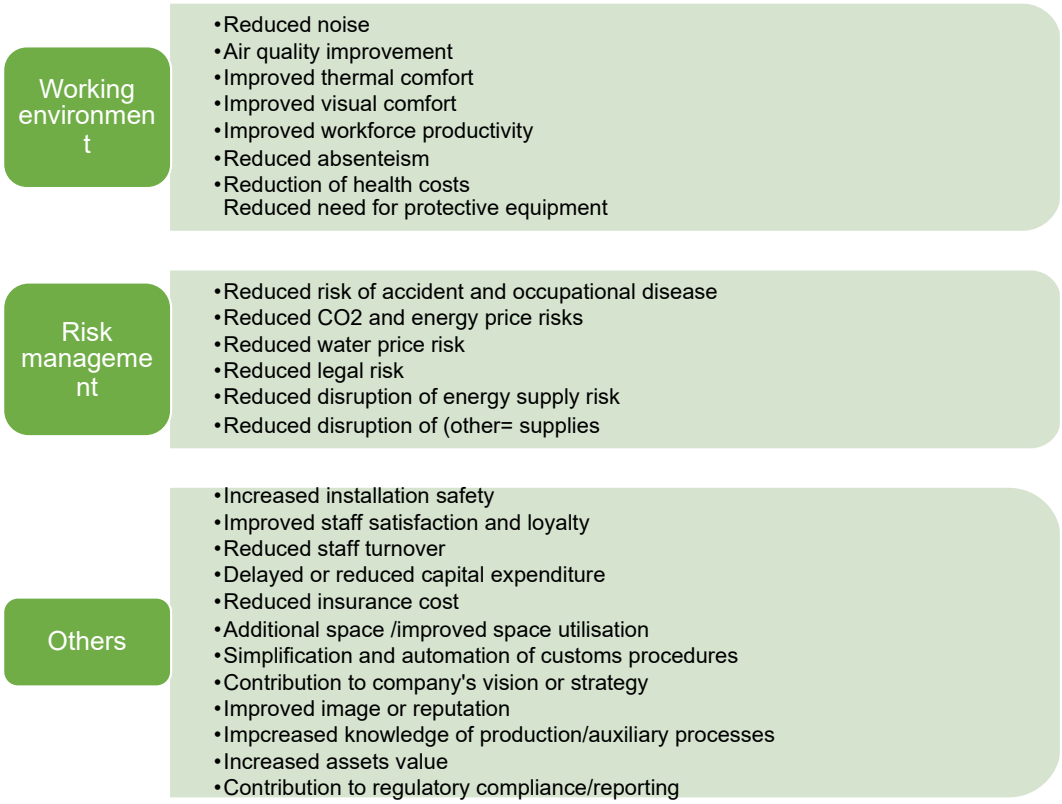


Figure 8: Area and non-energy benefits considered in the ICCEE tool.

Figure 9 depicts the NEBs analysis results for the towel reuse program intervention suggested for the illustrative example in the hotel industry.

	NEBs for cost decrease	Key performance indicator (overwrite if needed)	Data source for indicator (e.g. company department)	Expected impact on others in the cold supply chain
Area: COSTS	Reduced raw material need	Percent of raw materials of production volume (in t/y) * costs of material (in EUR/t)	Laundry service provider	low
	Reduced maintenance cost	Wages (Euro/h) * reduced maintenance hours (h/y)	Laundry service provider	low
	Reduced machinery and equipment wear and tear	Longer lifetime of equipment so reduced levelised costs machinery	Laundry service provider Transportation activities	high

	NEBs for value proposition increase	Key performance indicator (overwrite if needed)	Data source for indicator (e.g. company department)	Expected impact on others in the cold supply chain
Area: VALUE PROPOSITION	Improved product quality /consistency	Reduction of production losses - redo	Laundry service provider	low
	Reduced water consumption	Water - production volume (or in % of turnover) (m3/y) * costs of water (in EUR/m3)	Laundry service provider	high
	Reduced dust emissions	Quantity (total or as % of production)	Transportation activities	high
	Reduced CO, CO2, NOx, SOx emissions	Quantity (total or as % of production)	Transportation activities	high
	Improved image or reputation	-	Hotel	high
	NEBs for risk reduction	**Key performance indicator (overwrite if needed)**	**Data source for indicator (e.g. company department)**	**Expected impact on others in the cold supply chain**
Area: RISKS	Reduced water price risk	Uncertainty in water price or years for which water price is contractually agreed with supplier	Laundry service provider	low

Figure 9: Illustrative example of the NEBs analysis considering EEM2 - towel reuse program.

CONCLUSIONS

The integrated economic model developed in this project presents a comprehensive and adaptable framework for evaluating Energy Efficiency Measures (EEMs) within the intricate and dynamic context of the HORECA (Hotel, Restaurant, and Catering) sector's value chains. This model stands out for its capacity to combine a granular analysis of energy consumption patterns throughout the value chain with a Life Cycle Cost (LCC) assessment, thereby enabling a detailed understanding of both the direct and long-term financial impacts associated with implementing EEMs.

What truly sets this model apart, however, is its ability to incorporate a strategic evaluation of Non-Energy Benefits (NEBs), which are often overlooked in conventional energy efficiency assessments. Traditional analyses tend to concentrate primarily on tangible outcomes such as energy savings and direct operational cost reductions. While these are undoubtedly important, such a narrow focus can miss a broad range of additional advantages that EEMs can deliver—benefits that may significantly influence decision-making in the HORECA industry. NEBs refer to a diverse set of positive externalities that extend well beyond simple energy or cost metrics. When properly accounted for, these benefits can enhance the overall value proposition of energy efficiency projects. Examples of NEBs include:

- **Improved operational efficiency**: EEMs can contribute to more reliable equipment performance, lower maintenance needs, longer equipment lifespan, and smoother day-to-day operations, resulting in productivity gains across the organization.
- **Enhanced product or service quality**: In the HORECA context, this can manifest as improved food preparation consistency, increased guest comfort, and reduced service-related errors or waste—factors that directly contribute to better customer experiences and satisfaction.
- **Reduction in overall resource use**: Effective EEMs can help decrease the consumption of resources beyond energy, such as water, cleaning agents, or raw materials, while also minimizing waste generation. This not only supports sustainability goals but can also lead to significant cost reductions over time.
- **Better working environments**: Measures that improve lighting, temperature regulation, and air quality can create safer, healthier, and more pleasant workplaces, boosting employee morale, reducing absenteeism, and increasing staff retention.
- **Risk management and resilience**: Investments in energy efficiency and renewable energy solutions can reduce exposure to volatile energy markets and potential disruptions in supply, thereby strengthening the business's operational stability.
- **Stronger brand reputation and market appeal**: Demonstrating a commitment to sustainability can enhance a business's image and credibility, helping to attract both environmentally conscious customers and potential investors who prioritize responsible business practices.

By systematically identifying, quantifying, and prioritizing these NEBs, the integrated model delivers a more nuanced and accurate representation of the full value that EEMs can offer. This holistic approach equips stakeholders in the HORECA sector with the insights needed to make better-informed, strategic investment decisions—decisions that not only improve economic performance but also contribute to broader sustainability goals and long-term resilience in an increasingly competitive and resource-conscious marketplace.

References

[1] Diaz F., Romagnoli F., Neusel L., Hirzel S., Paulus J., Marchi B., Zanoni S. (2022). The ICCEE Toolbox. A Holistic Instrument Supporting Energy Efficiency of Cold Food and Beverage Supply Chains. Environmental and Climate Technologies, 26 (1), 428-440.

[2] Marchi B., Zanoni S. (2017). Supply chain management for improved energy efficiency: review and opportunities. Energies, 10 (10), 1618.

[3] Hunkeler D., Lichtenvort K., Rebitzer G. (2008). Environmental Life Cycle Costing, SETAC, Ed., London: CRC Press.

[4] Nesuel L. Hirzel S. (2022) Energy efficiency in cold supply chains of the food sector: an exploration of conditions and perceptions. Cleaner Logistics and Supply Chain 5, 100082.

[5] Neusel L., Zanoni S., Hirzel S., Marchi B. (2020) Energy efficiency from farm to fork? On the relevance of non-energy benefits and behavioural aspects along the cold supply chain. Eceee Industrial Summer Study Proceedings, Vol. 2020 – September, 101-110.