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EE4HORECA

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**Topic: LIFE-2022-CET-BUSINESS**
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**Proposal acronym: EE4HORECA**

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

# D2.2 Map the 'energetic' value chain of the HORECA sector

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 WP2 that will Map the value chain of the HORECA sector, gather best practices and identify the multiple benefits achievable from collaborative approaches between large and small companies operating in the same value chain.

The overall objectives of the present work aim to activate the collaborative approach that will perdure throughout the whole project between the actors involved in the project and external stakeholders to:

- map the actors connected with the HORECA value chain, identifying the point of high environmental impact (D2.1 and D2.2);
- identify and select the best transferable practices for energy efficiency across the value chain at European level (D2.2 and D2.3).

The present work highlights the points of major energy consumption and propose a pragmatic approach for HORECA managers to self-assess internal energy efficiency and identify collaborative solution across the value chain.

The present work is Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

# MAP DIRECT AND INDIRECT ENERGY CONSUMPTION ACROSS THE HORECA SECTOR

The HORECA sector exhibits inherent variability that challenges the identification of a singular solution for analysing key energy consumption points across its entire value chain. Within the framework of the D2.1 project partners and working group participants have identified and validated the key actors involved in the value chain, paying special attention to their respective levels of influence, analysing all steps from departure to return back home of the guest experience. This methodological approach, which places a strong emphasis on understanding the dynamics and interactions within the value chain, inspires to the strategies employed by the UN Environment Programme in its Transforming Tourism Value Chain project and the scientific literature in the publication of Chambers (Environmental Assessment of a mass tourism package holiday and a responsible tourism package holiday, using Life Cycle Assessment and Ecological Footprint Analysis). In this second task, we focused on the identification of the principal energy consumption processes within the HORECA value chain. With this work we aim to introduce a simplified methodology specifically designed for SMEs to facilitate a deeper understanding of the energy consumption patterns and empower business owner to initiate and implement targeted initiatives on their journey towards energy efficiency.

**Direct energy consumption** refers to the amount of energy used directly by end-users (in the specific case business owners) for various purposes such as heating, cooling, lighting, transportation, and operating appliances and machinery. This type of energy consumption is measured at the point of use and encompasses the energy derived from primary sources that are consumed without any intermediate transformation or conversion processes. Examples include the gasoline used in vehicles, natural gas used for heating buildings and generating sanitary hot water, the electricity consumed for cooling the buildings and powering appliances and industrial machinery for task such as refrigeration and preparation of food and beverages.

**Indirect energy consumptions** are the energy processes associated with product and services not directly controlled and owned by the management of the HORECA facility as hotels, restaurants and catering owner, but the energy consumption due to the upstream activities related to purchased or acquired goods (tangible products) and services (intangible products).

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# ANALYSIS OF ENERGY CONSUMPTION AND PATTERNS ACROSS THE HORECA VALUE CHAIN

The European norm on energy audits (CEI EN 16247) delineates a precise and structured approach for analysing the direct energy consumption of buildings and processes. Concurrently, LCA (Life Cycle Analysis) stands as a widely embraced methodology for assessing the environmental footprint of individual products while GHG protocol offers a comprehensive system for accounting direct and indirect emissions associated with a process. However, while a preliminary energy consumption analysis can be conducted by individuals without specialized training, leading a comprehensive energy audit, performing a LCA and calculating GHG emission requires expertise. Moreover, LCA and GHG emission calculation do not provide a straightforward, actionable strategy for business owners—the primary audience of this project but only describe the impact of a single product or process. Given this context, and specifically for the objectives of EE4HORECA project, we propose a novel approach aimed at addressing energy consumption on the major energy processes of the HORECA sector.

## HOTSPOT IDENTIFICATION:

Identifying the major energy-consuming processes is central for effective energy management. However, conducting a detailed analysis of every energy-consuming activity across each stage of the value chain, is not only impractical but also overwhelming for managers and stakeholders without specialised competences in the field of energy management. In this perspective, this analysis aims to identify and highlight 'hotspots' - areas of highest energy consumption across the entire HORECA value chain and offer a simplified method to assess energy efficiency status for non-specialists. Our team screened, identified and selected all upstream activities that were significant in terms of size or number of orders, as these activities represent the greatest opportunities for improving data and reducing energy consumption within the value chain. This approach extends beyond hotels, restaurants and catering services to recognise energy consumption patterns of key suppliers. We focused on suppliers that interact more frequently with the HORECA industry such as food and beverage providers, laundry services, transportation and energy suppliers. These four categories exclude minor suppliers that have fewer interactions with HORECA in terms of size and number of orders (e.g. maintenance services, good and services suppliers). The analysis of typical consumption patterns within the HORECA sector was carried out by utilising benchmarks, energy indicators, and insights from national and European projects extensively documented in the literature, the knowledge emerged from the desk research was integrated with experiences and competencies of our team.

The CEI EN 16247standard on energy audits sets the framework for evaluating the energy efficiency of buildings, processes, and transportation. Its goal is to assist SMEs in adhering to the EU Directive 2012/27 and its subsequent amendments included in EU Directive 2018/2002 with regard to headline EU energy efficiency target for 2030. According to the standard, in order to develop an energy audit, the following steps are required:

- *collection and analysis of energy bills;*
- *analysis of the building;*
- *collection and analysis of the machineries and the plants;*
- *definition of the adjustment factors for invoiced consumption;*
- *analysis of energy services;*
- *construction of the energy inventory;*
- *calculation of energy performance indicators;*
- *identification of opportunities for improving efficiency energy;*
- *cost-benefit analysis;*
- *evaluation of the priority of interventions.*

This theoretical framework can be translated into a simplified series of straightforward steps for self-assessing plants features, internal consumption, and possible improvement measures. Research in this domain underscored the importance of improving knowledge on energy consumption as the first step for implementing energy efficiency measures. Of course, in order to obtain a deeper understanding, to elaborate a detailed quantification of energy performance indicators and a cost-benefit analysis require the support of an energy expert.

This guideline presents a series of steps for SME owners and facilities managers to self-assess their organization's energy efficiency and covers all the main components and features that contribute to energy consumption.

**Features of the building:**

*- intended use of the building;*
*- year of construction;*
*- description of any retrofitting made and year of renovation;*
*- planimetric drawing (of the building and production layout);*
*- section and elevation drawing;*
*- if present, technical report describing typological factors (e.g. technical and construction data of the building, structures and installations);*

**Electrical system and electrical equipment features:**
*- electricity consumption invoices for the last 3 years;*
*- if available, load curve (chronological representation of electricity load in kW or MW) of at least one-year (downloadable from the distributor's website or by delegation from the distributor's portal to a technician), it should be available for POD (point of delivery) electricity meter with power greater than 30 kW;*
*- heat consumption invoices (gas or other fuels) for the last 3 years;*
*- fuel consumption for vehicle traction and fleet data (number, type and power supply of vehicles);*
*- data on the use of the building and installations (opening/operating hours, any closing periods)*
*- operating hours of any heating or cooling systems;*
*- number of employees or users;*
*- type and number of lamps in the building;*
*- number, type, power of electrical equipment used (production machinery, any internal canteen machinery, PCs, printers, refreshment area and anything else deemed relevant);*

**Thermal plant:**
*- diagram of the thermal systems and distribution/emission;*
*- diagram of central heating plant;*
*- plant and/or central plant logbook;*
*- data on existing generators and air-conditioning system components (type, make and model year of installation, type of terminals such as radiators/fans/etc. and in which zone);*

**Forced ventilation system**:
*- drawings;*
*- machine data;*
*- times of use;*
*- if heat recovery units are present;*

**Sanitary hot water system**:
*- generators;*
*- cubic meter of storage tanks;*
*- year of installation;*

**Renewable source systems if present:**
*- solar thermal (type and sqm of collectors, type and cubic meter of storage tanks, year of installation);*
*- solar photovoltaic (type and sqm of panels, year of installation, any production monitoring data);*

**Fleet:**
- *number and type of vehicles;*
- *year;*
- *average annual kilometres travelled*
- *fuel.*

Segmenting the entire facility into smaller, manageable components fosters a more pragmatic approach, allowing for targeted analysis of individual facilities. This strategy enables a detailed comparison of various components, thereby enhancing the understanding of the construction's current technological and operational standards, its systems, and pinpointing precise starting points for implementing energy-efficient renovations.

# MAIN ENERGY CONSUMER IN THE HORECA SECTOR

This report builds on the work of the hospitality industry's maps for restaurants and catering services developed in D2.1 Map the HORECA Value chain. It aims to detail the primary internal consumption and the main energy-consuming suppliers across the three sectors of the HORECA industry.

As outlined in D2.1, the purpose of these maps is to thoroughly identify all participants within the HORECA value chain, illustrate their interconnections, and foster dialogue among them. This dialogue is intended to encourage innovative solutions through working groups and living labs. The maps in this report have been updated to spotlight the hotspots previously identified (marked with red rectangles). These hotspots are critical areas within the value chain where energy use and environmental impacts are most significant.

As presented in D2.1, the maps divide into two main areas, indirect and direct energy processes:

- The upper part of the maps focuses on indirect energy processes, highlighting upstream businesses and activities crucial for providing good and services to hotel guests.
- Conversely, the lower part of the maps, under the blue arrows that trace the customer experience, showcases direct energy processes. This section includes the direct energy consumption of appliances and the energy and water systems integrated within the HORECA facilities.

The pie chart presented beside the direct energy consumption, provides a quick overview and general quantification of the structure's HORECA internal direct consumptions. An in-depth analysis of the estimation of internal consumption is presented in the subsequent paragraph.

The analysis of internal consumption, which can be conducted through billing analysis by HORECA facility managers, are instrumental to activate a self-assessment energy efficiency and develop tailored solutions for each facility.On the other side, identifying and analysing hotspots across the value chain is strategic for addressing the main energy demanding processes and encouraging a collaborative approach across the value chain to effectively tackle these challenges.

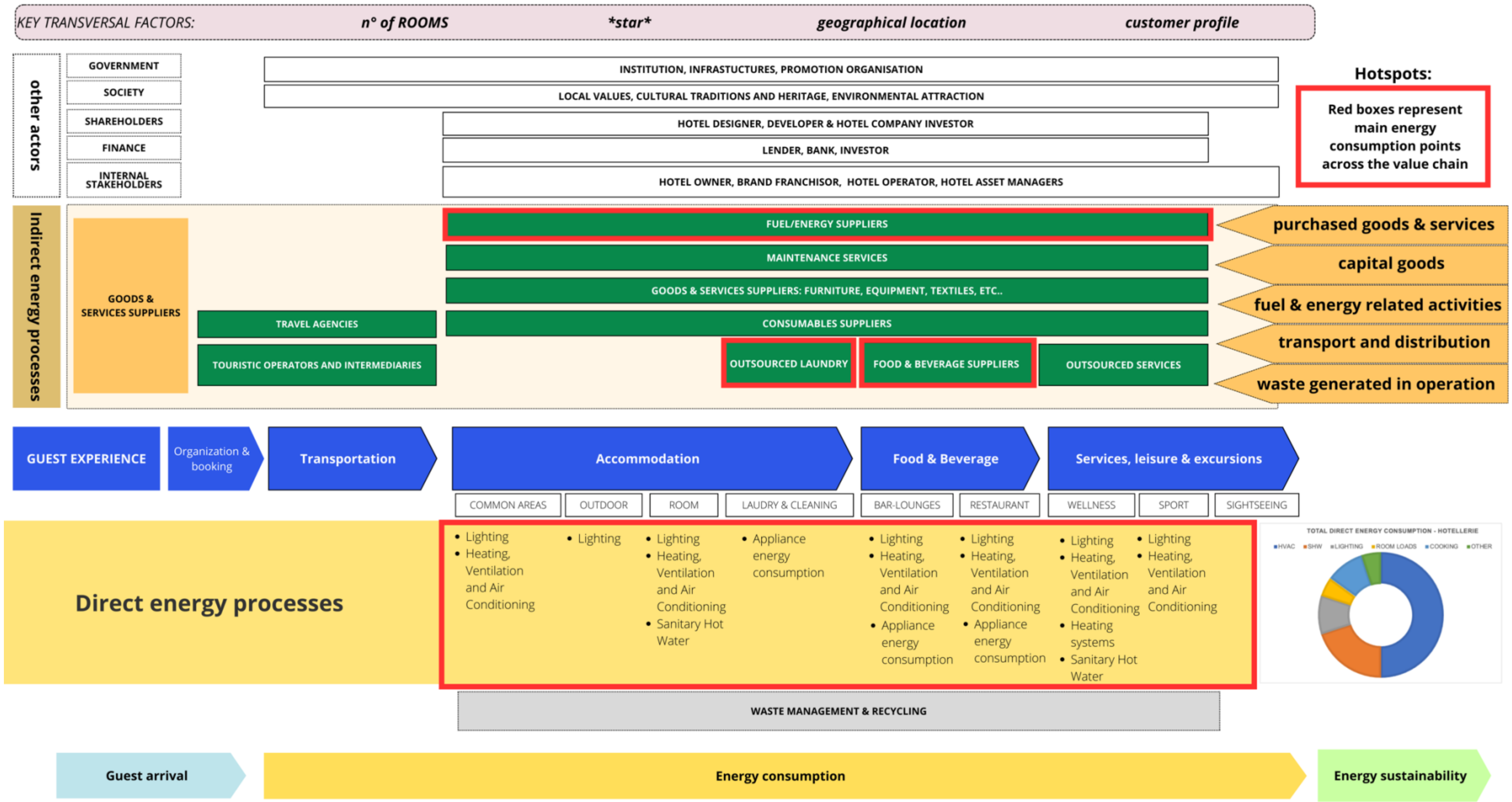


*Figure 1 Main energy consumers in Hotellerie*

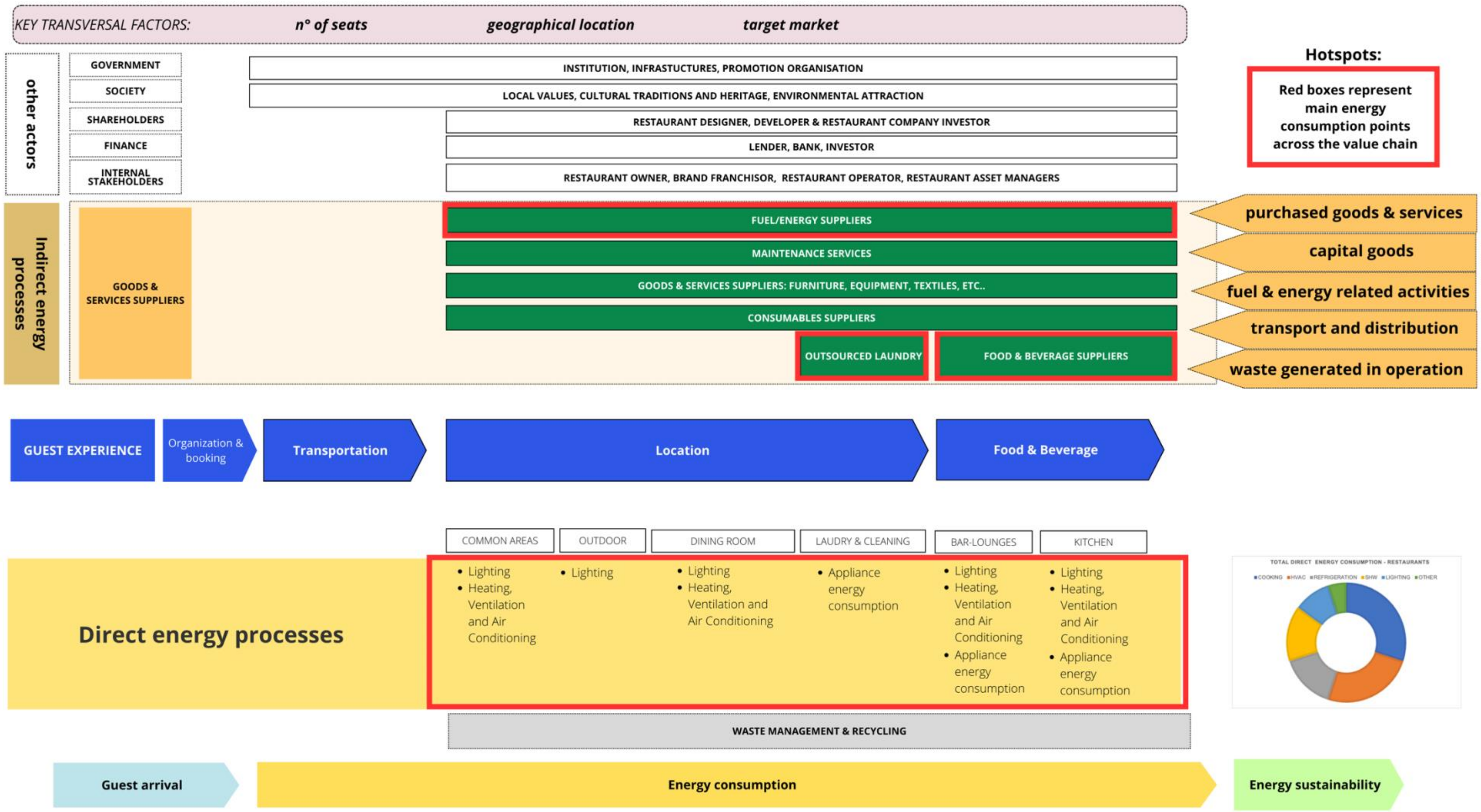


*Figure 2 Main energy consumers in Restaurants*

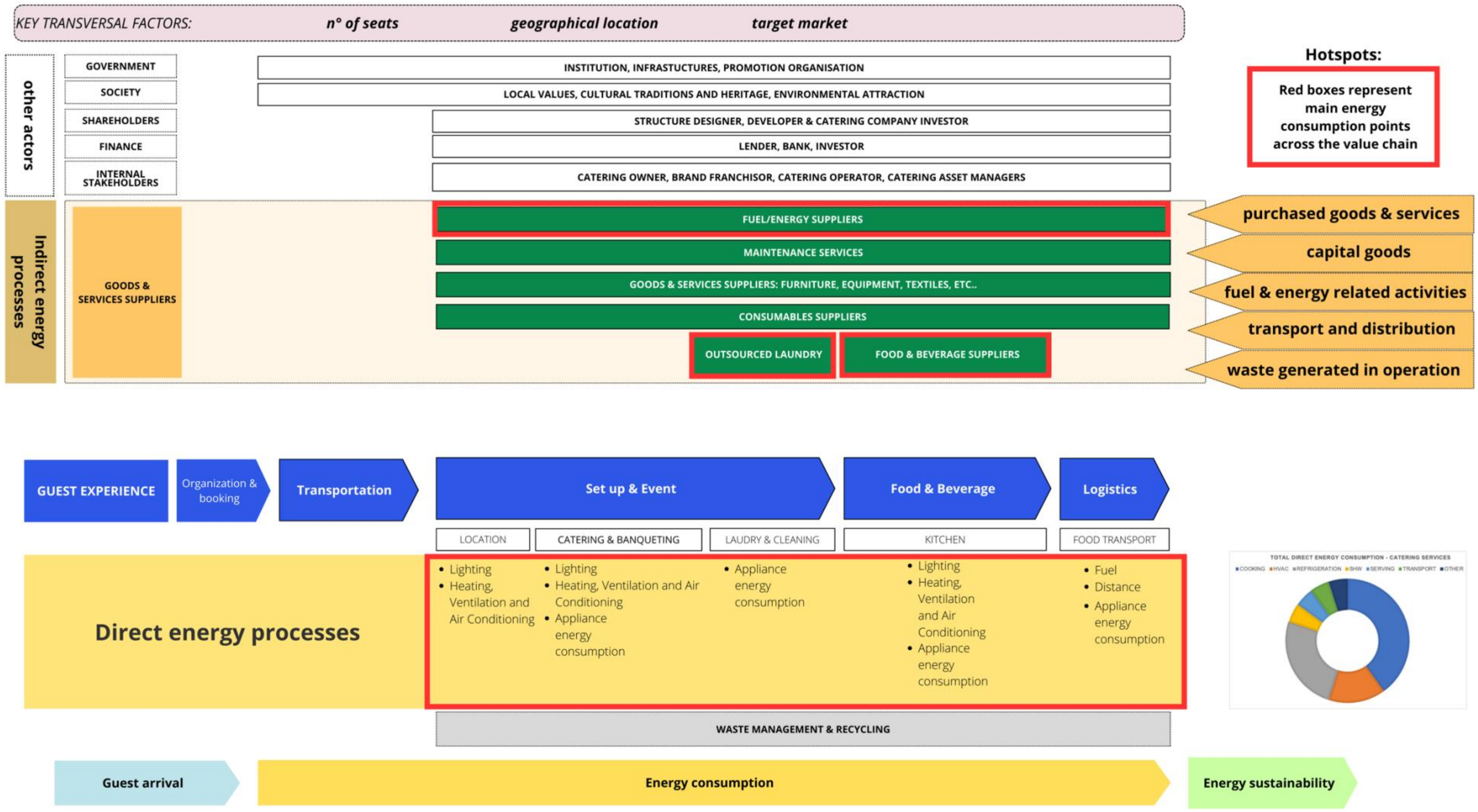


*Figure 3 Main energy consumers in Catering services*

# IN-DEPTH ANALYSIS OF INTERNAL CONSUMPTION

## HOTELS

When analysing energy consumption in hotel structures, key factors to consider include environmental climate conditions, facility design, and the size of the establishment. These variables, along with any additional factor identified during the analysis, should be prioritized at the outset of assessment. Energy demand across all sectors of the hotel is evaluated from a comprehensive standpoint. Data utilized for this analysis are drawn from various literature sources, including dataset for a period up to 20 years, as infrastructure investments in hotels tend to have a long lifespan, resulting in relatively slow changes in consumption patterns over time. For most hotels, energy use falls in the range 200-400 kWh/m$^2$/yr; combining data from all the various studies reveals that average energy use by hotels is in the range 305-330 kWh/m$^2$/yr according to Hotel Energy Solution analysis.

Energy consumption within hotel structures is a dynamic aspect, however, for the purpose of this analysis, an indicative average value representing the total energy consumption is considered. It's important to note that there can be a notable variance between the actual energy consumption and the computed average, primarily influenced by usage patterns due to the specific context. In delineating the energy consumption breakdown of a hotel facility based on its systems and services offered to guests, several primary categories emerge, each corresponding to specific services or functional areas. These encompass HVAC (Heating, Ventilation, and Air Conditioning), SHW (Sanitary Hot Water), lighting, swimming pool & spa facilities, kitchen operations, and internal laundry services. Space conditioning, predominantly constituted by HVAC operations, typically accounts for approximately half of the total energy demand. SHW, laundry equipment, lighting, and kitchen functions contribute the remainder of total energy consumption. It is clear that while many hotels offer various amenities such as restaurants, swimming pools, spas, and conference rooms, not all establishments provide these services. Operating elevators, escalators, pumps, and other auxiliary equipment typically contributes to only a small percentage of the overall energy expenditure, although their significance may vary depending on the specific context.
Of particular note, swimming pools and spas are equipped with packaged filtration and recirculation systems, which operate throughout the day, with recirculation pumps being particularly relevant. Furthermore, these facilities often require substantial amounts of SHW for various purposes. The consumption of the described components is quantified by end use through a percentage of the total value, as illustrated in Figure 4.

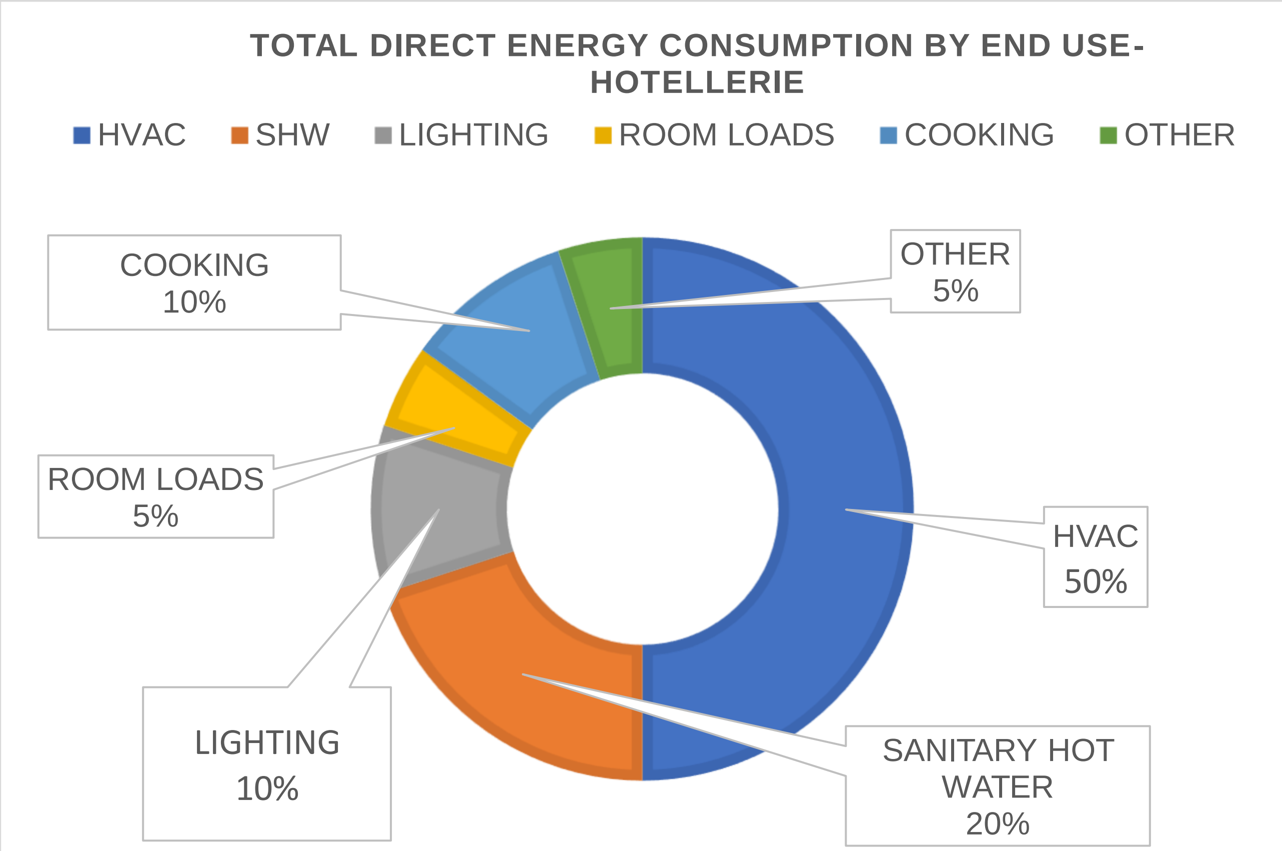


*Figure 4 Hotellerie energy consumption in percentage*

With a primary emphasis on HVAC, particularly in regions with extreme climatic conditions, its prominence may diminish in more temperate zones where kitchen and SHW demands may be prevalent. However, irrespective of geographical context, HVAC systems present inherent challenges in management, particularly evident in their asynchronous utilization, fluctuating energy loads, and the unpredictability in guest's perception of thermal comfort and indoor climate. This outcome confirms the importance of performing automatic control systems, such as Building Management System (BMS), with particular attention towards managing room loads (the consumption of electric energy linked to appliances installed within the guest's room, such as minibars, TVs, hair dryers, lighting, etc). The impact of such control measures on overall energy consumption is noteworthy, with room loads potentially influencing up to 10% of the total energy usage, the upper limit being characteristic, in upscale accommodations such as four and five-star hotels, where hotel guests tend to be very demanding in terms of comfort. Additionally, implementing a BMS can raise awareness among guests and increase their concern regarding energy usage issues. Moreover, the integration of occupancy sensors for lighting and temperature room control is a straightforward application of BMS technology. These sensors enable the automatic adjustment of lighting and temperature room levels based on room occupancy, contributing to energy efficiency without compromising guest comfort.

The most effective method for consumption analysis in facilities is Load Profile Analysis (a graph that shows energy usage on a daily or seasonal basis), showing energy consumption patterns as presented in Figure 5. It provides accurate information through the analysis of data emerging from the energy bills and consumption over time. It offers insights into temporal consumption trends, depicting variations across time scales (typically hours) or seasons. This approach facilitates informed decision-making on resource management and optimization. By examining load profiles, hotel managers can identify peak demand periods, assess energy efficiency measures, and tailor consumption strategies to reduce costs and environmental impact. The load profile is a chart showcasing energy consumption over time. It precisely illustrates power absorbed (measured in kW) throughout the day. The load profile graphically represents variations in energy load, offering insights into peak demand periods and overall consumption patterns. Understanding these fluctuations aids in efficient energy management, allowing businesses to optimize usage, mitigate peak demand charges, and plan for capacity needs effectively. It also provides inputs on possible innovation measures such as retrofitting the older systems or installing new technologies like photovoltaic, energy storage, and solar thermal power.

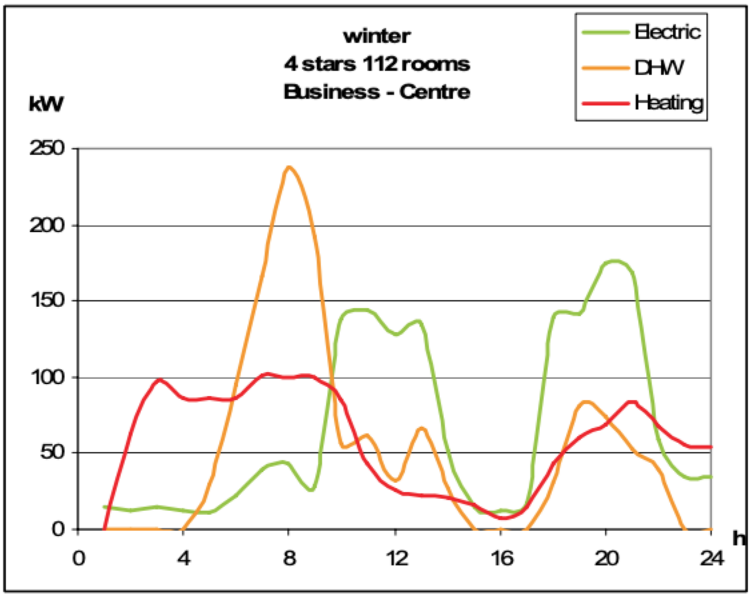


*Figure 5 Typical load profile analysis of hotels, elaborated the study run by ENEA and the Politecnico di Milano (DHW stand for Domestic Hot water and is equivalent of SHW, Sanitary Hot Water).*

Figure 5 provides insights into energy peak periods and illustrates how customer demand fluctuates throughout a typical day. Although load profiles can reveal the general energy demand, it is important to note that they do not provide visibility into the specific electricity consumption for individual services; this limitation makes it difficult to ascertain accurate usage data for each system or facility. Therefore, to measure the consumption of each system accurately, it is necessary to install energy meters and continuously monitor them.

The importance of load profile is further supported by the fact that any improvement interventions during the design and planning phase require a specific consumption load value for the system or service being addressed.

When obtaining a load curve is not feasible, energy consumption data derived from literature can serve as Energy Performance Indicators (EPIs), providing approximate insights into the overall energy consumption of the facility. However, this approach does not provide precise information regarding individual service or system consumptions, but only offers rough estimates in the absence of more accurate data. EPIs are useful for obtaining a general understanding of energy usage throughout the facility and compare it with internal consumption. In our literature review, we identified common units of measurement for benchmarking general energy consumption in hotels. These include annual energy consumption per unit of gross floor area or consumption per room. The table below presents a range of energy consumption for the identified benchmarks.

| Benchmark | Value range |
|---|---|
| Yearly energy consumption for winter heating | 2.5−3.5 MWh/room |
| Yearly energy consumption for hot sanitary water | 3.8−4.4 MWh/room |
| Yearly energy consumption for summer air conditioning | 1.0−3.5 MWh/room |
| Yearly Electricity Consumption | 5.0−11.0 MWh/room |

*Figure 6 Specific energy consumption of Italian hotels – Report RSE/2009/162*

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## RESTAURANTS

Restaurants stand out as energy-intensive establishments, consuming approximately 5 to 7 times more energy per square foot compared to other commercial buildings like offices and retail stores. Notably, high-volume quick-service restaurants may exhibit energy consumption rates up to 10 times higher per square foot than their commercial counterparts. The distinctive service characteristics of various restaurant types significantly influence energy demand management. For instance, quick-service take-away restaurants operate differently from other restaurant models, where customers typically order and consume meals onsite. Within restaurant structures, as for hotels, both indoor and outdoor areas contribute to energy consumption, with the bulk of usage concentrated indoors, particularly within kitchen facilities. In the following main kitchen energy consuming equipment are listed:

- *Refrigerators and Freezers*
- *Walk-In Refrigerators and Freezers*
- *Ice Makers*
- *Blast Chillers*
- *Steam Cookers*
- *Fryers*
- *Ovens*
- *Griddles*
- *Hot Food Holding Cabinets*
- *Dishwashers*
- *Broilers*
- *Ranges*
- *Induction cooks top*
- *Vent hoods*
- *Stand mixers*

It is evident that, in addressing energy efficiency within restaurant operations, the adoption of high-efficiency cooking equipment emerges as a promising strategy. Such equipment can deliver notable energy savings, with potential efficiency gains ranging from 15 to 30% compared to standard equipment. Examples include induction cookware and retrofitting the refrigerators, freezers and walk-in cooling rooms.

High energy consumption also arises from HVAC systems in dining and kitchen areas. In particular, the kitchen ventilation system can absorb a considerable amount of energy due to its continuous operation. Additionally, freezing and refrigeration chambers constitute another substantial portion of energy consumption, running continuously.

The consumption of the main restaurant components is determined as a percentage of the total value, as shown in Figure 7.

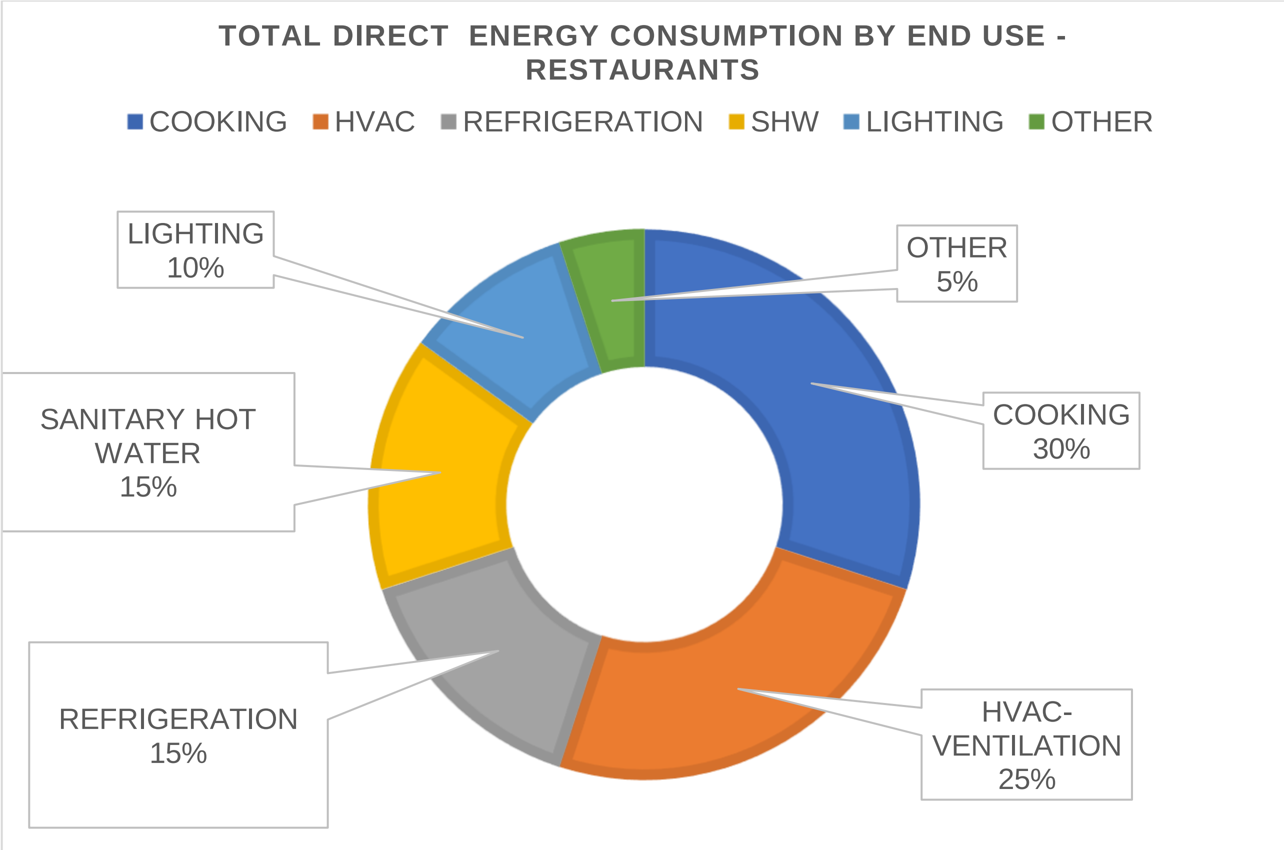


*Figure 7 Restaurant energy consumption in percentage*

In an attempt to identify a benchmark and standardise the energy demand per customer, our team consulted the literature and found that Bohdanowicz and Martinac (2007) argue that one food cover in a hotel restaurant requires approximately 4-6 kWh of energy. These figures are consistent with estimates by Deng (2007), who found that one food cover for hotel catering services requires 3-10 kWh of energy. According to Karagiorgas et al. (2007), the specific energy consumption per lunch in a deluxe Greek hotel is 5.5 kWh. As is commonly known, resources demand varies greatly according to the diet. Of course, these estimations can only roughly represent details on the food origin and type. The table below presents an estimation of energy requirements for meal preparation in hotels, which can be applied to individual restaurant and catering services.

| **Bibliographic source** | **Average energy demand per meal** |
|---|---|
| Bohdanowicz and Martinac (2007) | 4.0 − 6.0 kWh/food cover |
| Deng (2007) | 3.0 − 10.0 kWh/food cover |
| Karagiorgas et al. (2007) | 5.5 kWh/lunch |

*Figure 8 Meal energy demand benchmarks*

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## CATERING SERVICES

Analysing direct energy consumption in catering services reveals parallels with restaurant operations, yet it necessitates additional considerations, particularly regarding transportation and logistics. Catering services typically involve two main areas of energy consumption: the central kitchen and the event venue. This separation underscores the diverse energy demands across different stages of food preparation and service.

Regarding the energy consumption associated with the kitchen, the main consumptions are linked to kitchen ventilation, refrigeration for food preparation and preservation, and sanitary hot water. In some contexts, the energy consumption for food and beverage serving components can vary significantly within catering services, potentially resulting in substantial energy consumption.

Transportation and storage are as well significant energy-consuming aspects of catering operations. The energy consumption associated with transportation depends largely on the distance travelled and the efficiency of logistics coordination. Various types of catering services exist, including those employing cook-chill systems, restaurant-style cook-serve systems, delivery of prepared food, and home-meal replacements. Each service type presents unique energy challenges, with logistics playing a central role in overall performance. Interestingly, proximity between producers and consumers does not always translate to lower emissions. Inefficient local distribution systems, characterized by poor transport logistics coordination or frequent deliveries with partially loaded trucks, can outweigh the benefits of shorter distances as highlighted by Paciarotti.

In light of this, efforts to mitigate energy consumption and environmental impact in catering services beside the consideration already made for restaurants, involve the adoption of "green" vehicles for delivery. However, addressing energy consumption comprehensively requires a holistic approach that include not only transportation but also energy-efficient practices in food preparation, storage, and service. The quantification of these direct consumption is represented as a percentage of the total, as visualized in Figure 9.

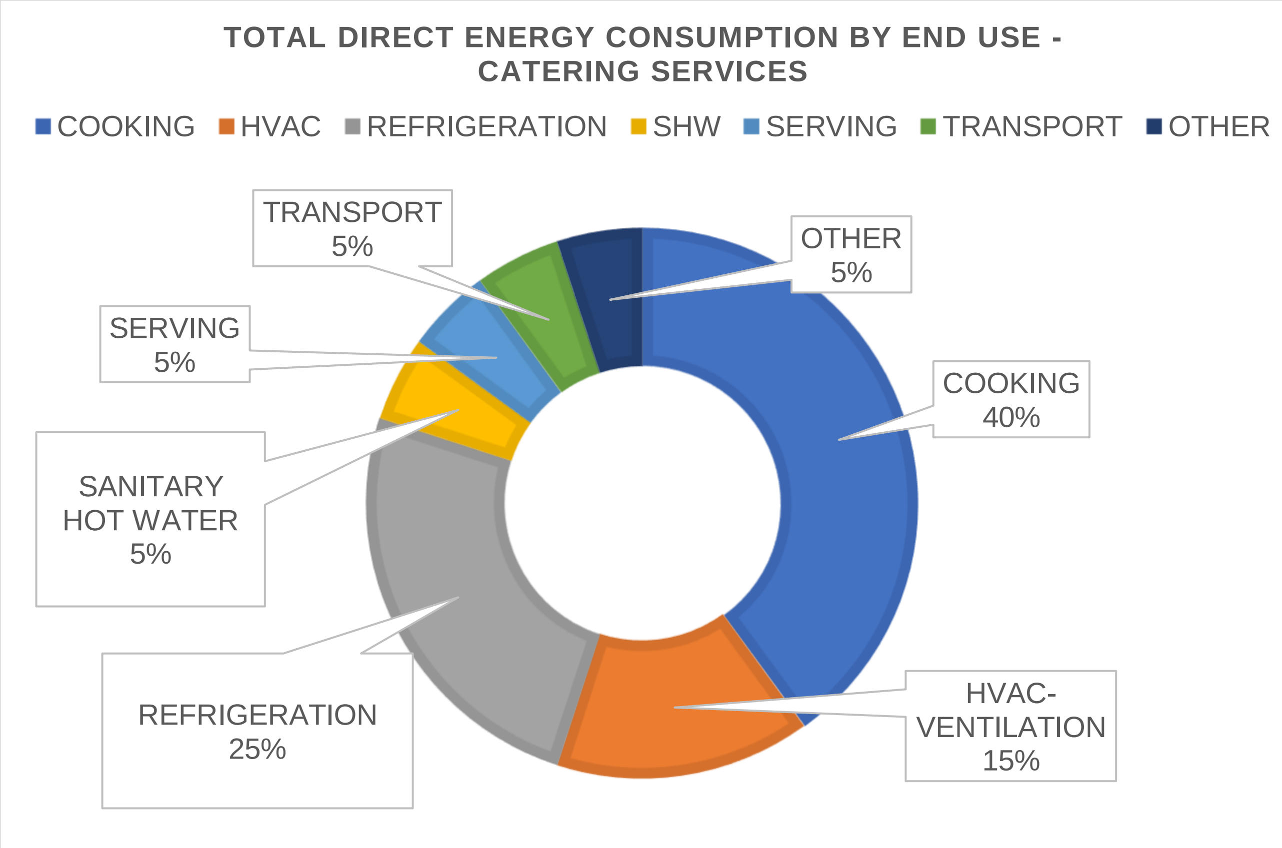


*Figure 9 Catering service energy consumption in percentage*

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# HORECA VALUE CHAIN SUPPLIERS ENERGY CONSUMPTION ANALYSIS

In literature, numerous studies focus on internal consumption measured within HORECA service facilities, yet there is a glaring gap in research encompassing the entire value chain across this sector. Existing literature tends to compartmentalize analyses, addressing suppliers within the HORECA sector in a sectoral way rather than holistically. While systematically requesting each supplier to compile their respective consumption data within their value chain may seem feasible, the truth is that player of the value chain often have limited insight into each other's operations. Moreover, another obstacle in adopting such a broad approach stems from the necessity to consider the plethora of services and goods procured by HORECA operators. However, attempting to assess the entire spectrum of purchases, in terms of energy demand, proves practically unfeasible from the perspective of a hotel or restaurant managers.

For this reason, the focus is solely on suppliers responsible for the most significant energy consumption across the value chain, identified as "HOTSPOTs."

The following section examines four suppliers identified as the most impactful in terms of energy consumption across both hotel and food service sectors, including meal preparation services as catering:

- **OUTSORCED LAUDRY SERVICES** (with focus on energy for washing operations);

- **FOOD & BEVERAGE SUPPLIERS** (with focus on cold chain food preservation);

- **TRANSPORTATION** (with a focus on fleet emissions and cost travel);

- **FUEL & ENERGY SUPPLIERS** (with focus on type of primary energy utilized and electricity generation mix).

## LAUNDRY

Outsourced laundry suppliers in the HORECA industry plays a significant role in understanding energy consumption dynamics within hospitality establishments. Typically, laundry services, encompassing washing, drying, and ironing, are substantial consumers of electricity and hot water, operating at temperatures ranging from 60 to 80 degrees Celsius.
These are the main energy consumption phases, followed by transportation which have a dedicated chapter and office energy consumption.
Collecting data from scientific literature and experiences we can suggest that energy consumption per kilogram of bed linen hovers around 2 kWh, regardless of whether the laundry service is conducted in-house or outsourced.
According to Máša et al. (2013) approximately 0.2 kWh of thermal energy and 0.1 kWh of electricity are utilized to wash 1 kg of laundry in a modern low-capacity industrial laundry (handling 300–500 kg of laundry per shift). An additional 1.5 kWh of heat energy and 0.1 kWh of electrical energy are necessary for the drying process.
The electricity utilized in laundry operations directly correlates with the number of guests and, inherently, the bed occupancy rate. This enables us to roughly estimate the consumption associated with laundry services. Applying the concept of 'single guest load' helps quantify the individual energy use attributed to laundry services, on a weekly basis:

**Weekly laundry load to be processed =**
**Number of guests x 'Single guest load' [kg] x Weekly changes**

| Benchmarks | Notes |
|---|---|
| Number of guests | The size of the structure and occupancy rates are taken into consideration. |
| 'Single guest load' | Depending on the typology of businesses, it can be assumed that for an hotel, the amount might be 3 kg, whereas for the meal service, it might be 0.5 kg. |
| Weekly changes | Depending on the type of businesses, it can be expected that for a hotel, the frequency might be 3 times or 7 times per week, while for the meal service, it might be 1, 2 or 3 times per day. |

*Figure 10 Laundry energy consumption benchmarks*

In this analysis, the energy demand associated with transporting linen pieces to and from the laundry, as well as the energy embodied for the infrastructure of the laundry have not been considered. However, these factors may be considered secondary in comparison to the energy used for washing operations. The present methodology hinges on comparing several calculations tailored to the unique data profiles of each business. As mentioned before a deeper analysis of the energy consumption within laundry service sector require a specific evaluation of the single organization.

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## FOOD & BEVERAGE COLD CHAIN

The food and beverage "cold chain" comprehends the sequence of stages that a refrigerated product undergoes, from its origin point to its final delivery to the consumer. Food and beverage "cold chain" represents an energy intensive industry that consumes a significant amount of energy and carbon emissions from the rapid freezing of products, low temperature preservation, low temperature processing, distribution and thermal transport. This complex process is essential for mitigating the natural degradation of perishable goods. Managing the temperature at which these products are processed, stored and transported, it is possible to significantly slow their deterioration. Within the food and beverage industry, the control of temperature plays a critical role not only in the transformation and preservation of food but also in ensuring the entire supply chain operates efficiently and sustainably. From the initial producer to the end consumer, each step of the value chain demands a precise and consistent application of energy resources. This is to maintain fresh goods within a specific temperature range, thereby safeguarding the quality of the products and ensuring food safety. The following table represent the temperature range foreseen for transportation and storage of some food categories.

| Food category | Transportation temperature | Storage temperature |
|---|---|---|
| Beverages from fresh products | +8°C | +4°C |
| Dairy products | +8°C | +4°C |
| Fish | 0°C /-18°C | 0°C /-18°C |
| Fruit and vegetables | +8°C /-18°C | +8°C /-18°C |
| Meat | +4°C | +2°C /-18°C |

*Figure 11 Food category and temperature range for transportation and storage*

The energy efficiency of the cold chain directly impacts the environmental footprint of the food and beverage industry and the overall sustainability of food systems. Innovations in refrigeration technologies, renewable energy sources, and logistics management are continually being explored and implemented to enhance the energy efficiency of the cold chain. These advancements aim to reduce energy consumption and greenhouse gas emissions while maintaining the integrity and safety of food products throughout their journey from farm to fork.

The topic of improving energy efficiency in the cold chain has been deeply analysed within the project Horizon ICCEE which developed a model and a practical tool for the calculation of cold chain energy consumption. As shown in the best practices identified by the project, and in other paper of our scientific literature review, the HORECA sector has important opportunities to improve the sustainability through:

- the adoption of new technology or improve the existent ones,
- the improvement in energy efficiency of the building and the refrigeration system,
- the adoption of new behaviours such as predictive maintenance, regular cleaning, adjust cooling temperatures.

With the tool developed in ICCEE available in the IMPAWATT platform, it becomes feasible to evaluate and calculate the energy consumption associated with food and beverage cold supply chain.

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## TRANSPORTATION

Transportation serves as a critical, cross-sectoral service utilized by a diverse range of suppliers and customers within the HORECA industry for the movement of goods, personnel and customers. This indispensable service facilitates the efficient and timely delivery of products, ingredients, and supplies essential for the day-to-day operations businesses. Additionally, it can play an important role in ensuring the mobility of staff and guests, enhancing the overall operational fluidity and customer experience within the HORECA sector. The sustainability of transportation systems is a multifaceted issue that centres on several critical factors. These factors can be broadly categorized into fuel type and consumption, related to $CO_2$ emissions, and operational efficiencies, including load, eventual refrigeration and vehicle mileage. Improving the sustainability of transportation involves a comprehensive understanding of these elements and their interdependencies.

**Fuel Type and Consumption**

The type of fuel used by vehicles plays a significant role in determining their environmental impact. Different fuels emit varying amounts of $CO_2$, a primary greenhouse gas contributing to global warming. The following table resume the $CO_2$ emission per fuel type:

| Fuel Type | $CO_2$ Emissions per litre of fuel |
|---|---|
| Gasoline | 2,380 g |
| Liquefied Petroleum Gas (LPG) | 1,610 g |
| Compressed Natural Gas | 2,750 g |
| Diesel | 2,650 g |
| Electrical | 0,000 g |

*Figure 12 Fuel type and $CO_2$ emissions*

**Fuel Consumption and Driving Efficiency**

Fuel consumption is significantly influenced by driving style, vehicle load, and operational efficiency. Aggressive driving, excessive running, and carrying unnecessary weight can increase fuel consumption, thereby raising operational costs and $CO_2$ emissions. Fleet management strategies that prioritize fuel-efficient driving practices and optimal vehicle loading can enhance the sustainability of transportation operations.

**Operational Efficiencies and Mileage Costs**

The cost of freight transportation, often measured in freight ton-kilometres, is a critical metric for assessing the efficiency of transportation operations. Factors such as vehicle type, cargo weight, travel speed, and engine efficiency play focal roles in determining truck mileage costs. On average, trucks may consume between 30 to 40 litres of fuel per 100 kilometres, though this can vary widely based on the aforementioned factors. Urban versus suburban road types also affect fuel consumption rates, with urban routes typically resulting in higher consumption due to frequent stops and starts. According to the Italian Ministry of Transportation in January 2023 indicative reference values of the operating costs of an Italian road haulage company for hire or reward vary between 1,478€ and 2,985€ per kilometre. Optimisation of the routes and number of trips, selection of local providers, rising awareness on drivers are some of the opportunities to reduce the impact of the value chain together with the adoption of more efficient fleet.

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## ENERGY EMISSIONS ACCORDING TO ENERGY SOURCE

Hotels are major consumers of energy, and their energy bills can significantly impact budgets due to high consumption and associated costs. To improve energy and fuel supply management, it is necessary to initially estimate the volume of fuel consumed for energy source (natural gas, oil, electricity, nuclear etc.), including electricity, fossil fuels such as natural gas, liquid gas, heating oil, diesel, biomass, or pellets used within the facility.

Although emissions from fossil fuels are often seen as inevitable, it is possible to generate electricity using green energy sources. The hospitality sector, which includes hotels, restaurants, and cafes (HORECA), has many opportunities to increase its use of renewable energy. It is important to note, however, that not all electricity is currently produced from renewable sources.

As an example, the electricity generation mix for Italy are reported below utilizing data from the IEA (International Energy Agency), which delineates the primary energy sources utilized to generate electricity. These sources can be translated into contributions in terms of $CO_2$ emissions. By considering the emission factor per MWh for each fossil fuel type, as outlined in the table beneath, it is possible to quantify the emissions of carbon dioxide attributable to each generation source.

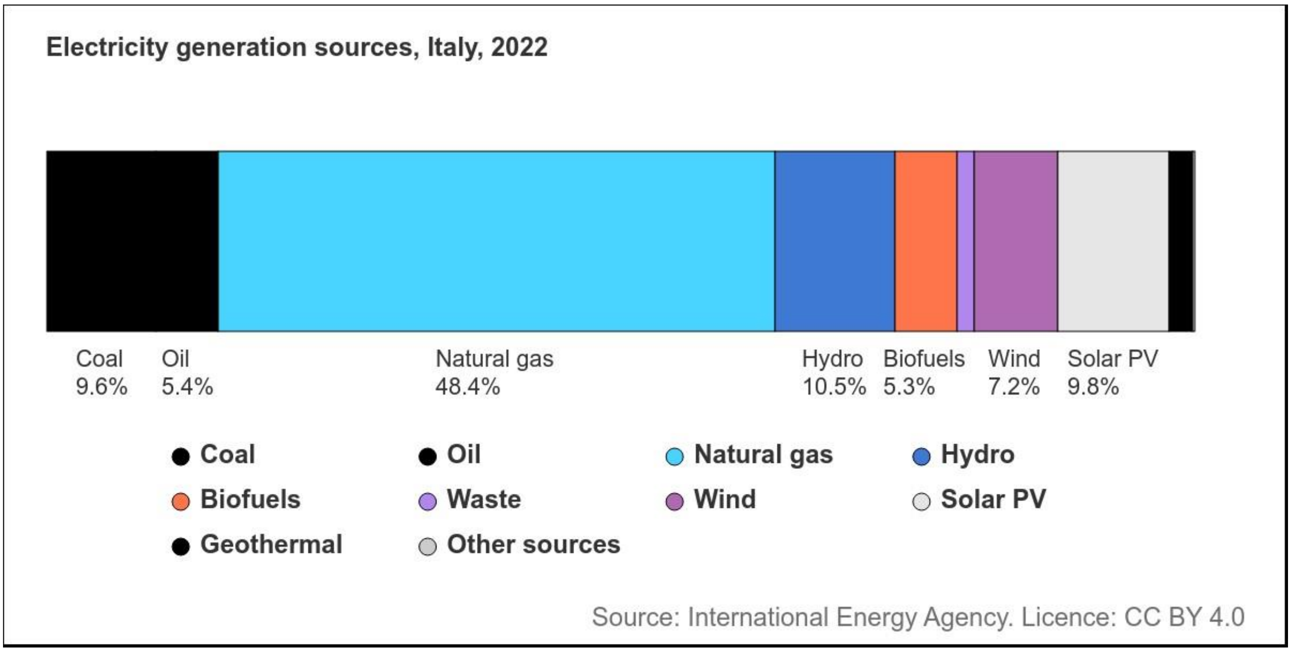


*Figure 13 Electricity generation sources, Italy, 2022*

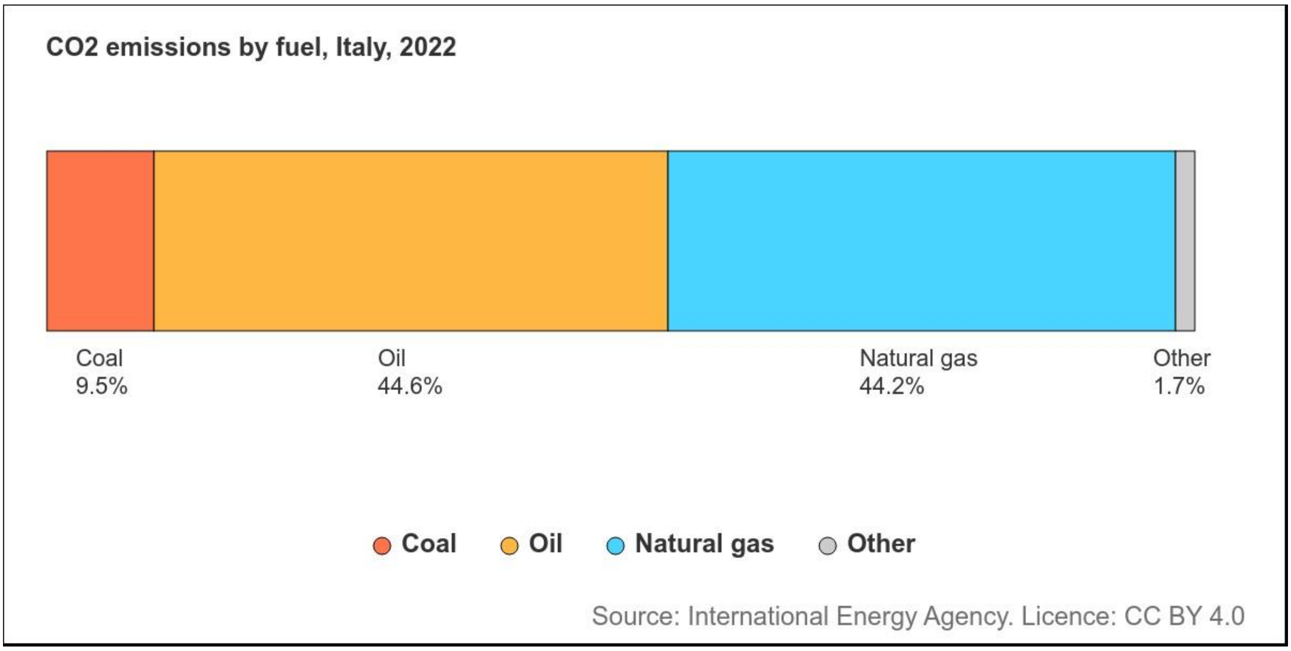


*Figure 14 Italian $CO_2$ Emissions by fuel 2022*

| Energy carriers IPCC denomination | Standard (IPCC, 2006) | LCA 2008-2015 |
|---|---|---|
| | t $CO_2$-eq/MWh | t $CO_2$-eq/MWh |
| Natural gas | 0.202 | 0.240 |
| Liquefied Petroleum Gases | 0.227 | 0.281 |
| Natural Gas Liquids | 0.231 | 0.272 |
| Gas/Diesel oil | 0.268 | 0.306 |
| Gas/Diesel oil | 0.268 | 0.306 |
| Motor gasoline | 0.250 | 0.314 |
| Lignite | 0.365 | 0.375 |
| Anthracite | 0.356 | 0.370 |
| Other Bituminous Coal | 0.342 | 0.358 |
| Sub-Bituminous Coal | 0.348 | 0.363 |
| Peat | 0.383 | 0.390 |
| Municipal Wastes (non-biomass fraction) | 0.337 | 0. 295 |

*Figure 15 Energy carriers and relative emissions - JRC TECHNICAL REPORTS, 2017.*

| Electricity generation from renewable energy source (RES) | Standard (IPCC, 2006) | LCA 2008-2015 |
|---|---|---|
| | t CO2-eq/MWh | t CO2-eq/MWh |
| Wind | 0 | 0.010 |
| Hydroelectric | 0 | 0.006 |
| Photovoltaics | 0 | 0.030 |

*Figure 16 Renewable Energy and relative emissions - JRC TECHNICAL REPORTS, 2017*

*In the previous table are reported the emissions for traditional and renewable energy carriers according to IPCC and LCA standards:*
*Intergovernmental Panel for Climate Change (IPCC) provides values (expressed in $tCO_2$ equivalent/MWh) to be used to estimate* standard direct emissions as default emission factors for stationary combustion for the energy carriers and Renewable Energy Sources. In the second column, default emission factors are reported to estimate local emissions using the Life Cycle Assessment approach, which includes emissions for the whole life from cradle to grave. According to these data, renewable energies nearly eliminate emissions, although considering the Life Cycle Assessment (LCA) approach, they still result in a minimal amount of $CO_2$ emissions throughout their entire life cycle.
In recent years, more and more technologies are adopting electricity as energy vector. According to Terna (the owner of the Italian national transmission grid for high and extra-high voltage electricity) in Italy the HORECA sector consumed 12.2 TWh of electricity in 2022 and this amount its growing year after year. In this perspective, effective strategies adoptable by business managers include self-generating electricity, primarily through photovoltaic installations, to reduce energy transportation costs or the production of hot water through solar thermal collectors avoiding the use of non-renewable sources. Another action easily adoptable is the option of purchasing 'green' electricity from renewable sources through their electricity providers. This approach represents another possible move towards sustainability in the hospitality industry, in line with global efforts to mitigate climate change.

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