Doctoral Thesis

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A multicriteria perspective to integrate environmental management and environmental accounting in the tourism industry

The case of Small and Medium-sized Hotel Enterprises (SMHEs) in the Alpine Province of Trento

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Abstract

The environment, understood as the biophysical support to human society and economic systems, is a relevant variable to firm management. The way the environment is managed can affect not only firm competitiveness but also firm environmental performance both in the short and long-term. The environment generates the inputs (in terms of stocks of natural capital and flows of ecosystem services) supporting human economy and receives back outputs and by-products (waste and emissions) generated by human activities. Therefore the environment does a constant work providing inputs and receiving outputs throughout each function and businesses phase of firms, playing a key role for their development and sustainability. This thesis examines the following two main issues: 1) how to apply environmental management theory in the context of tourism industry, and 2) how to assess the environmental performance and sustainability of Small and Medium-sized Hotel Enterprises (SMHEs) by using a multicriteria assessment framework. Both a specific economic sector and different type of firms are investigated: the tourism industry and selected SMHEs in the Province of Trento.

The environmental management theory, through an online survey of SMHEs in the Province of Trento, explores the implementation of environmental practices, the characteristics of enterprises as environmental determinants and the motivations and perceptions to environmental commitment. Environmental accounting is instead employed to assess environmental costs and impacts associated to selected hotels in the Province of Trento.

Keywords: environmental management, environmental performance, sustainability, hotels, multicriteria assessment framework, environmental accounting, emergy accounting.

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1 INTRODUCTION

1.1 Context, main definitions, innovative aspects

The context of this thesis is the environmental management. The environment, understood as the biophysical support to human society and economic systems, is a relevant variable to firm management. From a biophysical viewpoint, the environment generates raw resources, stocks of natural capital, and flows of ecosystem services, providing inputs supporting human economy and receiving waste and emissions generated by human activities. The environmental management can affect the environmental performance and support the competitiveness of firms. This thesis investigated two issues: 1) how to apply environmental management theory in the context of tourism industry and 2) how to assess the environmental performance and sustainability of Small and Medium-sized Hotel Enterprises (SMHEs) by using a multicriteria assessment framework. A specific economic sector and different type of firms are investigated: the tourism industry and selected SMHEs in the Province of Trento.

In this context, these are the working definitions.

The environmental management is understood as the strategy deriving from the set of environmental practices which are planned and implemented by the firm in the long-run (Álvarez Gil et al., 2001).

The environmental performance is understood as the relationship between the flows of invested resources and the generated service or product. In the framework of Emergy accounting, input resources can be accounted for calculating the cumulative environmental support (i.e. the work of biosphere) needed for their generation. The lower is such environmental support to produce the same amount of output; the better is the performance of the process. For instance, to produce a same amount of electricity, system A uses fossil fuels while system B uses wood chips. The work done by the geobiosphere to make available fossil fuels is larger than that for wood chip. Thus, system B has a better environmental performance since it requires a smaller environmental support for the generation of the input resources needed to produce the same output. Input and output flows can be evaluated by using different environmental accounting methods. The Emergy accounting provides a donor-side or supply-side perspective to environmental accounting because the environmental assessment is based on both amount and "quality"[1] of input resources.

The environmental sustainability focuses more on the typology of used input resources. In particular, a system is more sustainable (from an environmental and biophysical viewpoint) when it runs on the base of a large share of local and renewable resources. Instead, a conventional economic approach is based on the so-called "receiver value perspective". In this case, the environmental assessment of a system would be performed by accounting only for those inputs and output flows showing an economic value (usually defined through the market price). A more holistic perspective is achieved adopting a multi-method and multicriteria assessment framework. The assessment framework applied in this thesis includes the following

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[1] In this context, the concept of quality is associated to both energy concentration and form of energy. According to the second law of thermodynamics, in each transformation the available potential energy decreases while the quality (of the remaining energy) increases. The energy (or the quality of the energy) used in a certain transformation process cannot be substituted with another. In effect, all energy can be converted into heat but different forms of energy cannot apply to different transformation processes by a simple substitution. Emergy accounting allows accounting for such differences. However, the concept of quality is not in absolute terms but it is associated to the system taken into account. In fact, quality is defined as a system property. Two additional properties are attributed to quality: "parallel" and "cross" quality. They are related to the concepts of transformity and hierarchy. Transformities allow the conversion of different forms of energy to emergy of one type. A more detailed definition of transformity will provide later, here it is worth to notice that transformities are quality indicators since they trace the amount of energy needed to a product among parallel and hierarchical process and quantify such amount. Considering a same hierarchical level, the efficiency is the ability of processes to use energy flows (parallel quality). Thus, it is a measure of the environmental costs comparing same outputs. Considering different hierarchical levels, the transformity allows comparing the organisation of a system (cross quality). This concept of quality, accounting for the form of energy and its concentration, refers to the amount of input resources (donor-based quality) rather than to the utility human economy can get from it (user-based quality) (Ulgiati and Brown, 2009).

methods: the Material Flow Accounting, the Gross Energy Requirement, the Emergy Accounting, the Emission Accounting and impact categories. This multicriteria approach was chosen to provide a comprehensive understanding of the performance and sustainability features of the investigated hotel systems by accounting for all main natural and human-driven resources, human labor and economic services.

Despite the recognition of the key role of both environmental management and sustainability in tourism, these concepts are not widely investigated. The limited availability of studies on these issues is even intensified with respect to SMHEs that are the largest type of enterprises in the tourism industry of several countries. In the majority of cases, the environmental performance and sustainability assessments are performed through single method, generally monetary evaluation. A small number of studies attempt to use a holistic perspective to investigate tourism systems and none of them attempts to apply a multicriteria perspective. Given this state of the art, the innovative aspect of this thesis encompasses managerial and environmental fields since it explores both the environmental management and the environmental performance of SMHEs. In addition, since the novelty of these topics applied to SMHEs, primary data were collected by means of an online survey and face-to-face interviews. The statement of both aim and research questions in section 1.2 provides additional explanations about these aspects.

1.2 Aim of the thesis and research questions

As suggested by a number of empirical studies, competitiveness of tourism enterprises is affected by environmental management practices. However, the operations of such enterprises generate environmental costs and impacts both locally and globally. Thus, the two main issues are: 1) how to investigate environmental management in SMHEs and 2) how to assess the environmental performance and sustainability of SMHEs. The goal of this thesis is to investigate such issues and explore the possibility to integrate the environmental management and the environmental accounting through a multicriteria perspective. Such investigation was grounded on a comprehensive literature review in which the topics were examined through a pyramidal structure. The aim was to answer the following research questions:

1. To what extent the environmental management of corporate enterprises can be applied to SMHEs?
2. Which are the main environmental practices adopted by SMHEs?
3. Can typology and extent in the adoption of environmental management practices be used as criteria to cluster SMHEs?
4. Which is the role of enterprise characteristics (size, age, affiliation to hotel chains) in the adoption of environmental practices in SMHEs?
5. Which are the perceptions and motivations of SMHEs for implementing environmentally friendly management policy?
6. How to account for environmental costs (material, energy, and emergy demands) and impacts (waste and emissions) generated by selected SMHEs?
7. Can environmental management be supported by environmental accounting to provide a more comprehensive understanding of SMHEs' features?

1.3 Structure of the thesis

The thesis is organized in five chapters, an appendix section and the references. The five chapters are: introduction, literature review, materials and methods, results and discussion, summary and concluding remarks.

The introduction briefly describes the context, the main definition and the innovative aspects of the thesis. The aim and the research questions are presented as well as the structure of the thesis.

Then, the theoretical framework is presented following an inverted pyramidal structure. The base of the pyramid consists of the analysis of the environment by means of management theory. The role of the environment is investigated within the tourism industry focusing on a particular type of tourism enterprises, the small and medium-sized hotel enterprises. This managerial framework is integrated through the description of the two main perspectives to address the environmental assessment and the added value to purse a multicriteria environmental assessment. Such background knowledge aims to frame the managerial and environmental bases of this thesis. Then, the focus is narrowed on the literature review related to the two main topics of thesis: the environmental management and the environmental performance in the hotel sector.

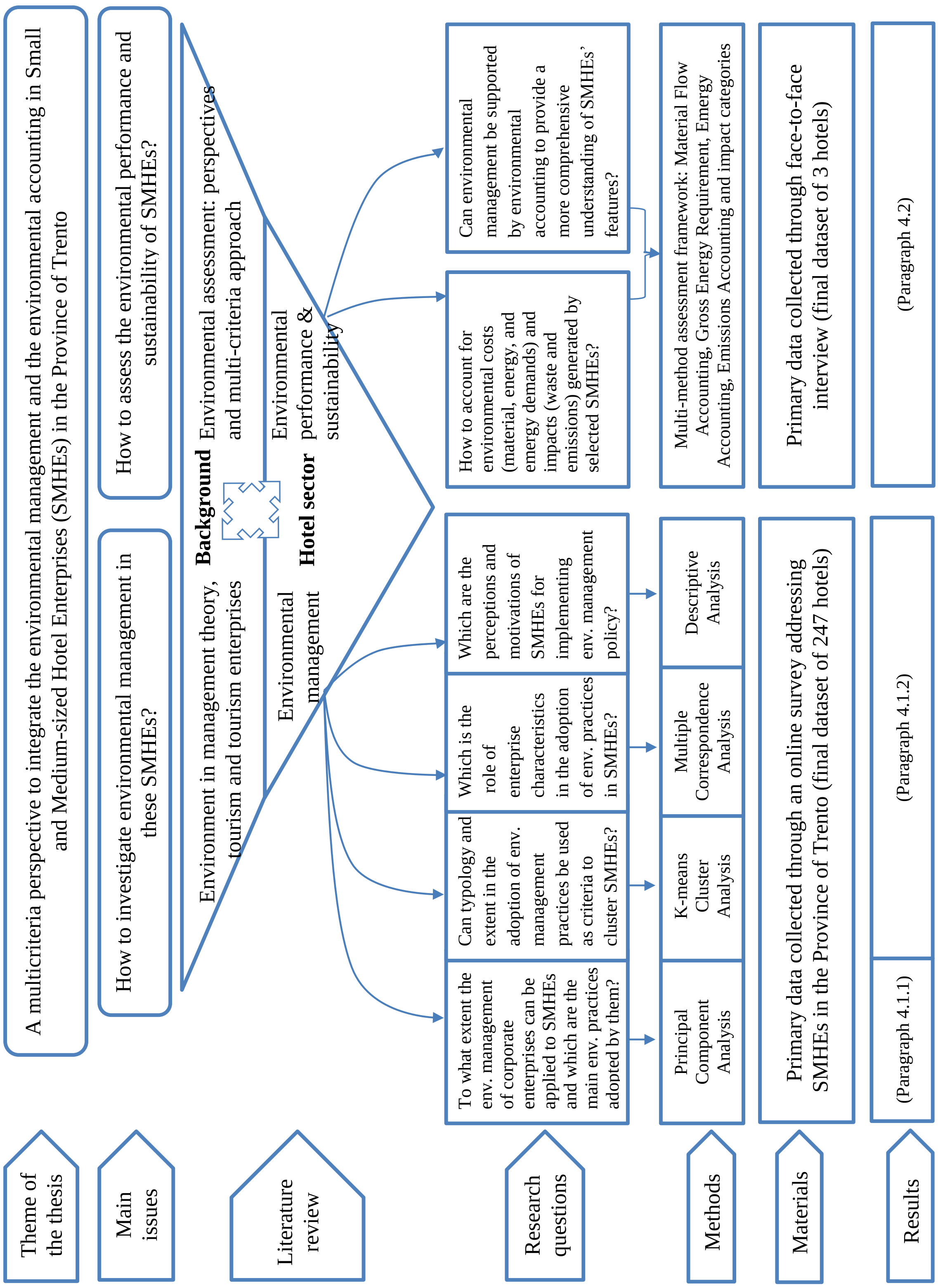
Then, the materials and methods applied to investigate each topic are introduced. The environmental management is investigated through a set of multivariate techniques: the Principal Component Analysis, the Multivariate Correspondence Analysis and the K-means Cluster Analysis. The area of study, the survey and sample characteristics are described and each multivariate technique is explained. This investigation involved a final dataset of 247 SMHEs located in the Province of Trento. Since the novelty of the investigation, and due to the lack of detailed data, the collection of primary data was needed. The environmental performance is investigated through a multi-method and multicriteria environmental accounting including four methods: Material Flow Accounting, the Gross Energy Requirement, Emergy Accounting, Emissions Accounting and impact categories. The investigated sisyem is presented and details are provided on goal, scope, boundaries and inventory data. This investigation involved three hotels located in the Province of Trento. Since the complexity of a multi-method approach, the amount, type and difficulty in collecting the necessary data, three hotels were selected as representative of the investigated sector. In addition to that, to my knowledge there are not same detailed studies on hotel systems performed through this multicriteria assessment. The data collection was performed by means of face-toface interviews. The accomodation was of two type: hotel and garnì-hotel. Two of the three hotels are a four stars category while the other is a three stars superior. To follow, the results of such analyses are reported. The environmental practices – operational, communicational, and organizational – as well as the determinants and the environmental commitment of the investigated SMHEs are detailed and discussed. The environmental performance of each hotel is examined and than a comparison among the three hotels is also accomplished. An additional analysis of waste flows is provided. It emcompassed the waste flows analysis of the three hotels in the light of Italian, regional and provincial waste flows per inhabitant and inhabitant equivalent[2]. Finally, a complete summary of the this thesis is provided along with concluding remarks.

The appendix section includes seven addenda: the questionnaire administer in the survey to SMHEs in the Province of Trento; the statistics on sample representativeness; the energy systems symbols; the chi-squared tests on selected SMHEs' characteristics; the calculation procedures for the multicriteria assessment for the three hotels; the table related to Material Flow Accounting, the Gross Energy Requirement, the Emergy Accounting, the Emissions Accounting and the impact categories analysis's tables per each hotel; and the input-output tables for the three hotels. Then, the full list of references is enclosed.

A schematic structure of this thesis is shown in Figure 1.

[2] The inhabitant equivalent is obtained as a sum of the resident population and the total number of tourists that are the number of overnight stays in hotels in the year divided by 365. This is the number the inhabitants equivalent including the daily average tourists. The amount of tourists is counted as number of overnight stays in the year.

Figure 1. Structure of the thesis.



Source: own elaboration.

2 LITERATURE REVIEW

2.1 Theoretical background

2.1.1 The environment in management theory

An important debate on management theory focuses on the role of the environment and natural resources to foster firm competitiveness. The theoretical framework provided by the resource-based view (RBV) affirms the importance of internal capabilities and resources for firm competitive advantage (Hart, 1995). Traditionally, external resources have received marginal interest: they are exogenous variables which are almost entirely out from firm control. Recently, the limited availability of and rivalry access to natural resources forced to rethink – at a global scale as well as at local scale – the contribution of these external resources to firm competitiveness. Natural resources are capable not only to contribute but also to constraint firm competitiveness[3]. The effort to include them in the theoretical framework of firm management led to the natural-resource-based view (NRBV). The NRBV provides a framework to recognize

[3] These constraints are mainly related to the scarcity of natural resources. The awareness about this scarcity is still recent and controversial. In the past, the Earth was considered an unlimited source of resources at human disposal; however, nowadays this mindset has been chanced. In this respect, Bresso (1982) suggests how the concept of scarcity, from an economic perspective, relates to demand/supply dynamics where the price allocated to scarce resource is a measurement of this relationship. This reasoning is economically straightforward but it is not such clear in absolute terms. The author’s suggestion is to make a distinction between scarce (in economic terms) and finite (in environmental terms) resources (or alternatively refers to the terms *relative scarcity* and *absolute finiteness*) (Bresso, 1982).

the critical constraints posed by biophysical resources to firm performance (Hart, 1995)[4]. These constraints affect not only business operations but also the biophysical environment and whole human activities. Given the increasing trend of human activities, not only academics but also practitioners, governments, and public opinions exert pressures to mitigate or prevent these effects (Muilerman and Blonk, 2001). Human economic activities use natural resources as inputs for production processes. However, most of these processes are not harmless; they entail environmental costs and impacts. A suitable level of both exploitation of and access to natural assets is required[5] as well as an assessment of these costs and impacts aiming to implement the best performing process (or strategy).

From a managerial viewpoint, the environment was traditionally perceived as a limit and/or an additional cost to business activities[6]. The so called Porter Hypothesis attempts to suggest a different perspective (Porter and Van der Linde, 1995). According to this hypothesis, the additional costs generated by environmental regulations are offset by savings in terms of a more efficient use of natural inputs[7]. Rigorous but appropriate environmental regulations offset the

[4] This original framework based on three main strategies – pollution prevention, product stewardship, and sustainable development – was enriched with strategies concerning social equity and clean technologies (Hart, 1995; Hart and Dowell, 2011).

[5] Since some natural resources are common goods, they are likely not only to experience the so called *tragedy of commons* (Hardin, 1968) but also to produce in the meantime negative externalities due to the overuse by certain users' groups and simultaneously to the limited availability for others.

[6] In effect, legal obligations and regulations were introduced to manage environmental issues. Such legislations aimed to internalize the negative externalities generated to the environment by economic and human activities. These regulations might be based on command and controlled mechanisms (such as legislative standards, bans, permits and quotas, zoning, legal responsibility). Recently other mechanisms based either on market rules (eco-taxes, user fees, deposit refund systems, property right allocations, subsidies, tradable permits, cap and trade systems) or voluntary engagement (public participation, information, disclosure, green labeling, environmental management systems, corporate social responsibility) have been introduced. Their implementation should be based on effectiveness in addressing the objective, efficiency in balancing benefits and costs of implementation, and reduction of costs when considering trade-off (The International Bank for Reconstruction and Development and The World Bank, 2003).

[7] Pollution entails inefficiencies in resources' use which can be manage through pollution prevention mechanisms aiming to reduce the amount of natural resources used (Moss, 2008). This approach to natural resources use clearly affects also firms performance by improving efficiency in resources consumption and enhancing productivity. These results are generated because firms signal to the market potential improvements in efficiency, increase in their environmental awareness, confirm the effectiveness of the investments, create stimuli for innovative behaviors, equalize the legal environmental requirements and thus

additional costs deriving from the implementation of regulations, promote innovations instead of preventing it, and improve both environmental and business performance (Ambec et al., 2013). In effect, at the end of 1990s several authors discussed the green investments and innovations undertaken by a growing number of enterprises which perceived the advantages and the opportunities offered by such investments[8]. To better frame the drivers behind the growing interests in green investments and environmental management, Orsato (2006) distinguishes investments on the basis of organizational processes or those connected with products/services. In making this distinction he refers to the Porter's theory of competitive advantage and the abovementioned Resource-Based View (RBV) theory. The former theory identifies two different types of competitive advantage either based on lower cost or differentiation[9]. The RBV theory, does not consider competitive advantage to be linked to pricing or differentiation strategies, but rather to be generated by a firm's ability to maximize its capacities and resources. Thus, the organizational capacities can stimulate organizational processes which lead to firm competitive

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reduce free-riding behaviors (of those firms which otherwise would have avoided the environmental investments) (Porter and Van der Linde, 1995).

[8] Green investments are defined as a set of business practices which contribute, either directly or indirectly, to reduce the environmental impacts of organizational methods, and generally to reduce the impact of products and services life cycles (Reinhardt, 1998). The OECD, underlining the importance of investment in eco-innovations, defines them as "the implementation of new, or significantly improved, products (goods and services), processes, marketing methods, organizational structures and institutional arrangements which, with or without intent, lead to environmental improvements compared to relevant alternatives" (Machiba, 2012). The Eco-Innovation Observatory ("Eco Innovation Observatory (EIO)," 2013) provides another definition: "Eco-innovation is any innovation that reduces the use of natural resources and decreases the release of harmful substances across the whole life-cycle". Then, it is worth to notice that a similar concept of eco-innovation has been already included also in the NRBV but it should not be misunderstood with the clean technologies strategic capability. Hart (1995) firstly framed the NRBV according to three strategic capabilities of proactive environmental firms – pollution prevention, product stewardship, and sustainable development – and further he proposed to integrate two more capabilities: clean technology and based of pyramid (Hart, 1997; Prahalad and Hart, 2002; Simanis and Hart, 2008). In this respect, clean technologies have not the same meaning as eco-innovations. Actually, according to Hart (1997) pollution prevention and product stewardship are "greening" strategies. They represent improvements of products and processes in use. They match the definition of eco-innovations proposed above. Clean technologies belong to "beyond greening" strategies. They represent improvements of future products and processes. However, it is worth to notice that despite these clean technologies are valuable dynamic capabilities, they are characterized by alterations and uncertainty which do not enable to predict any competitive advantage once these investments are undertaken (Fiol, 2001; Hart and Dowell, 2011).

[9] Porter (1980) suggested three main generic strategic approaches to cope with the five competitive forces (suppliers, potential entrants, substitutes, buyers, competitors). They are (overall) cost leadership, differentiation, and focus. Either cost or differentiation strategies can be applied industrywide; the focus strategy, instead, might be applied to particular segment only. Thus, a focus strategy by cost leadership aims at pursuing a cost advantage limited to one or a few market segments; a focus strategy by differentiation aims at pursuing a differentiation advantage through the identification of a segment of customers who is particularly sensitive to the feature (for instance the quality) of the product. One of the risks associated with this strategy comes from the fact that the chosen niche is not large enough to allow companies to operate efficiently (Porter, 1980).

advantage. This approach supports the idea of environmental management systems (EMS) as capable to generate competitive advantage. Certification schemes, EMS, and Total Quality Management (TQM) therefore assume considerable importance for enterprises[10] (Orsato, 2006).

Basically, the managerial theory on one hand is recognizing the environmental limits and natural resources' constraints to which firms are subjected; on the other hand is more aware about the key role played by the environmental management to firm competitive advantage. Such considerations apply to firms in each industry sectors, particular in the most growing ones for which the economic growth might entail also an increase of environmental issues. This is the case of the tourism industry.

2.1.2 The role of the environment and sustainability in tourism enterprises

Tourism is a growing industry in comparison to other industries that have been negatively affected by recent economic and financial crises. The World Travel and Tourism Council estimated that the growth of the total contribution from tourism activities to world GDP in 2013 was around 3 percent (WTTC, 2013). It is also estimated that other measures of economic impact – such as employment, exports, and investment – are increasing. In effect, the tourism industry appears to be an attractive option for developing countries (Sinclair, 1998) and has strongly performance in developed countries (Milne and Ateljevic, 2001). While empirical evidence recognizes the contribution of tourism to economic growth and local development[11] further

[10] The improvements brought by EMS can be associated to those resulting from quality management. Nevertheless, there are clear differences between enterprise processes oriented to quality and those concerning environment management. Improvements in quality can be transferred from organizational processes to the products and services bought directly by consumers. This embeddedness allows quality to become private profit. Enterprises investing in products and services which do not damage the environment are generally described as practicing green marketing and strategies.

[11] The concept of local development, within the existing global dynamic trends, combines local economic pressures with environmental and socio-cultural claims, and provides an interpretation of the relationship between enterprises and the

investigations are needed because of tourism capability to produce not only economic but also social and environmental effects that can be both positive and negative (Milne and Ateljevic, 2001). In order to take advantage of the positive effects and mitigate the negative ones, tourism management should be oriented to a sustainable development[12]. Sharpley (2000) argues that the sustainable development[13] must be holistic, long-termed and equity-driven. Transferring these elements to tourism activities involves three main considerations. First, a holistic approach to development and environmental issues implies a comprehensive assessment of the natural resources needed and affected by potential tourism activities. Second, this assessment must account for long-term capacity of the ecosystem not only to provide inputs (i.e., natural resources), but also to mitigate its negative outputs (i.e., emissions and wastes). Third, the access

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environment (Rispoli, 2002). Since the crisis of Fordism development model during 1970s and the shift from large sized enterprises to SMEs, the environment has been interpreted as a determinant either exogenous or endogenous. The endogenous determinants are not only spatial and physical resources, but also networks and relationships among local communities and institutions. The main theories based on this concept of environment are industrial districts, milieu innovateur, and learning regions theories (Capello, 2004). Italy experienced a wide diffusion of industrial district areas characterized by SMEs (Bagnasco, 1986; Becattini, 1987) whose additional value was based on participation, and sharing of knowledge and resources among the local network (Di Bernardo and Rullani, 1985). Thus, local communities and territories are recognized as drivers for development at local and regional levels. As noted by Blakely: "communities put themselves in a position to market their resources intelligently and must use their current human, social, institutional and physical resources to build a self-sustaining economic system" (Blakely, 1989). With respect to the territory, Garofoli (2002) defines it as "the historical and cultural conditions and the socio-economic characteristics of the various regions" which are capable to explain the differences in "the diverse paths of development undertaken in various historical and geographical circumstances" (Garofoli, 2002). Given certain analogies between industrial districts and tourist districts, some authors suggest an interpretation of destinations as based on industrial district theories (Pencarelli, 2003; Sainaghi, 2004) to support the contribution of tourism to local development as did by industrial manufacturing districts. However, caution is required in this analysis because of intrinsic peculiarities and differences due to the service-based nature of the tourism industry versus the product-based nature of manufacturing industry.

[12] Early definitions of sustainable development were based on homocentric approaches to natural resources management while later ones have entailed a more ecocentric approach. However, two are the main paradigms of sustainability: weak and strong (Neumayer, 2003). Weak sustainability is based on the work of neoclassical economists, who argues that there is an unrestricted availability of natural resources and the possibility of substituting natural for built resources (Hartwick, 1977; Solow, 1974). Strong sustainability paradigm has less clear origins and several scholars have contributed to formulating it. According to this stream, there is a need to maintain a minimum stock of natural resources given the uniqueness and limited availability of these natural resources (Costanza and Daly, 1992; Goodland and Daly, 1992; Pearce and Turner, 1990). Therefore, the possibility to substitute natural for built resources is not always guaranteed.

[13] The sustainable model reported by Sharpley (2000) consists of: three fundamental principles (a holistic approach capable to integrate development and environmental issues; a long-term view to ecosystem capacity; equity when dealing with resource use and access), four development objectives (improvement of quality of life, satisfaction of basic needs, self-determination, endogenous development); four sustainability objectives (sustainable population levels, minimal depletion of non-renewable natural resources, sustainable use of renewable resources, pollution emissions within the assimilative capacity of the environment); and four requirements for sustainable development (adoption of a new social paradigm, equitable development and resource use, technological systems for new solutions to environmental problems, global alliance for integrated development policies at all levels).

to and the use of these natural resources must be guaranteed to both an inter-and-intra generational set of stakeholders (Sharpley, 2000).

Despite the relevance of these considerations to sustainability management in tourism, the structure of tourism industry makes difficult to apply such framework. Tourism is an heterogeneous industry characterized by a dual economic structure: there are large firms such as tour operators, hotel chains, and airline companies but also SMEs such as small hotel companies and catering services (Keller, 2004). Large part of developed economies, where the tourism industry is well established, are mostly characterized by small to micro enterprises (OECD Tourism Committee, 2004). Although this composition, few studies have examined SMEs in the tourism sector compared to the broader literature on large sized enterprises. These studies have focused on definitions and typologies of SMEs (Thomas, 1998; Thomas et al., 2011), ability to face uncertainty, entrepreneurship and ownership, access to capital, and motivation to innovate (Morrison, 2006; Morrison et al., 1999). In addition, the environmental management adopted, as well as environmental impact generated, by SMEs are not fully understood and assessed[14]. A part of studies suggest negative environmental impact generated by SMEs (Vernon et al., 2003) while other provides evidence of the positive environmental management through the implementation of a large number of environmentally-friendly practices such as: eco-innovations, environmental labeling, and voluntary practices (Álvarez Gil et al., 2001; Molina-Azorín et al., 2009; Oreja-Rodríguez and Armas-Cruz, 2012; Orfila-Sintes et al., 2005). Most of these studies focus on hotel sector. Accommodation is a key component of tourist supply (other

[14] It is worth to clarify that generally, beyond tourism enterprises, the environmental management of SMEs has been poorly investigated although both the large number of SMEs both in manufacturing and service industry and the evidence of aggregate environmental effects they produced. This aggregate effect may overcome that of large enterprises (Hillary, 2000) putting SMEs in charge for around 70% of the total global pollution produced (Smith & Kemp, 1998) and around 60% of the total carbon emissions (Marshall, 1998). However, these data are mainly based on hypotheses rather than on empirical evidence given the limited researches on these enterprises, scarce availability of data, low redemption in data collection or inappropriate interpretations of survey’s questions (Merritt, 1998).

tourist supply components are other hospitality enterprises, infrastructures and tourist attractions) and SMHEs are the majority number of businesses in the accommodation sector. Hotel services represent the largest part of overall tourist expenditure and generate the majority of the direct, indirect and induced effects to local economies. However, hotels consume large amounts of resources and energy to produce such services (Bohdanowicz, 2005; Bohdanowicz and Martinac, 2007; UNEP, 2011).

Thus, despite the relevance of SMEs (and particular of SMHEs) in tourism industry, the sustainability and environmental management of such enterprises is not fully explored and a further theoretical development is required (Thomas et al., 2011). The priorities are at least two: 1) to investigate the environmental management of such SMHEs and 2) to provide an assessment of their environmental performance and sustainability. However, there are specific issues to be taken into account when exploring each of the two priorities. The investigation of the environmental management in SMEs should set a suitable framework to account for strategies, practices and determinants typical of such type of enterprises. Then, the assessment of the environmental performance and sustainability instead should set an integrated perspective to investigate in a comprehensive way such crucial a topic.

2.1.3 Environmental assessment: the receiver and the donor-side perspectives

The biophysical environment supports human societies through environment processes which generate stocks of natural capital[15] and flows of ecosystem services[16] necessary for human well-

[15] There are different types of capital which may be referred not only to natural assets but also to social, human, and built capital. Human capital consists of knowledge and education, social capital consists of institutions and social norms, built capital consists of buildings and infrastructures. "Natural capital can be defined as the world's stocks of natural assets which include geology, soil, air, water and all living things" (World Forum on Natural Capital, 2015). From these stocks human societies obtain vital ecosystem services. It is worth to notice that natural capital can be either renewable or non-renewable. The former is naturally

being as well as for socio-economic systems survival: the environment provides stocks of capital and flows of services which feed socio-economic systems; socio-economic system, in turn, produces waste and emissions which are feedback in natural system. Indeed, socio-economic system is constantly interacting with the environment. This interaction is essential but also complicated because of the limit of natural systems both in providing natural capital and ecosystem services, and absorbing back waste and emissions. The assessment and the evaluation of these stocks, flows, and feedbacks is a key task to sized appropriate socio-economic systems (Daly, 1992). This task can be undertaken following different perspectives: environmentally, economically, and socially. The integration of these three perspectives is crucial to provide a comprehensive understanding of the environmental performance and sustainability of human systems (Franzese et al., 2014). However, most of the evaluations do not integrate all these three perspectives nor even apply similar systems of values.

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reproducible and not exhaustible; the latter is naturally reproducible according to timeframe longer than human lifetimes. Among non-renewable resources there are not only minerals but also organic elements such as oil or coal; among renewable resources there are soil, water, and solar elements. These elements, together with the ecosystems they generate, determine the availability of additional resources both animal and vegetal. However, unless the solar energy, all the other renewable resources have potentially exhaustible flows. In fact, an over exploitation or withdrawal might compromise their quality (and eventually their utility too) or might harm their reproduction cycles. Dasgupta and Heal (1979) suggest that it would be appropriate to define these resources as exhaustible ones (making use of the famous fish example). An optimal timeframe planning involving natural resources is a widely discussed issue which entails also a sustainability approach to the management of natural resources (Dasgupta and Heal, 1979). The well-known definition of sustainable development as that "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development (WCED), 1987) establishing an intergenerational deal, frames the definition according to human needs. However, the relationship between human needs and natural resources is more complex. According to Neumayer there are two main paradigms of sustainability: weak and strong (Neumayer, 2003). Weak sustainability is based on the work of neoclassical economists, who argues that there is unrestricted availability of natural resources and the possibility of substituting natural for built resources (Hartwick, 1977; Solow, 1974). Strong sustainability paradigm has less clear origins and several scholars have contributed to formulating it. According to this stream, there is a need to maintain a minimum stock of natural resources given the uniqueness and limited availability of these natural resources (Costanza and Daly, 1992; Goodland and Daly, 1992; Pearce and Turner, 1990). This minimum stock of natural resources is interpreted as that part of natural resources which play essential and non-substitutable functions associated with life-support and ecological services. This term is the critical natural capital (Chiesura and De Groot, 2003). Therefore, the possibility to substitute natural for built resources is not always guaranteed.

[16] About ecosystem and ecosystem services, there are several studies proposing a wide range of classifications and definitions. For an in depth-analysis see Häyhä and Franzese (2014) which provides a comprehensive review on ecosystem services including definitions, classifications, and scientific approaches from an ecological-economic perspective (Häyhä and Franzese, 2014). Here in short, it is worth to provide a working definition of ecosystem services as the benefits people obtain from ecosystems. A common classification of ecosystem services includes four main services: provision, regulating, cultural and supporting services (Millenium Ecosystem Assessment (MEA), 2003). The importance of these services raises the interest for their monetary value, tools to internalize the externalities produced because their public good nature (often not excludable and not rival and most often exposed to the so called Tragedy of commons (Hardin, 1968), and payment schemes to compensate individuals helping to preserve ecosystem services' provision.

In effect, economists, even when try to include those three perspectives, provide monetary evaluations based on market mechanisms, individual utilities and preferences. Monetary evaluations are based on the concept of Total Economic Value (TEV) to evaluate environmental resources. The TEV is based on two values: use value and non-use value. The use value are classified as direct, indirect or option value. The direct use value is attributed according to the utility users may derived from the *consumption* of the resource, while the indirect use value is generally associated to a certain ecological function capable to generate some indirect utility to users. The option value is associated to the future potential utility users could get from the effective use of the resource even if at the moment of the valuation that resource is not used yet. The non-use values are bequest and existence values. The existence value represents the value that individuals attribute to a resource just because of its simple presence in the world while the bequest value consists of the satisfaction individuals get from the resource preservation for future users or the happiness it could give to other people (in an altruistic meaning of the resource value) (Pearce, 1993). On this basis, researchers attempted to provide methods capable to assign a monetary value to environmental resources. Give a right value to environmental goods could be a positive starting point to communicate the importance of those goods to policy makers and inspire effective management practices (Garrod and Willis, 1999). In this context, the value attributed to an environmental good is a monetary value which is based on preferences and utilities that individuals assigned to that good. Hence, in a free market, the demand and supply for environmental goods works as follows: individuals demand an environmental good according to their preference and derive a utility from good’s consumption; natural systems supply the good demanded. The equilibrium between demand and supply curves determines the market price for that good. The methods used by economists to evaluate environmental goods can be grouped in two typologies: methods based on the demand curve and methods that are not based on the demand curve. The methods based on the demand curve consist of two subsets: those based on revealed preferences and those based on stated preferences. The revealed preferences are based on the individual's behavior revealed by his actions and/or decisions. The travel cost and the hedonistic price belong to this group. By the travel cost method, the value of a good is derived from the travel expenditure to reach the destination. By the hedonistic price, the value of a good (considered in its single features) results in the individual expenditure for a certain good attributes. With stated preferences method, instead, the value of a good is obtained through the elicitation of the willingness to pay (or alternatively the willingness to accept a compensation for the diminishing in the quantity/quality of the good) for an improvement in the quality/quantity of a good. The willingness to pay (or to accept) is elicited through a questionnaire built according to a precise format. It aims to elicit an amount as much as possible closer to the real willingness to pay of people, assuming a real decision context. As a matter of fact, researchers create an ideal scenario in which the good in question is sold. This market and the overall scenario (including public institutions) are described to the respondent in order to allow him to make an aware bid. The contingent evaluation and the choice experiment techniques are examples of the stated preference method (Garrod and Willis, 1999). The methods that are not based on the demand curve generally provide a proxy of the values based on different costs. The production cost method is based on the estimation of the money needed to produce that service, the replacement cost method is based on the estimation of the money cost to replace that service by a technological substitute, the opportunity cost method is based on the estimation of the money needed to provide an alternative service to the one under evaluation (Garrod and Willis, 1999). The benefit transfer method is based on transferring the monetary evaluation from a study to another exploiting eventual similarity among different studies.

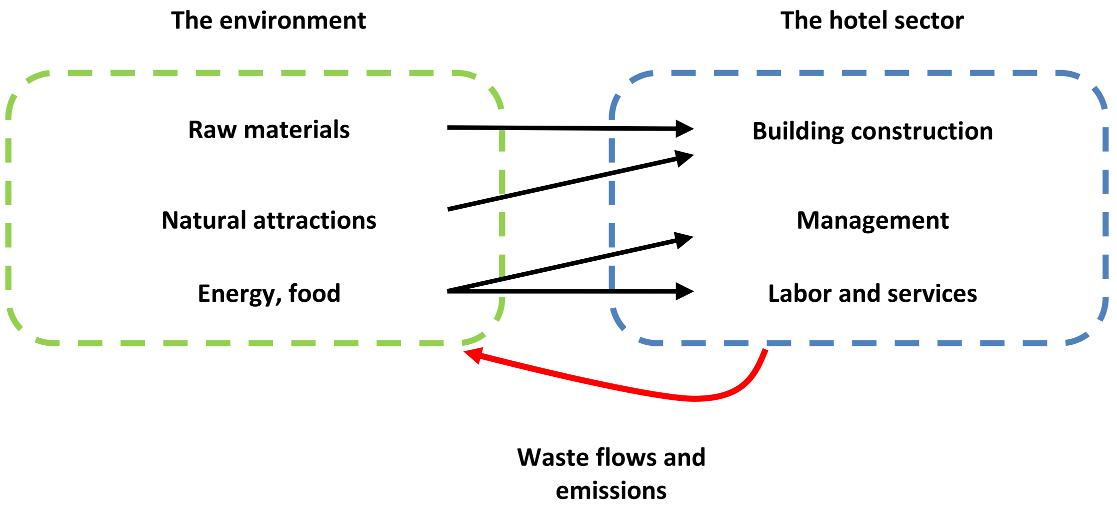
Ecologists instead, provide environmental assessments accounting for the work done by the geobiosphere to make available environmental resources. The work of geobiosphere and the environmental processes are driven by solar radiation, tide, and deep heat. In the absence of such energy flows any environmental processes and resources would not have been available. There are different methods of environmental accounting method. The emergy accounting investigates the energy needed to a system accounting for all the inputs and converting them to a common unity of measure (generally the solar energy). The material flow analysis evaluates environmental goods and services on the basis of the amount of material resources embodied in the goods. The ecological footprint measures the natural capital demanded by socio-economic systems providing on the basis of amount of land or sea required to satisfy the natural resource demanded. The Gross Energy Requirement is an energy analysis that provides information on the commercial energy required to a process or a system to work. The Life Cycle Assessment provides information about the potential environmental impact produced by good, service, or process under analysis. The recipe midpoint is a life cycle impact assessment method accounting for equivalent emissions produced by a process or system on the basis of impact categories.

2.1.4 The need for a multicriteria assessment framework

Human systems are complex and single criteria assessment methods are limited tools to investigate such complexity. Monetary evaluation provides partial information on environmental value and performance of human-driven systems: a multicriteria assessment would be a more adequate tool to investigate and understand it. The environment is relevant in each human driven-system but in specific system it has a key role. This is the case in tourism systems, particularly in hotel sector.

Hotels are constantly interacting with the natural environment. The interaction takes place with the building construction and carries on with daily operations in a constant process of production and consumption of services and natural inputs. Hotels are generally located in natural areas or historical sites characterized by both exceptional natural beauty and sensitive ecological equilibrium. This interaction between built and natural environment is preliminary but qualifying the tourism experience. A second interaction is mediated by customers' behavior which determines the actual amount of resources consumption when demanding accommodation services. A third interaction is performed by hotel management in accomplishing customers' demand. If the first interaction entirely depends on hotel management, the second and third interactions depend also on customers behavior (Kirk, 1995).

Figure 2. Interaction between the environment and the hotel sector.



Source: own elaboration.

The assessment of the environmental performance and sustainability of the hotel sector considering a single perspective could result in partial information about such a complex system of interactions. The economic evaluation accounts for inputs and output from a monetary viewpoint. A market value is assigned to each resource individually. Then, all monetary flows are analyzed by using a receiver value perspective. The Material Flow Accounting or the Gross Energy Requirement, if undertaken individually, would provide information limited to the amount of material consumed by this system or the amount of commercial energy, directly and indirectly, invested in this process. However, these methods do not provide information about the amount of renewable resources, labor or economic services involved in the process. An LCA approach would provide additional information about the output of that system in terms of waste and emissions. However, only a multicriteria perspective would holistically include the largest amount of information. A multicriteria assessment including emergy accounting allows accounting not only for material, energy and emissions flows but also for renewable resources, direct labor and economic services. Such a multicriteria assessment, integrated with the information provided by an analysis of the environmental management of hotel systems, would be a valuable tool to support decision makers both at the firm level and policy maker level.

2.2 The environmental management in hotel sector

Strategies and practices

Several authors provided a classification framework for the environmental management practices (Álvarez Gil et al., 2001; Aragón-Correa, 1998; Aragón-Correa et al., 2008; Aragón-Correa and Sharma, 2003; González-Benito and González-Benito, 2006). A functional classification distinguishes three main categories: operational practices, planning and organizational practices, and communicational practices. The operational practices involve both process and product related activities. This category of practices generates the most visible effects on the environmental management because they are directly associated with production operations and products. The operational practices which refer to product design are: "substitution of polluting and hazardous materials/parts, designs focused on reducing resource, consumption and waste generation during production and distribution, designs focused on reducing resource consumption and waste generation in product usage, design for disassembly, reusability and recyclability. The process design operational practices are: "emission filters and end-of-pipe controls, process design focused on reducing energy and natural resources consumption in operations, production planning and control focused on reducing waste and optimizing materials exploitation, acquisition of clean technology/equipment, preference for green products in purchasing, environmental criteria in supplier selection, shipments consolidation, selection of cleaner transportation methods, recyclable or reusable packaging/containers in logistics, ecological materials (González-Benito and González-Benito, 2006).

The following practices are allocated in the organizational and planning practices: "the explicit definition of environmental policy, clear objectives and long-term environmental plans, well defined environmental responsibilities, full-time employees devoted to environmental management, natural environment training programs for managers and employees, systems for measuring and assessing". The following practice are allocated in the communicational category:

"periodic elaboration of environmental reports, sponsoring of environmental events/collaboration with ecological organizations, environmental arguments in marketing, regular voluntary information about"[17] (González-Benito and González-Benito, 2006).

As mentioned, the attention about enterprises' proactivity in adopting environmental management practices is mostly generated by their potential effects on firm performance and their capability to create a competitive advantage. Lower costs and differentiation, environmental management, strategic resources and, lastly, abilities, are the possible sources of competitive advantage examined (González-Benito and González-Benito, 2006). Indeed, various are the reasons for *going green*, making green investments and adopting proactive environmental practices allow: cost savings, increased efficiency, improved economic performance, strategic advantages, competitive advantages, decreased environmental impact and the creation of a more attractive destination (Hart, 1995; Hart and Dowell, 2011; Molina-Azorín et al., 2009; Porter and Van der Linde, 1995). There have been several recent studies exploring the environmental management and green strategies adopted by hotel enterprises and the relationship with firm performance. Espino-Rodríguez and colleague (2015) provide a detailed analysis of operative decisions and propose a review in which such managerial decisions are divided into two areas: structural decisions and infrastructural decisions. The former include decisions about managerial factors: facilities, technology, integration; while the infrastructural decisions include quality

[17] Cramer suggests a classification in two groups: technical (hardware) and organizational (software) practices. Technical activities entail physical modifications of products or machineries while organizational activities refer mainly to planning and control measures (Cramer, 1998). According to this arrangement, the classification proposed by González-Benito and González-Benito (2006) may be understood as follow. The *communicational practices* and *planning and organizational practices* represent the organizational or software activities while *operative practices* represent the technical ones. The former group does not directly mitigate the environmental impacts neither improve the environmental performance of firms as the technical practices may do. However, the *communicational practices* integrate the marketing strategy and support firm approach to environmental concerns and generally their strategic importance is increasing. Transparency and responsibility are highly demanded (Rivoli and Waddock, 2011; Schwartz and Carroll, 2003) not only from consumers but also from other groups of stakeholders both internal such as employees (Park and Levy, 2014) and external such as public opinions and trade associations (Lund-Thomsen and Nadvi, 2010). Despite even *organizational and planning practices* do not directly contribute to the environmental cause, their implementation entails the formal commitment to certain procedures and methods, to clear assessment and duties, to shared vision and values that represent firm roadmap for the environmental management.

control schemes, production plans, the development of new services and processes, organizational structures, and human resource management (Espino-Rodríguez and Gil-Padilla, 2015). Leonidou and others (2013) have identified some of the drivers and outcomes of environmentally friendly marketing strategies in Greece by adopting the RBV (Leonidou et al., 2013). Oreja-Rodríguez and others (2012), recognizing the importance of environmental management, analyzed the environmental performance of a sample of hotels in Spain, based on both the impact of the hotels' activities on natural resources and the perceptions of social stakeholders (Oreja-Rodríguez and Armas-Cruz, 2012). Molina-Azorín and others (2009) evaluate hotels' environmental strategies, in particular their environmental proactivity and how they impacted on the economic performance of the business; their data also comes from a sample of Spanish hotels. The results of this study indicate that a greater environmental commitment translates into improved performance (Molina-Azorín et al., 2009).

Although several recent studies have explored the environmental management of hotel enterprises, to the best of my knowledge there are not available in depth analysis exploring environmental practices and strategies of Alpine hotels. Therefore, the aim of this analysis is to identify and analyze the environmental practices of alpine hotels and to verify to what extent the practices classification proposed in literature applies to Alpine hotels by answering to the following research questions:

1. To what extent the environmental management of corporate enterprises can be applied to SMHEs?
2. Which are the main environmental practices adopted by them?

To improve the knowledge about the behavior of Alpine hotels in managing the environment and to answer to the previous research questions, the SMHEs located in the Alpine Province of Trento was explored. Based on the literature review about environmental practices' classification, three sets of practices were analyzed: operational practices, planning and organizational practices, and communicational practices. By adapting the theoretical framework provided by González-Benito and colleague (2006) to this area of study, a list of variables for each group of practices was identified. Given the lack of existing data on these practices nor for the selected area nor for other Alpine destination, primary data were collected by means of an online questionnaire. The resulted dataset is original, not available in literature. Details about the survey and methods of analysis are provided in paragraph 3.1.

Determinants and commitment

The environmental management of hotel enterprises is denoted by the adoption of practices that do not damage the environment and/or mitigate the environmental effects. These practices can be classified in operational, planning and organizational, and communicational practices. Another classification proposes two main groups of practices technical and organizational ones (for further details see the previous paragraph and in particular footnote number 17). In literature, the analysis of such environmental management practices aimed not only to identify and classify them but also to detect factors that can influence the adoption of such practices. Such factors are understood as determinants of proactive behaviors in enterprises' environmental management. In effect, the enterprise's environmental management could be affected by size facility (Álvarez Gil et al., 2001; Anton et al., 2004; Céspedes-Lorente et al., 2003; Mensah and Blankson, 2013; Önüt and Soner, 2006; Wahab and Pigram, 1997), age facility (Álvarez Gil et al., 2001; Mensah and Blankson, 2013; Theyel, 2000) and affiliation to (corporate) hotel chains (Álvarez Gil et al., 2001; Bohdanowicz, 2005; Ingram and Baum, 1997; Mensah and Blankson, 2013). Also González-Benito and colleague (2006) provided a general review of such determinant factors and included additional determinants by grouping them into three large categories: characteristics of enterprises, stakeholder pressure, and external factors. The characteristics of enterprises include: size of the company and availability of resources, the level of internationalization, managerial attitude and motivation, strategic attitude. The pressure of stakeholders includes: internal and external stakeholders, primary and secondary stakeholders. The external factors include: industrial sector (environmental risk, concentration, and cohesion), geographical location. This first determinant is the enterprise size: the higher the size of the company the greater is its proactivity. The enterprise size is measured by number of employees or level of turnover. The availability of resources is measured through the availability of staff capable to manage and implement the environmental practices. The influence of enterprise size is measured in terms of correlation between size and adoption of environmental practices. Larger-sized enterprises have available lager amount of resources (even physical) to be allocated to environmental management; have to face greater pressure from stakeholders to define an enterprise's environmental management system; have more opportunities of investment in technology, human resources, processes and certifications for environmental management. Internationalization is a factor that positively affects the company's environmental management as well as the affiliate company in multinational groups. In this context, it should be noted that the level of internationalization is correlated to the implementation of deliberate strategies for the internationalization. The position in relation to the value chain is understood as the proximity of a company to customers. The role of stakeholders in the definition of environmental proactivity is carried out through the exercise of pressure that can be more or less strong and oriented to support environmental responsibility through enterprise integrity, compliance with standards, transparency, accountability (González-Benito and González-Benito, 2006). Among the stakeholders, the public decision makers and public institutions holds a relevant role in affecting the environmental management of enterprises since they set constraints and opportunities to firms management. Regulations, funding support, and political lobbies are only some of the mechanisms which can be carried to affect firm environmental management.

According to Álvarez Gil and colleagues (Álvarez Gil et al., 2001), the corporate environmental management is determined by facility age, size, affiliation to hotel chains, stakeholder pressure and operations management. They underlined a positive association between certain enterprise characteristics and the implementation of environmental management practices suggesting that those characteristics are determinant factors (or predictor) for environmental management practices. Modern facilities, of large size, affiliated to hotel chains, influenced by stakeholder pressures, implementing operation management techniques are more likely to adopt extensive environmental management (Álvarez Gil et al., 2001, p. 2). It is worth to stress that this study examines corporate hotels. In the Alpine context, hotels are mainly SMEs often hosted in old-fashioned buildings, run as family business. Stakeholder pressure is generally limited as well as their capability to implement operative management techniques. As shown by the previous analyses, these hotels are SMEs which implement environmental practices by different patterns in comparison to corporate hotels. In effect, the adoption of environmental practices is significant in Alpine hotels but the aggregation of each variable to the other suggests a different classification compared to the ones of corporate hotel enterprises.

Thus, to explore the relationship between adoption of environmental practices and hotel characteristics in those small and medium-sized hotel enterprises, a set of determinant factors – facility size, facility age, and affiliation to hotel chains – was investigated. Therefore, the aim of this analysis was firstly to identify and analyze the presence of clusters of hotels according to type of practices and extent in their adoption; secondly to verify to what extent the determinants of the environmental management proposed in literature – facility size, facility age, affiliation to hotel chains – applies also to those small and medium-sized hotel enterprises. These aims translated in the following research questions:

3. Can typology and extent in the adoption of environmental management practices be used as criteria to cluster SMHEs?

4. Which is the role of SMHEs' characteristics in the adoption of environmental practices?

Then a further aspect is considered. In the analysis of factors affecting the adoption of environmental management practices, a relevant role is played by the managerial attitude toward environmental issues and the abilities to face such issues. Most of the literature focuses on the motivations to *going green*, or in other words, why enterprises are incentivized to adopt practices that benefit the environment. Generally, the fulfillment of legal obligations (Porter and Van der Linde, 1995), lower energy costs (Bohdanowicz, 2005), benefits from green marketing campaigns (Bohdanowicz, 2005; Leonidou et al., 2013), and ethical issues (Sampaio et al., 2012) are the prevalent motivations. Rodríguez and colleague (Rodríguez and del Mar Armas Cruz, 2007), in their analysis, highlighted similar motivations: risk reduction, quality improvement; costs' reduction, new target opportunities, image improvement; social responsibility; long term vision; new business opportunities.

To explore such motivations, as well as the perceptions, the SMHEs' environmental commitment was investigated. This analysis aimed to answer the following research question:

5. Which are the perceptions and motivations of SMHEs for implementing environmental management policy?

To answer to these last three research questions, the same dataset mentioned before (derived from primary data collected through an online survey) was used. Details about material and methods are provided in paragraph 3.1.

2.3 The environmental performance and sustainability of hotel sector

The interaction between natural and socio-economic systems is particularly important in the tourism industry. Tourism services such as holiday, travels, accommodation services, transportations, and recreational activities are regularly based on natural resources consumption and release of emissions and waste to the environment. In effect, tourism is acknowledged as a consumer of natural resources and a producer of environmental impacts (Gössling, 2015; Gössling et al., 2005). The need for a sustainability assessment of human activities, particular in the tourism industry, is growing. Such as in the case of complex systems, a comprehensive evaluation approach encompassing not only environmental impact but also socio-economic aspects is necessary. In fact, also in tourism studies, an integrated approach to sustainability assessment is widely recommended (Castellani and Sala, 2010). Notwithstanding the sustainability assessment of tourism activities is recently growing and the need for a multicriteria environmental assessment framework is acknowledged, there is a limited number of studies based on multicriteria and integrated approaches to explore sustainability, environmental costs, and environmental impacts. Generally, the assessment of the environment performance and sustainability of tourism systems and enterprises is performed through monetary evaluations (see paragraph 2.1.3). This is a partial perspective to approach such complex systems as hotels are. The need for a multicriteria assessment framework would be a valuable tool for this type of evaluation. However, such multicriteria framework is characterized by a limited number of applications to tourism and even lesser to accommodation sector. Moreover, to my knowledge, also the single methods of environmental accounting are not largely considered when evaluating the tourism industry. The MFA and GER are not used to investigate tourism neither individually nor in conjunction with other techniques. Emergy analysis recorded a larger consensus but a limited number of applications can be accounted in tourism. Some applications are related to: ecotourism in the Caribbean (Abel, 2003, 2000); resorts in Mexico and Papua New Guinea

(Brown and Ulgiati, 2001); tourism industry of Macao (Lei and Wang, 2008); life cycle model to investigate the emergy flow of tourists and residents for an Italian coastal resort region (Vassallo et al., 2009). Actually, the advantages of applying the emergy analysis to tourism are several as stressed by several authors. Emergy analysis is an appropriate methodology to evaluate tourism system because it allows to account for all types of input flows and to distinguish them also by their quality[18]. The evaluation of labor and services is performed through an holistic approach which allows to account for the work of the geobiosphere in providing these goods (Lei et al., 2011; Wang et al., 2015). In this context, Lei et al. (2011) undertook a review of emergy analysis applied to tourism case studies and underlined four main approaches. A first approach is based on the conversion of euro into emergy flows by applying a conversion factor. Tourism money are considered as exogenous to the system, such as external investment and thus the embodied emergy of tourists is something external to the system and it depend on specific technological conditions of tourism home nations. An issue is related to the emergy consumed by tourists and how to deal with that data. In this case, emergy analysis allows accounting for all goods consumed by tourists from a comprehensive perspective that explains the work of the biosphere to provide those goods. In this way, the evaluations of goods and services include not only the willingness to pay of tourists but also the externalities associated to those production processes. Finally, attention is required in potential double counting when considering tourism as exported emergy. The second approach is based on case studies focusing on single resort such as the study undertaken by Brown and Ulgiati (2001) while a third approach is based on the case focusing on small areas as Abel (2000) and Vassalo and colleagues (2009) did. These last studies included not only local services, imported goods and labor but also transportation which is generally a complex issue to manage because of data availability. The fourth approach is based on case

[18] Here, the term quality is referred to the definition of quality provided in footnotes 1.

studies where tourism is only a portion of the total emergy of a larger system. This is the case of the study proposed by Lei and Wang (2008) which estimated tourists' emergy as a portion of the total emergy for Macao City assuming that since Macao is tourism-dominated, local inhabitants and tourists share the same infrastructures and services. Therefore, tourists' emergy flows are a portion of the total emergy flows of the city.

Limited applications are dedicated also to Life Cycle Analysis (LCA) approach to environmental impact assessment of tourism activities. Despite tourism services individually may produce low environmental impacts, from a global perspective they assume relevance. De Camillis et al. (2010) provided a comparative analysis of LCA applied to tourism case studies based on the ISO 14044:2006 elements[19] (De Camillis et al., 2010).

The benefits of LCA are multiples both from a private and public viewpoint. From a private perspective, LCA helps in assessing the environmental performance, identifying hot spots, improving the performance, compare and sustain eco-design choices, support green marketing. From a governmental perspective, beyond helps in assessing the environmental burden and performance, LCA compares development plans related to waste management, mobility and the like.

De Camillis and colleagues (2010) reviewed ten case studies related to hotel facilities, holiday package and tourism sector. These studies have different characteristics and apply different boundaries. The studies focusing on hotel facilities follow two main approaches: a group of studies set system boundaries within the building itself, while the other account for hotel services only. Transports are not always included in the boundaries and there is a debate about including

[19] The ISO 14044:2006 elements for a LCA are study object, goals, functional unit, system boundaries, inventory data quality and assessment methods of environmental impacts. In additions, purposes of the studies, product categories, and boundaries are also considered.

them as part of the holiday experience or live them out from the system boundaries. The idea behind the inclusion is a “door to door” approach that includes all tourist activities from departure to return.

As underlined in this review, there is a limited number of LCA studies applied to tourism. The authors suggest some potential reasons attributed to the complexity of tourism system, lack of ad hoc database, limited focus on local environmental issues by current applications of Life Cycle Impact Assessment and eventually the limited awareness of the potentiality of LCA to explore tourism environmental impact and performance. Since the publication of this review in 2010, to the best of my knowledge, few more studies have been published and the majority of them combine LCA with carbon footprint analysis applying this approach to accommodation services in Italy (Castellani and Sala, 2012), in UK (Filimonau et al., 2011), in China (Hu et al., 2015; Li et al., 2014) and in Greece (Michailidou et al., 2015).

Given not only the need for a multicriteria assessment framework to study the environmental performance and sustainability of hotel sector, but also the gap in the tourism literature on such type of investigations despite their necessity is widely acknowledged, the following research questions derived:

6. How to account for environmental costs (material, energy, and emergy demands) and impacts (waste and emissions) generated by selected SMHEs?
7. Can environmental management be supported by environmental accounting to provide a more comprehensive understanding of SMHEs’ features?

A multicriteria assessment framework (including the following methods: Material Flow Accounting, Gross Energy Requirement, Emergy Accounting, Emission Accounting and impact categories) was used and three hotels in the Province of Trento were selected and investigated. Details about material and methods are provided in paragraph 3.2.

3 MATERIALS AND METHODS

3.1 Environmental management

3.1.1 Area of study

3.1.1.1 Tourism and hotel sector in the Alps

Tourism development in the Alps began in the XVIII century, the early tourists were climbers and walkers, scientific researchers and aristocrats (Battilani, 2001; Bätzing, 2005). Currently, the main economic sectors in the Alps, in terms of their contribution to GNP, are: service, political and public services, and new, old, and traditional economies (Ruffini et al., 2007)[20]. The service sector is the biggest, and tourism is one of the most important industries in the Alps (Schönthaler and Andrian-Werburg, 2007). With over 30 million arrivals per year, the Alps are the main destination in central Europe (ASTAT, 2014). Nevertheless, specific aspects of Alpine tourism make the sustainable management of tourism enterprises particularly critical. The area's main attractions are its cultural and natural heritage, but tourism poses a potential threat to these natural resources, especially when these resources are exploited beyond their carrying and resilience capacities, and the enterprises are not managed sustainably, or regulated effectively (*Sustainable Tourism in the Alps*, 2013).

In addition, the Alpine tourism market is very complex: the countries in the Alpine arc all have their own organizational structures, different legal perspectives and a wide variety of form for tourism enterprises in general and hotels in particular. From a touristic viewpoint, in Austria only municipalities which register at least 1,000 overnight stays are counted; in Germany only establishments with at least nine beds qualify as hotels; in Liechtenstein private accommodation is also included; in Slovenia, comprehensive data are not available since, under its national hospitality law, second houses are not officially included in the accommodation capacity statistics; both Switzerland and France only include hotel beds and beds in Spa centers located in municipalities where at least three hospitality businesses are registered.

On the one hand, the demand has to face many changes and even more complex and well-designed tourist products are expected (Grissemann et al., 2013). Tourists are increasingly less willing to be guided, choosing instead to self-organize (Franch and Martini, 2002). On the other

[20] The service sector or urban sector consists of business activities, hotels, restaurants, real estate, transport, financial services; the political sector includes services such as public administration, education, and healthcare; the new economy is based on IT services and telecommunication; the old economy is based on chemical and mechanical industries, the traditional economy is based on food, textiles, metal-work, and construction (Ruffini et al., 2007).

hand, the tourist offer is characterized by numerous small – sometimes even micro – and medium sized hotels with a high level of heterogeneity between the Alpine arc countries. Size is one of the sector's most heterogeneous characteristics. Others are its fragmentation; enterprises' connection to the territory but modest ability to undertake systemic collaboration among stakeholders, which, in such small business communities inevitably translates into fewer opportunities to exploit economies of scale (*Sustainable Tourism in the Alps*, 2013). In a context in which more tourists are self-organizing and putting together their own tourist products, these heterogeneous, non-cooperative enterprises have to work extremely hard to create high quality, integrated products (Franch and Martini, 2002).

In the Alps, there are almost 20,000 hotels in the Alpine region, providing over 806,000 beds. In 2013 both the number of enterprises (–0.7%) and of beds (+0.5%) remained almost constant. The tourist demand, in contrast, increased, both in terms of arrivals (+2.0%) and of overnight stays (+0.6%). The numbers of arrivals and overnight stays in 2013 are over 31 million and over 116 million, respectively. Hotels only register about 115 million overnight stays in 2013 (ASTAT, 2014). Given such large dimension, hotels are not only one of the biggest component of tourist spending but also one of the main consumers of energy (Bohdanowicz, 2005; *Sustainable Tourism in the Alps*, 2013).

3.1.1.2 The hotel sector in the Province of Trento

The Province of Trento (also known as Trentino) is an autonomous Italian Province located in the north eastern Alps. It has a population of 530,308 and an area of 6,200 square kilometers. Tourism is an important local industry: in 2013 tourist spending exceeded 2,5 billion euro (about 2,9 billion US dollars). The economic impact of the tourist spending in the Province of Trento is estimated in two steps. Through a survey, the daily tourist spending for each destination in Trentino is valued; then, the impact of the overall tourist spending is measured by applying the input-output tables. Hotels receive the biggest share of these spending, producing direct, indirect and induced effects within the local community. The tourist industry generates approximately 11% of the Province's GDP (this figure just includes overnight stays, excluding excursionists; it includes the direct taxes) and accounts for over 9% of its internal production (Mirabella, 2014). The hotel sector – there are over 1,528 establishments, offering 93,754 beds – is thus key to local tourism, counting for 2,6 million arrivals and 11 million overnight stays per year (ASTAT 2014). As in many Alpine destinations, hotels in Trentino are usually small or micro family-run enterprises.

From a legislative point of view, the population of hotels in the Province of Trento is grouped four typologies of facilities as defined by the provincial law n. 7, May 15th 2002 (PAT, 2002) which both regulates hotels, other types of accommodation and fosters accommodations' quality. The definition provided by this legislation is the following: "hotel-like facilities are hospitality infrastructures consists of at least seven housing units unitary managed and arranged to offer sleeping accommodation service and to serve food and beverage to any guests willing to pay the price for these services. This unitary management is qualified either as a single person or different persons up to manage sleeping, food and beverage services. In this last case, permission is needed to define the allocation of responsibilities on the different services".

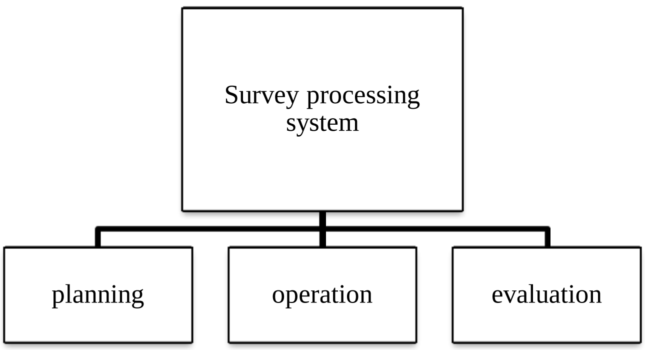
A further definition has been provided to identify the typologies of facilities included in this group. These typologies are four: hotel, *garnì hotel*, *residenza turistico alberghiera*, *villaggio albergo*. Hotel provides sleeping accommodation service, breakfast, food and beverage services in housing units which are not equipped with kitchen service (or otherwise for a maximum of 30%). *Garnì hotel* provides sleeping accommodation service, breakfast and beverage services. In case the beverage service is provided, food service is allowed only within the law for public business. *Residenza turistico alberghiera* (RTA) provides sleeping accommodation service in housing units which are equipped with kitchen service (or otherwise for a minimum of 70%).

Breakfast and beverage services are also required. *Villaggio albergo* are hotels and *garnì hotels* geographically located as defined with certain criteria. They provide central services in housing units located in different establishments. Therefore, according to this definition there are four typologies of hotel facility in the Province of Trento.

3.1.2 Survey processing system

As recommended by many statistical offices, the survey processing system consists of three stages: planning, operation and evaluation (see Figure 3). The planning stage includes preliminary decisions concerning the definition of survey purposes, output and final users. The aim is to identify: survey contents, data collection process, and statistical analysis to be performed. The operational stage includes the main processes such as: framework creation, sampling, survey technique's identification, questionnaire design, data preparation, archiving, estimation and analysis, reporting. The aim is to define and accurately manage the entire set of operative tasks necessary to undertake the survey. The evaluation stage includes survey output's checking to ensure a quality survey processing system (Sundgren, 1999).

Figure 3. Survey processing system.



Source: own elaboration from Sundgren, 1999, p. 14.

Similar guidelines are provided also by national statistic offices (ISTAT, 1989; Lehtonen and Djerf, 2008; Statistics Finland, 2007). In fact, ISTAT provides a checklist to manage each survey phase such as: purposes, definitions and classifications, survey design, typology of survey, operative steps, available budget and time, quality control system, statistical analysis and dissemination of the results (Fortini, 2000).

One of the key decisions in a survey planning process is the selection of the survey technique. There are several survey techniques: interview (face-to-face, by telephone), questionnaire (by postal mail, computer-assisted), focus group, panel, observational research techniques, and/or diaries. The most appropriate technique depends on several factors such as the phenomenon under analysis, the sampling design, the target population, the budget and time available. In quantitative research implying primary data collection, interview and questionnaire are the most used survey techniques (Fortini, 2000)[21].

The present research followed the guidelines previously discussed. The planning stage describes survey purposes and research focuses. The operational stage describes the database, the questionnaire contents, the survey technique, the pre-testing and final administration; the evaluation stage describes the sample representativeness and the comparison among target population and the complement of target population. Finally, some preliminary analyses are presented.

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[21] The classification of survey techniques can be by type of technology (hard-copy or web-based support) and administration method (self-administered or by interviewer). Diaries and email survey are hard-copy support survey, self-administered; Computerized Self-Administered Questionnaire (CSAQ) or Direct Computer Interviewing (DCI) are web-based support, self-administered; Computer Assisted Self-Interviewing: with Interviewer Present (CASIIP) (either question text on screen, visual (CASI-V) or question text on screen and Audio (CASI-A)) are hard-copy support survey elicited by interviewer while Computer Assisted Personal Interviewing (CAPI) Computer Assisted Telephone Interviewing (CATI) are web-based support survey elicited by interviewer (Chisnall, 1990; De Leeuw and Nicholls, 1996; O' Brien and Dugdale, 1978; Statistics Finland, 2007).

3.1.2.1 Planning stage

The survey collected data related to the environmental management of hotel enterprises located in Trentino. The main research areas were five:

1. hotel and management profile;
2. hotel characteristics which are determinant factors for the environmental strategy;
3. the environmental strategy implemented by hotels (considering the three main groups of practices: operational, communication, organizational and planning ones);
4. the environmental commitment of hotel managers;
5. the access of hotels to local subsidies to finance the implementation of green practices.

The first focus – the hotel and management profile – provides a detailed description of hotel building features which might influence the hotel environmental performance, hotel management attitude, market and target tourists, and staff management. The second focus – the hotel characteristics – verifies which are the determinant factors mostly affecting the environmental proactivity of such enterprises. The third focus – the environmental strategy – examines the types of green activities and innovations introduced by these enterprises and the fourth focus – the environmental commitment – investigates which are the main motivations and perception for being environmental proactivity. Finally, a fifth part investigated if the adoption of environmental activities is either mainly supported by public funding or by private investments. Then, a questionnaire evaluation section was included. The tree of these five research areas was represented in Figure 4. This survey addressed SMHEs located in Trentino.

3.1.2.2 Operational and evaluation stages

The email addresses to implement the survey were provided by ASAT which is the acronyms for the association of hoteliers and tourism enterprises in the Province of Trento[22]. ASAT provided a database of 1444 email contacts (hereafter ASAT database). A second database was employed. It was based on an open access database available online[23] (hereafter OA PAT database) which included 1494 emails. According to the local statistical service in 2013, in the Province of Trento, there were 1528 hotels which represented the entire hotel population. A preliminary check of the ASAT database was performed. There were 38 invalid or misspelled email contacts. Afterward, a match between the two databases, ASAT and OA PAT, was performed. The match underlined that there were common email contacts, double email contact for a same hotels and email contacts available only in one of the two databases. Details are provided in Table 1 (*Hotels with a double email contact* were in both database with two different emails; *hotels with a single email contact* were in both database with same email; *hotels with invalid email contact* were unavailable email items; *hotels with only ASAT email contact* were only in the ASAT database). Therefore, the final database (cleaned from the 38 invalid email items), representing the target population of this study, contained 1406 email, 38 email of this final database belonged to the ASAT database.

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[22] This is one of the two local associations of hoteliers in Trentino. The other is UNAT (acronym for *Union of Hoteliers in Trentino*). The participation to one and/or the other is not compulsory not forbidden. Recently, a third minority hotelier association was founded named *Albergatori in Trentino* (March, 2015).

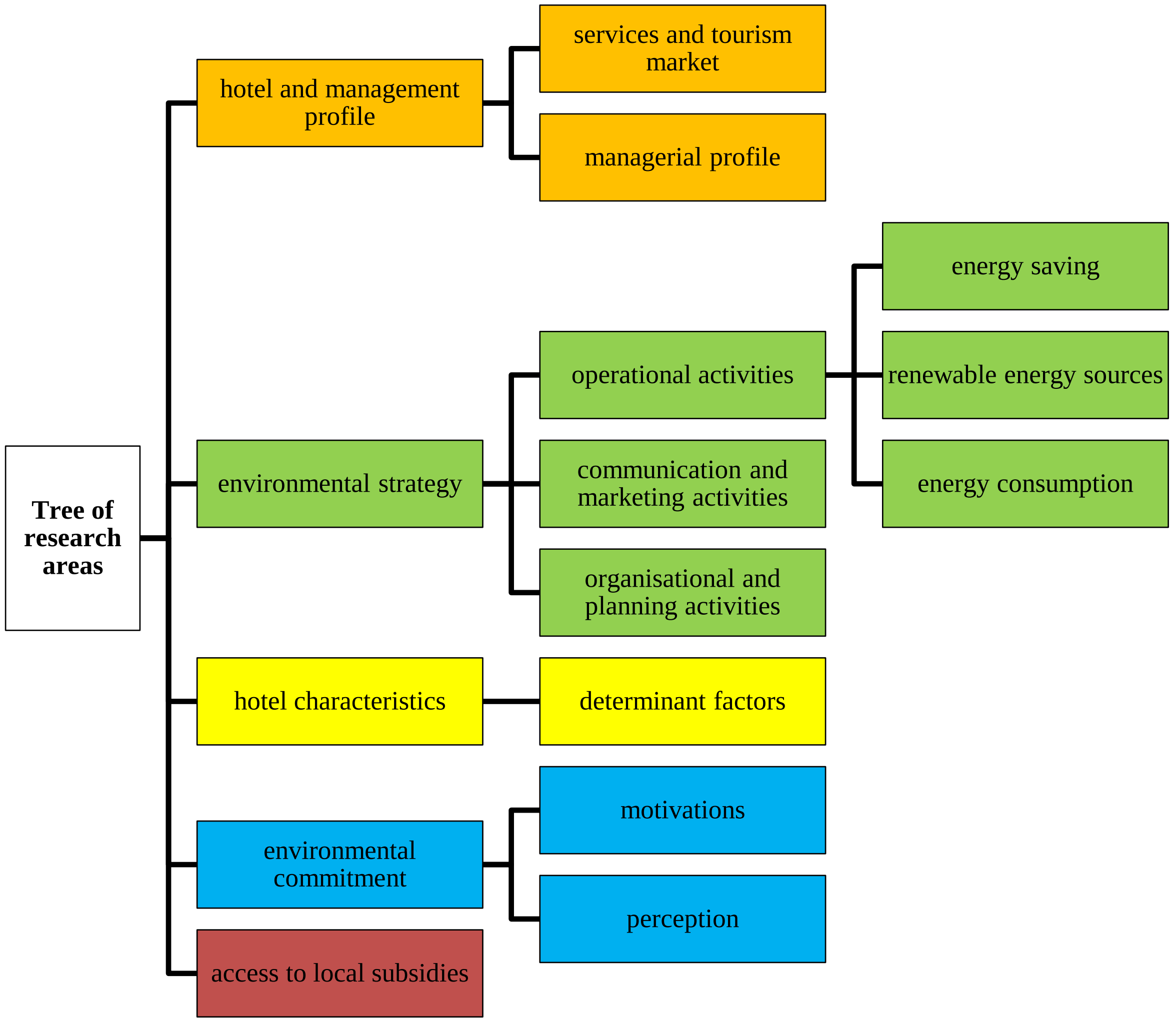
[23] These data are available at http://dati.trentino.it/en/ ("OPENdata Trentino," PAT). OPENdata Trentino is a portal which collects open data related to the Province of Trento. This catalogue is promoted by the Province of Trento. More information and legal notes are available at: http://dati.trentino.it/en/legal-notes (PAT, 2015). Both databases refers to hotels in the Province of Trento. The difference between the two databases is that the ASAT database contained only the email addresses of hotels members of this association while the OA databased contained emails plus a number of additional information of a larger number of hotels.

Table 1. Match and check of email contact.

	Hotels	Garnì hotel	RTA	Villaggio albergo	Other	Total
Hotels with a double email contact	229	26	8			263
Hotels with a single email contact	912	132	53	8		1105
Hotels with invalid email contact	3				35	38
Hotels with only ASAT email contact					38	38
Total	1144	158	61	8	73	1444
Target population						1406

Source: own elaboration.

Figure 4. Tree of research areas in the questionnaire.



Source: own elaboration.

The following step involved the transformation of these research areas into measureable variables. This effort resulted into a set of variables grouped into 9 sections. The question types and the response formats were mainly: open-ended, close-ended, or partially open-ended (multiple-choice with 'other' as option). The details were presented in Table 2.

Table 2. Questionnaire: sections, variables, response formats.

Sections	Variables	FQ24	Question type	Response format	Response options
Hotel enterprise characteristics					
Determinant factors	number of stars		multiple choice (single answer)	partially open-ended	6 options
	location		multiple choice (single answer)	close-ended	217 options
	year of building construction		multiple choice (single answer)	close-ended	7 classes
	energy label		multiple choice (single answer)	close-ended	9 classes
	year of energy-efficient improvements	x	multiple choice (single answer)	close-ended	5 classes
	energy-efficient improvements type		open question	open-ended	short answer
	numbers of room		open question	open-ended	short answer
	numbers of beds		open question	open-ended	short answer
	square meters of surface		open question	open-ended	short answer
	seasonal opening		multiple choice (multiple answers)	close-ended	13 items
	hotel facilities		dichotomous (multiple items)	close-ended	7 items
Hotel and management profile					
Hotel manager profile	respondent		multiple choice (single answer)	partially open-ended	4 options
	affiliations		multiple choice (single answer)	partially open-ended	4 items
	ownership asset		partially dichotomous	close-ended	3 options
	age of hotel manager		multiple choice (single answer)	close-ended	5 classes
	level of education		multiple choice (single answer)	close-ended	5 classes
	training courses	x	dichotomous	close-ended	yes/no
	type of training courses		open question	open-ended	short answer
	hospitality skills from family business		partially dichotomous	close-ended	yes/no/don't know-no answer
	associated business activities		partially dichotomous (multiple items)	close-ended	4 items
	relatives in associated business activities		partially dichotomous (multiple items)	close-ended	4 items
Service and tourism market	typology of target tourist		multiple choice (multiple answers, 3 max)	close-ended	7 items
	origin	x	multiple choice (multiple answers, 3 max)	close-ended	6 items
	nationality when origin is Europe		multiple choice (multiple answers, 3 max)	close-ended	9 items
	type of holiday	x	multiple choice	close-ended	3 items

[24] FQ stands for filter questions.

			(single answer)		
	main motivation		multiple choice (single answer)	close-ended	5 items
	environmentally-friendly label	x	dichotomous	close-ended	yes/no
	typology of label		multiple choice (single answer)	close-ended	7 items
	number of employees (summer/winter)		open question	open-ended	short answer
	number of family worker (summer/winter)		open question	open-ended	short answer
	summer occupancy rate		multiple choice (single answer)	close-ended	5 classes
	winter occupancy rate		multiple choice (single answer)	close-ended	5 classes
Environmental strategy					
Operational activities	number of energy saving devices per room		multiple choice (single answer)	close-ended	5 classes per 9 items
Energy saving	other energy saving practices in hotel		dichotomous	close-ended	3 items
Renewable energy sources	renewable energy equipment in hotel		dichotomous	close-ended	11 items
Energy consumption	electricity, water, fossil fuels, biomass		open question	open-ended	short answer
	kwh of energy produced		open question	open-ended	short answer
Communication and marketing activities	green communication activities	x	dichotomous	close-ended	5 items
	type of label		multiple choice (single answer)	partially open-ended	3 items
	other green activities		multiple choice (single answer)	close-ended	5 classes per 4 items
Organizational and planning activities	planning practices		dichotomous	close ended	2 items
Environmental commitment					
	motivation		multiple choice (single answer)	close-ended	Likert scale (1 to 7) for 7 items
	perception		multiple choice (single answer)	close-ended	Likert scale (1 to 7) for 7 items
Subsides					
	access to subsides in the last 5 years	x	dichotomous	close-ended	yes/no
	access to subsides (by recent laws)	x	dichotomous	close-ended	yes/no
	type of subsides use		open question	open-ended	short answer
	year		open question	open-ended	short answer
	other investments	x	dichotomous	close-ended	yes/no
	other typology of investment		open question	open-ended	short answer
	declaration of interest about subsides		dichotomous	close-ended	yes/no
Questionnaire evaluation					
	questionnaire evaluation		multiple choice (single answer)	close-ended	Likert scale (1 to 7) for 3 items
	comments/feedbacks		open question	open-ended	short answer

Source: own elaboration.

3.1.2.3 Survey technique

This survey was based on a computer-assisted technique[25] by means of the online system LimeSurvey[26]. LimeSurvey allows managing all the phases characterizing the administration process: loading of the questionnaire; managing of respondents' contacts, remind, thank-you, and responses; collection, storage, and download of data.

Since the target population was Italian mother tongue, the survey language was Italian. The survey implementation benefited from the support of ASAT which managed the pre-notification of the survey. The other field activities such as the invitation, the thank-you and the remind emails were delivered through LimeSurvey. The invitation email was delivered once. A token was included in the body text in the form of a web-link where the questionnaire page was available to compile. The thank-you email was delivered once the questionnaire was both fully compiled and sent back. The remind email was delivered for a maximum of three times to respondents not providing any answer and included the web-link to the questionnaire page. Invitation, thank-you and remind emails all contained a common header, a body text, contact information, and signature.

LimeSurvey system allowed respondents to save partial responses to gain access to new sessions without lost previous compiling work. A short introduction was provided at the beginning of the questionnaire. Attention was paid to make use of light colors, familiar font, and clear wording. Where needed, further information and explanation to interpretation of both questions and

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[25] The advantages of this technique are numerous: it allows to minimize contact between respondents and interviewer and to reduce biases ascribed to the interviewer; to carry out certain quality checks directly from the system at the compiling time; to manage very complex questionnaires; to prevent errors ascribed to data-entry. The disadvantages are lower than those of other survey techniques: the respondent does not have the possibility to ask directly for clarification on questionnaire wording and contents; the possibility of having a larger number of incomplete questionnaires is higher.

[26] Details are available at https://www.limesurvey.org/en/.

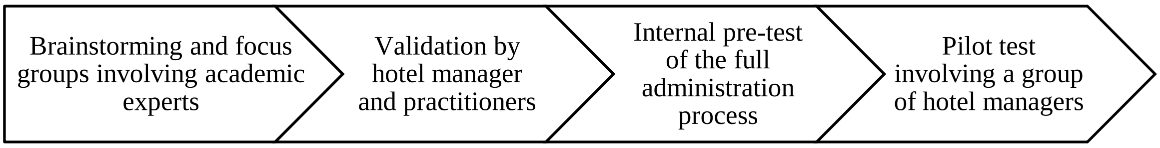
answer have been provided. Then, additional precautions to prevent typing error have been included by setting either limits or range to the response field.

3.1.2.4 Pre-testing and survey administration

Pre-testing of both questionnaire and administration processes were performed. Contents, wording, ordering of questions, and layout were designed and pre-tested in four steps (Figure 5):

1. A brainstorming session and a focus group involving academic experts in different fields (tourism management, marketing, environmental economics, statistics);
2. A validation session involving practitioners and hotel managers;
3. An internal pre-test involving a simulation of the full administration process;
4. A pilot test involving 8 hotels managers.

Figure 5. Pre-testing process.

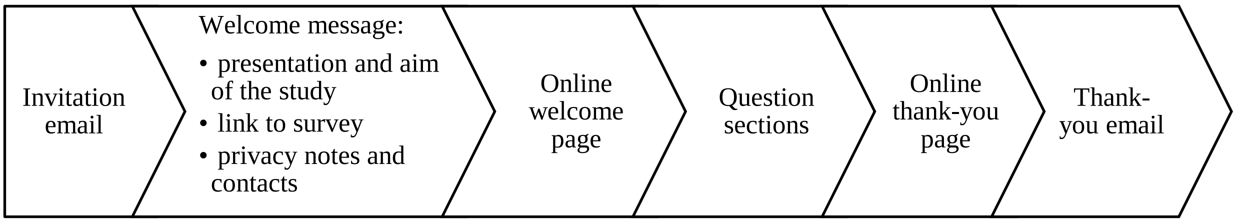


Source: own elaboration.

The pilot administration lasted for two weeks in July and August 2014. ASAT staff provided to pre-notify the survey test by telephone. Then, respondents received an invitation email containing the survey link. A single remind was sent. The compiling task lasted on average 32 minutes. The pilot test revealed certain problems related to questions ordering. The questions in every section were understood easily but the questions related to energy consumption signed the edge of partial responses. The majority of uncompleted questionnaires were interrupted at that point. This finding helped to re-ordering the questions and the related sections in order to maximize the amount of sections completed (given the opportunity to collect partial responses).

The final administration lasted for three months – August, September, October – in 2014. The target population received a first invitation by email including a welcome message, information on the survey and the survey web-link. The final questionnaire, formerly tested through the pilot test, is available in Appendix A and the online information flow of the final survey is shown in Figure 6.

Figure 6. Online information flow of the final survey.

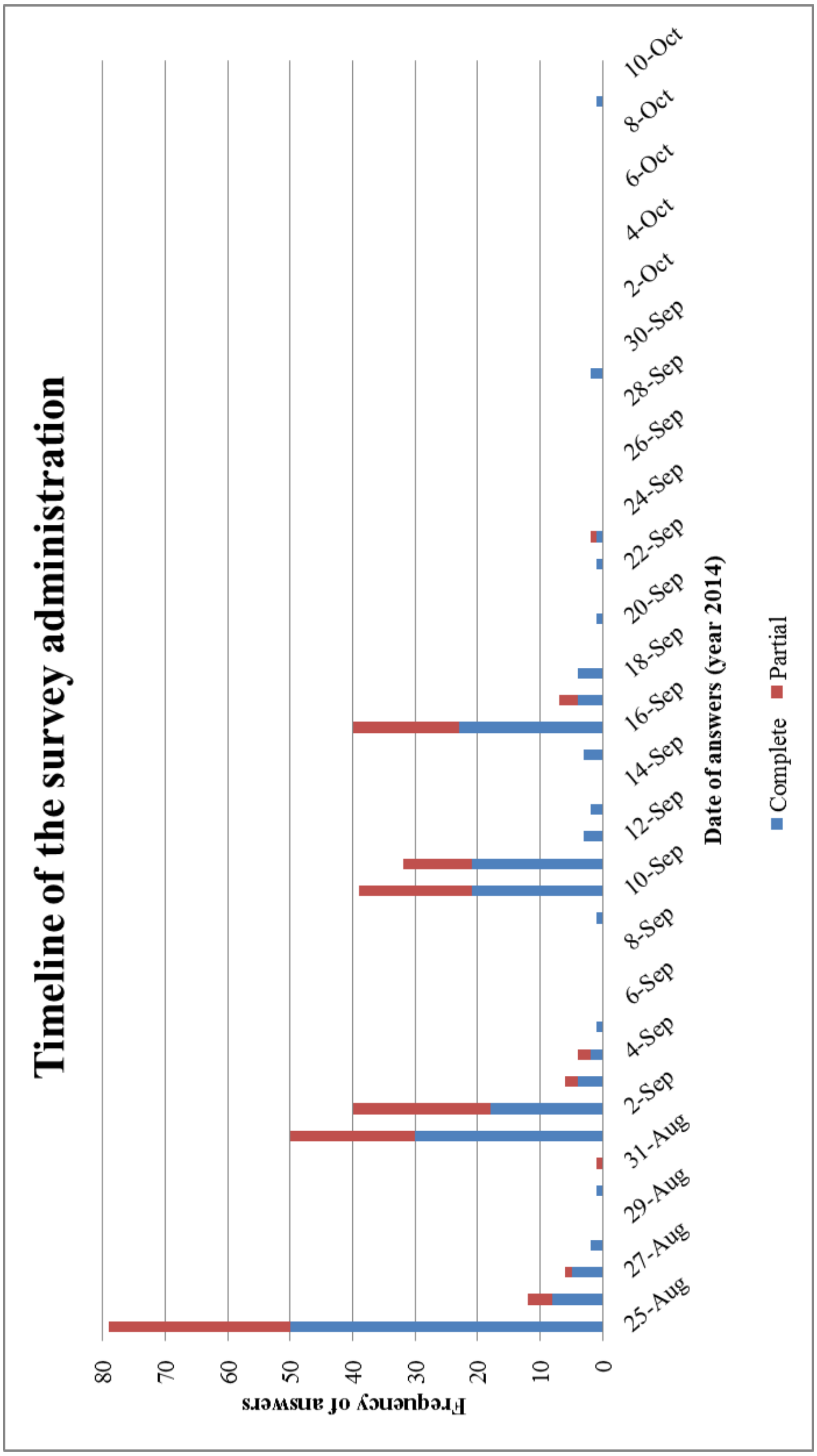


Source: own elaboration.

The first administration session pointed out additional invalid email addresses. A further check on these invalid email addresses was performed: in case a second email address from the OA PAT database was available, a second invitation was sent to the same hotel using this new email address; in case a second email address was not available, the respondent was excluded from the survey. A total of three invitations were sent (to be intended as first invitation addressed to new emails). For each of them, three reminds were sent.

After the elimination of invalid emails, 1311 invitations were sent. The total answers were 343 of which 209 fully and 134 partially completed. The fully compiling task lasted on average 18 minutes. Figure 7 shows the trend of the answers to the survey. The four peaks corresponded to the first invitation and the first three reminds. Including the pilot test's result, 1319 email addresses were available, valid, and received the survey invitation (8 pilot test, 1311 final survey). Thus, the final target population consisted of 1319 hotels. The survey totalized 351 answers of which 217 fully and 134 partially completed.

Figure 7. Timeline of the survey administration, pilot test excluded.



Source: own elaboration.

3.1.3 Sample representativeness

The survey is based on the self-selection sampling. The survey was available online and the participants were invited via email to voluntarily take part in the research. Self-selection sampling is a sampling design widely adopted in psychology, sociology, and economics. In despite of this popularity, there are at least two potential biases: a self-selection and a sample not enough representative of the population. In this study, both biased were checked.

A validation of the sample representativeness was performed through a proportionate stratified allocation according to four sample characteristics: type of accommodation, geographical location, altitude, and tourism board. The validation was accomplished not only on the full set of responses (351 observations) but also on the partial set of completed responses (217 observations). This self-selected sample was compared to the ASAT database, OA PAT database and hotel population provided by the statistical service of the Province of Trento.

The validation of the sample representativeness was largely positive. By type of accommodation, the full sample (351 observations) is representative of the provincial accommodations. The RTA is under representative; however RTA and Hotel-villages do not represent the majority of the provincial population in the hotel accommodation sector. From a geographical point of view, five are the locations not enough represented; however they account only for 12 observations and many of the remaining locations are over sampled. The tourism board feature reflects the geographical location. The mountain level of the accommodations in the sample cannot be compared to the provincial population; however, compared to the OA PAT population the sample is representative. The validation of the representativeness of the full set of completed responses (217 observations) is also representative of the provincial accommodations even though under sampling circumstances are more frequently compared to the full sample. By type of accommodations, the RTA are still under represented. From a geographical point of view, eight are the locations not enough represented accounting for about 22 observations. The tourism board feature reflects the geographical location. The mountain level of the accommodations in the sample cannot be compared to the provincial population; however, compared to the OA PAT population the sample is enough representative (see full table details in Appendix B).

3.1.3.1 Comparison between the target population and the complement

A further check on potential biases attributed to the complement of the target population (hereafter complement) was checked. The complement consisted of 209 hotels given as a difference between the final ASAT database (1319 hotels) and the official statistics (1528 hotels in the Province of Trento in 2013). Since detailed data on the provincial hotels were not available, the OA PAT database was used. The difference between this two databased consisted of 125 hotel. Thus, the final check was performed comparing the two groups: 125 hotels (OA PAT databased) and 1319 (ASAT database). This check revealed that the first group (125 hotels) had certain different characteristics compared to the other. The major differences are related to the percentage of Garnì-hotel; the percentage of accommodation for the locations of Primiero, Fassa valley and Rotaliana-Kőnigsberg but only the last one is underestimated in the target population. Those differences are evident also in data related to Tourism board. No relevant differences are evident comparing the mountain level of the accommodation (see Table 3.a, b, c, and d).

Table 3. Comparison between the target population and the complement.

Table 3.a. Comparison by accommodation type.

Type	complement	final target population
Hotels	67.2%	83.0%
Garnì-hotel	26.4%	11.6%
RTA	6.4%	4.2%
Hotel-village	0.0%	0.6%
Not classifiable (NC)	0.0%	0.6%
	N=125	N=1319

Table 3.b. Comparison by mountain level.

Mountain level	complement	final target population
High	52.0%	46.4%
Medium	47.2%	52.6%
Low	0.8%	0.4%
NC	0.0%	0.6%
	N=125	N=1319

Table 3.c. Comparison by geographical location.

Geographical location	complement	final target population
Fassa valley	8.0%	19.9%
Alta Valsugana and Bersntol	5.6%	7.5%
Garda and Ledro	15.2%	12.6%
Paganella	8.8%	8.9%
Val di Non	6.4%	3.2%
Vallagarina	4.0%	2.4%
Laghi	1.6%	0.5%
Cembra valley	0.0%	0.6%
Sole valley	4.8%	10.0%
Giudicarie	16.0%	12.5%
Primiero	3.2%	6.0%
Rotaliana-Kőnigsberg	1.6%	0.8%
Fiemme valley	4.0%	6.7%
Valsugana and Tesino	8.8%	1.3%
Altipiani Cimbri	10.4%	4.2%
Adige valley	1.6%	2.4%
NC	0.0%	0.6%
	N=125	N=1319

Table 3.d. Comparison by local tourism board.

Tourism board	complement	final target population
Altipiani Folgaria Lavarone Luserna	10.4%	4.2%
Ambito Trento, Monte Bondone, Valle dei Laghi	1.6%	2.9%
Altopiano di Pinè, Valle di Cembra	1.6%	2.2%
Rovereto, Vallagarina	4.8%	2.4%
Dolomiti di Brenta, Altopiano Paganella	3.2%	8.9%
Garda Trentino	9.6%	10.8%
Madonna di Campiglio, Pinzolo, Rendena	12.0%	7.5%
S. Martino di Castrozza, Primiero	4.8%	6.0%
Terme Comano, Dolomiti di Brenta	0.8%	2.2%
Valle di Fassa	8.0%	19.9%
Valle di Fiemme	4.0%	6.7%
Valle di Non	10.4%	3.2%
Valli di Sole, Pejo, Rabbi	6.4%	10.0%
Valsugana Tesino	6.4%	6.5%
Other areas	16.0%	6.7%
	N=125	N=1319

Source: own elaboration.

3.1.4 Sample characteristics

Redemption rate

The questionnaires collected were 351: 217 fully and 134 partially completed. The redemption rate is about 27 percent on a total of 1319 invitations accounting for a total of 17 percent of completed responses. The amount of completed responses on the full sample (351 observations) is about 62 percent (Table 4).

Table 4. Redemption rate.
Table 4.a. Redemption rate on the total amount of invitations (1319).

	Value	Redemption rate (%)
Full sample	351	27%
Partial responses	134	10%
Completed responses	217	17%

Source: own elaboration.

Table 4.b. Redemption rate on the total sample (351 responses).

	Value	Redemption rate (%)
Partial responses	134	38%
Completed responses	217	62%

Source: own elaboration.

The questionnaire consists of eleven sections. The completed responses contained responses to every section. 77 questionnaires covered less than 1/3 of the sections; therefore they were not included in any further analysis. 263 questionnaires covered 1/3 of the sections and 247 covered 2/3 of the sections. 217 questionnaires were fully completed accounting for 62 percent of the overall sample (Table 4, part b).

Respondents' characteristics

The characteristic of the 351 questionnaires collected were the following. The respondents to the sample were mainly owner and/or manager of the facility (about 71 percent). The 351 observations were distributed among 16 geographical areas which correspond to provincial administrative bodies. More than 70 percent of the observations were located in Fassa valley, Sole valley, Giudicarie, Garda Lake and Fiemme valley. Apart for the Garda lake area, all the other locations are mountain areas. In fact, 52 percent of accommodation were located between 1000 and 2000 amsl, 47 percent under 1000 amsl and the remaining facilities were placed more than 2000 amsl. The local tourist boards are 21 and have three main organization forms: large tourist boards (14), consortia (5) or associations (3). More than 96 percent of the sample belonged to tourist boards, 2.5 percent to consortia, and less than 1 percent to tourist associations. About 63 percent of the accommodations were three star hotels, 16 percent four star hotels, and 12 percent two star hotels. The remaining accommodation was one or three-superior stars. The average size of the sample was about 32 rooms. 51 percent of the facilities had less than 30 rooms, 40 percent had between 30 and 55 rooms, 6 percent ranged between 56 and 81, and the remaining ranged from 82 to 133 rooms. The facilities were relatively old infrastructures. 8 percent of them were built before the 1900, 10 percent between 1900 and 1945, 14 percent between 1946 and 1960, 33 percent between 1961 and 1980, 17 percent between 1981 and 2000, only 9 percent were built after 2000. For about 9 percent of the facilities this data was missing. About 52 percent of the facilities had refurbished after 2001 and 13 percent before 2001. However, 12 percent of facilities had never refurbished (about 22 percent of the facilities did not reply to this question). Only about 25 percent of the sample got an energy label for the infrastructure. Nearly 68 percent did not provide, did not know or skipped this data. More than 76 percent of the facilities were independent hotels. Less than 3 percent were brand-affiliated and only 1 percent was chain-affiliated hotels. The manager profile was the following: almost 24 percent of the managers were younger than 45 years old. 44 percent of the managers were between 46 and 60 years old, 13 percent were older than 61 years old, and only 7 percent were younger than 30 years old. About 13 percent of the manager got a primary of secondary education; 46 percent got a diploma, 22 percent got a specialization or a degree. 56 percent of the sample stated to attend training courses. More than 70 percent of the facilities were owned by the manager and almost 52 percent had some family experience in the hospitality sector. About 17 percent of these managers managed other facilities and 16 percent stated to manage other business enterprises; 7 percent were appointed with institutional roles and 16 had other significant roles. It is worth to notice that same percentages were registered for eventual relatives of the owner/manager involved in the same business or institutional roles. For about 18 percent of the facilities such data were missing. During the winter season, 26 percent of the facilities stated an occupancy rate lesser than 39 percent of the rooms while almost 52 percent ranged between 60 to 100 percent of rooms occupied. About 62 percent of the facilities employed less than 2 family workers (on average 1.35 family workers) but almost 61 percent of the facilities hired between none and 11 workers (on average 7 employees). During the summer season, 10 percent of the facilities stated an occupancy rate lesser than 39 percent of the rooms while almost 68 percent ranged between 60 to 100 percent of rooms occupied. About 58 percent of the facilities employed less than 2 family workers (on average 1.6 family workers) but almost 61 percent of the facilities hired between none and 11 workers (on average 8 employees). The missing data for such data was about 22 percent.

The final dataset

To the purpose of this analysis, the final dataset consisted of 247 observations from the 351 questionnaires collected. The selection of these 247 observations was based on the amount responses provided. Such questionnaires included both completed responses (88 percent, all the 217 completed responses) and partial responses (12 percent).

The characteristics of these 247 observations were the following. 48 percent of the hotels had fewer than 30 rooms, 42 percent had between 30 and 54 rooms, 6 percent between 55 and 79 rooms and only 4 percent had more than 88 rooms. 69 percent had 3 stars, 17 percent had 4 and 14 percent had 1 or 2 stars. 87 percent of the respondents said they owned the business and 94 percent said that they managed their hotel independently – only 6 percent were brand-hotels or affiliated to a chain. 2 percent of the owners were under 30 years old, 28 percent were between 30 and 45 years old, 54 percent between 46 and 60 years old and 16 percent were over 60 years old. A majority of the owners had high school diplomas, 14 percent were graduates and 13 percent had done specialized hotel training.

3.1.5 Multivariate analyses

Principal Component Analysis (PCA)

The PCA is a multivariate analysis. Given a dataset of correlated variables, the PCA allows to reduce the dimensionality of these data ensuring the maintenance of as much as possible the variability of the data. This technique allows reducing data dimensionality by obtaining new variables which capture latent aspects (or factors). Those variables are named principal components. In addition, these principal components are ordered according to the variance (deriving from the original data) they are able to represent. From a mathematical point of view, these components represent the solution of an eigenvalue-eigenvector problem applied to a positive-semidefinite symmetric matrix as correlation matrix (Jolliffe, 2002). This procedure although have been shown to be suitable for continuous data, it is less suitable when applied to ordinal data. The polychoric correlation matrix proved to overcome such problem and to be appropriate in situations where the data are discrete and ordinal. The main problem of ordinal data when performing traditional PCA (especially in case of dummy variables with more than two categories for each variable) is the introduction of spurious correlations. The polychoric matrix is estimated by the maximum likelihood that is based on the maximization of the objective function under a set of constraints. The maximum likelihood estimators do have optimal asymptotic properties. For large sample, they are consistent, and have a normal, asymptotically efficient distribution (Kolenikov and Angeles, 2009). Thus, the PCA applied to a polychoric correlation matrix is the suitable methods to analysis the association among the investigated environmental practices and to identify the possible principal components.

Multiple Correspondence Analysis (MCA)

The MCA is a multivariate analysis capable to reduce data complexity without a priori assumptions about models or particular structures. It is a highly appropriate technique for obtaining both descriptive and graphical representations of data structure. It is a graphical device to represent the degree of association using the modalities of a set of variables (usually qualitative). Starting from a multidimensional contingency table, it codifies rows and columns of that table in geometric points to generate orthogonal components and assign them a score according to an optimal principle that is guaranteed to be as representative as possible of the original data (Greenacre, 1984, 1993).

Generally, the MCA, as well as the PCA, are applied to understand and characterized the potential clusters of dataset.

K-means Cluster Analysis

K-means is a non-hierarchical cluster analysis. Given a data set and a pre-determined number of clusters k, this analysis provides a partitioning of that data into a smaller number of clusters. Thus, k-means, it is essentially an optimization problem aiming to find the positions for the clusters that minimize the distance from the data points to the cluster (MacQueen, 1967). The first step consists to decide the number of cluster k. Then, the center of the clusters is initialized and the attribution of each data point to a cluster is based on the minimization of the distance from the barycenter of that cluster. Then, the positon of each cluster is set according to the mean distance of all data belonging to that cluster. Since this procedure aims to balance the clusters by a convergence to the barycenter through an iterative process, the attribution of each data to a cluster is not permanent but follows until the convergence is reached.

It is a non-hierarchical procedure since there is a direct partition of data into the clusters. A hierarchical procedure, instead, is based on a classification in which small clusters consisting of very similar observations are nested within larger clusters characterized by fewer similarities.

3.1.5.1 Variables' description for each analysis

The PCA was applied to a polychoric correlation matrix. The variables analyzed were presented in Table 5 and are grouped by type of the environmental practices. Eleven environmental management practices were considered. These eleven practices were just as many variables and were grouped in the following manner according to the classification framework proposed by González-Benito et al. (2006). The variables for operational practices included the retrofitting of building by insulation (Insulation), the use of renewable energy by solar and/or photovoltaic panels (Renewables), biomass (Biomass boiler) and/or multi-fuel boilers (Multi-fuel boiler), and waste management (Waste). The variables for communication practices were the following: the promotion of green events (Green events), the dissemination of green report of the sustainable activities offered by the hotel (Green report), and the green marketing activities (Green marketing). The variables for organizational practices were the introduction of environmental management systems (EMS), the monitoring of consumption (Environmental monitor), and the setting of business objectives aimed at achieving environmental sustainability (Environmental objectives). Each variable was dichotomously measured (Yes: practices adopted; No: practices not adopted). Access or not to subsidies were used as supplementary variables.

The PCA helped in reducing the dimensions of the original data set. The variables ordered by variances (from larger to smaller) were subjected to a linear transformation by a projection of the variables in a new Cartesian system.

Table 5. Variables examined through the PCA.

Environmental practices	Variables
Operational practices	Renewables (solar and photovoltaic panels)
	Insulation
	Biomass boiler
	Multi-fuel boiler
	Waste
Communicational practices	Green events
	Green report
	Green marketing
Planning and organizational practices	EMS
	Environmental monitoring
	Environmental objectives

Source: own elaboration.

The new variables were those principal components which reproduced the maximum variance. In this analysis, three were the most significant principal components (see Table 18). Thus, the original data dimension in R^{11} was represented in R^3. The three principal components were renamed according to the set of practices most correlated to each of them. Based on this reduction of dimensions, each observation was projected according to the new systems of coordinates. Thus, each observation's position was then defined by the new axis' coordinates corresponding to three sets of environmental practices. These findings represented the input data for the k-means cluster analysis. The advantage of using the new principal components as coordinates for each observation (rather than the raw data) was given by the opportunity to account for the relationships between the environmental management practices under analysis and used the PCA to characterize the clusters. Then, clusters analysis was performed by a k-means non-hierarchical clustering.

The identification of the determinants of environmental management – facility size, age, and affiliation to hotel chains – was based on the literature. They were measured as follows. The variable used to measure facility size is either number of rooms per hotel or number of employees per season. The variable used in this study was the number of rooms. The facility age was measured in year of hotel construction. The affiliation to hotel chains was measured dichotomously as hotel being independent (1) or affiliated (0). Table 6 presented these variables and the related aggregations in classes.

The majority of hotels were small-sized hotels: class 1 accounted for 47 percent while class 2 counted the 42 percent of hotels (class 3, 4 and 5 counted respectively 7 percent, 3 percent and 1 percent of hotels respectively). Referring to the facility age class 1 and 2 accounted for 20 percent of hotels each. Class 3, 4 and 5 accounted for 16 percent, 33 percent and 19 percent of hotels respectively. Class 6 accounted for 10 percent of hotels while class 0 accounted for 2 percent of hotel hotels (corresponding to 5 observations). Referring to affiliation to hotel chains, the majority of hotels were independent (93 percent of the sample). Such determinant factors were investigated through the MCA and the clusters obtained by the k-means cluster analysis where introduced as supplementary variables.

Table 6. Variables examined through the MCA.

Determinants of environmental management	Variables	Variables aggregation
Facility size	Number of rooms	class 1= <30 rooms class 2= 30 < rooms > 54 class 3= 55 < rooms >79 class 4= 80 < rooms > 104 class 5= 105 < rooms > 129
Facility age	Year of hotel construction	class 1= before year 1900 class 2= 1900 < years > 1945 class 3= 1946 < years > 1960 class 4= 1961 < years > 1980 class 5= 1981 < years > 2000 class 6= after year 2000 class 0= data not available
Affiliation to hotel chains	Dichotomous: Independent/Affiliated	independent = 1 affiliated = 0
Supplementary variables	Clusters obtained by the k-means cluster analysis	cluster 1 – cluster 2 – cluster 3 – cluster 4 – cluster 5

Source: own elaboration.

The analysis of environmental commitment was performed through a descriptive analysis of a set of variables which investigate both motivations and perceptions of hotel managers about the adoption of environmental management practices (Table 7). A Likert scale was applied to explore the level of agreement with 14 sentences: 7 related to motivations and 7 to perceptions (see the *Environmental commitment* section in Appendix A for details on sentences and questions' format). The Likert scale measured from 1 to 7 the level of importance (from 1= not important at all to 7= very important) per each sentence.

Table 7. Variables to examine the environmental commitment.

Environmental commitment	Variables aggregation
Motivations	compliance to legal requirement (Legal compliance) pressure exert by local government (Local govern vision) pressure exert by hotel's stakeholders (Stakeholder pressure) gaining competitive advantage (Competitive advantage) promote environmentally-friendly campaigns (Marketing support) reduction of energy costs (Cost reduction) social responsibility toward environment and society (Env. Responsibility)
Perceptions	to reach a large number of market and targets (Market advantages) to attract Italian guests (Attract Italians) to attract foreign guests (Attract foreign) to attract guest with large spending power (Attract spender) to lower the amount of costs allocated to energy inputs (Cost reduction) to do not pay back the green investments (Costs are higher than benefits) to improve hotel green image (Hotel image).

Source: own elaboration.

3.2 Environmental accounting: a multicriteria assessment framework

The environmental performance and sustainability of processes in human-driven systems might be assessed through different methods which entail different perspectives. The majority of times, single environmental accounting methods and single assessment criteria are applied. The Life Cycle Assessment (LCA) is one of the most popular techniques to assess environmental impacts generated through the product's lifetime from cradle to grave. LCA provides indicators assigned to specific impact categories (contribution to energy resource depletion, global warming potential, rain acidification potential, etc.). These indicators can be used to define appropriate management or optimization of products and resources. This technique accounts for resources, energy flows and inputs under human control. This entails that flows without market value or not related to significant matter but mostly associated to intangible inputs (such as labor and services) are not included in the assessment. However, they are key flows particularly in socio-economic systems. This type of flows should be accounted to fully investigate the performance and the sustainability of processes based on this type of systems.

To overcome such limitations, the Emergy Synthesis (ES) was used to complement the LCA perspective. The ES accounts for different type of inputs: renewable resources lacking of market price, different forms of energy, human and labor services. The solar energy works as a common basis for the evaluation of the whole set of inputs (Ulgiati et al., 2011). The assessment is performed accounting for both the renewable inputs and the efforts undertaken by the geobiosphere to make those resources available. Such a holistic approach was applied to overcome main focus of LCA based on emissions accounting and related environmental impacts assessment.

As notice by Ulgiati et al. (2006), the need for multiple criteria is extremely important but the integration of different method is not always beneficial. To benefit from the additional information provided through the ES, a multicriteria assessment framework was developed: the

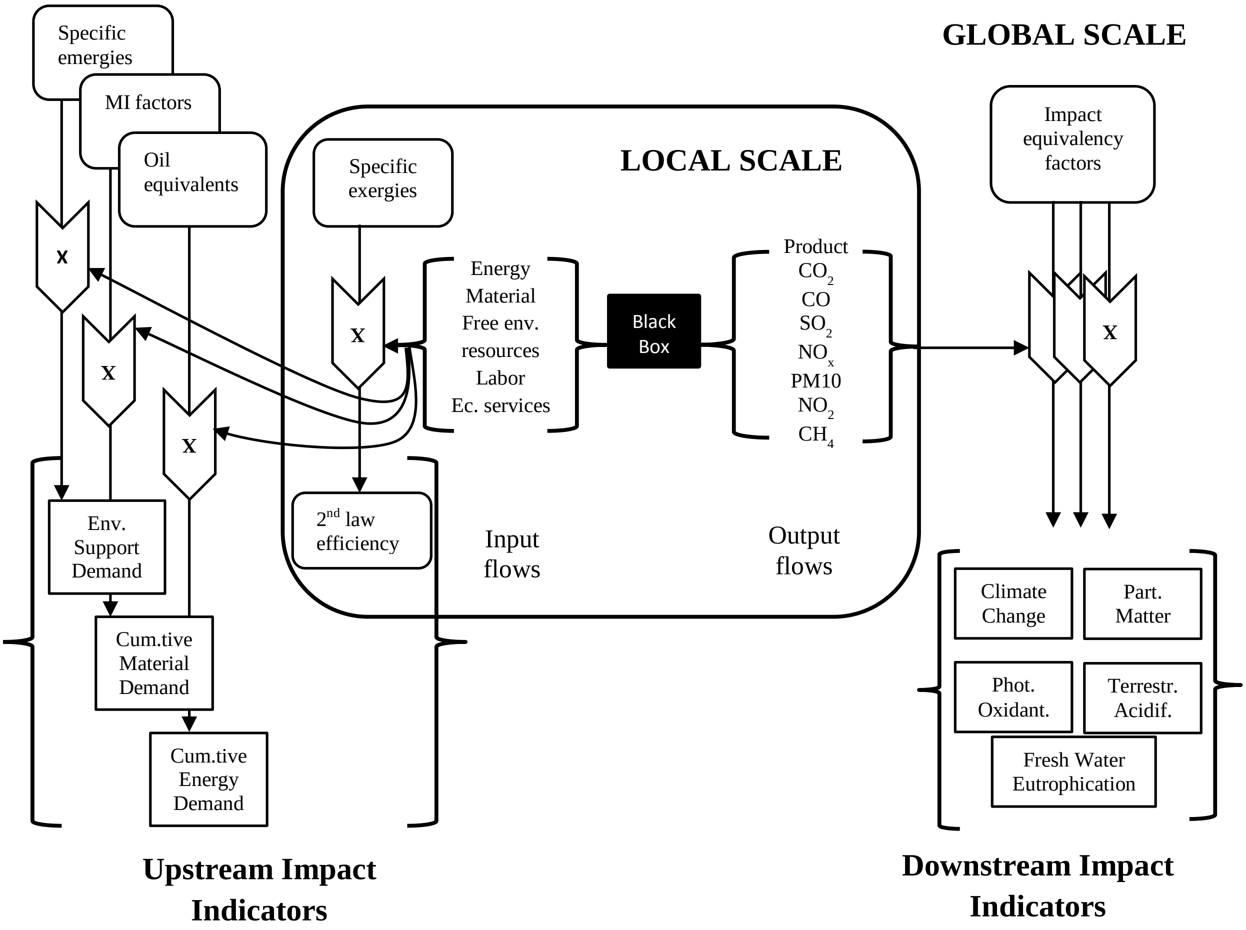
SUstainability Multicriteria Multiscale Assessment (SUMMA). It integrates multi-criteria and multi-scale framework to assess environmental costs impacts combining upstream and downstream methods. The upstream methods investigate the amount of inputs used by the investigated system and provide information about the environmental costs associated to it. The downstream methods investigate amount of outputs produced by the system in terms of emissions and waste and provide information about the environmental impacts generated at a local level.

The upstream methods are: Material Flow Accounting (MFA), Embodied Energy Analysis, Exergy Analysis, and Emergy Accounting[27]. The downstream methods chemically evaluate the outputs (emissions and waste) generated by the investigated system. Such outputs are evaluated in terms of environmental impacts associated to specific impact categories. Such categories are identified by the Recipe midpoint method.

The individual indicators for each method are preserved but integrated to provide a comprehensive understanding of the system. Both intensive and extensive indicators are provided. The extensive indicators depend and describe the physical size of the system. The intensive indicators evaluate the environmental performance of the investigated system in terms of energy and resources required per units of system output (Buonocore et al., 2014). The final aim is to provide a valuable framework in complex decision making process where multiple perspectives (the environmental, social and economic ones) are needed to be taken into account.

[27] As above mention, all the methods included in SUMMA will be described apart from the Exergy Analysis which will not be implemented in this research. However, it is worth to provide a brief description of this method. The Exergy Analysis measures the maximum conversion efficiency derivable from a process in theoretical reversible condition therefore is a measure of the environmental performance of a process (Ulgiati et al., 2006). Together with the Embodied Energy Analysis, the Exergy Analysis estimates the efficiency of a process and relate to the economic value, cost and scarcity of the resources used.

Figure 8. The multicriteria assessment framework for an hotel system.



Source: own elaboration from Ulgiati et al. 2006.

The system is treated as a black box, a unit process that includes more than one single operation unit processes (ILCD Handbook, 2010). The assessment framework is performed at different space scale (both at local and global) and timeframe (see Figure 8). According to the scale level, production processes of components and raw masses are included. For instance, at the local scale, production processes of system’s component such as building materials are accounted. At a larger scale also the mass of raw materials are included and contribute to indicators calculation. The input flows are accounted according to the time frame of the analysis. For instance, if the time frame of the analysis is one year, all the input flows are divided by the lifetime and thus converted into annual flows. However, both spatial scale and time are selected to be the most appropriate to approach the investigated system.

The calculation procedures are carried out through the Excel program. The spreadsheets are organized in eleven parts. The *user's interface spreadsheet* collects all input and output flow, the *calculation procedure spreadsheet* contains all the details on calculation procedures, the *MIF spreadsheet* contains the Material Intensity Factors (MIFs), the *EIF spreadsheet* contains the Energy Intensity Factors (EIFs), the *UEVs spreadsheet* contains the Transformity that are the Unit Emergy Values (UEVs), the *Characterization factors spreadsheet* contains the Converting factors per each impact categories, the *mass spreadsheet* contains all the calculations related to mass flows and corresponding indicators, the *energy spreadsheet* contains all the calculations related to energy flows and corresponding indicators, the *emergy spreadsheet* contains all the calculations related to environmental flows and corresponding indicators, the *emissions spreadsheet* contains all the calculations related to emissions flows and corresponding impact categories, the *summary spreadsheet* contains the indicators calculated for each methods.

Raw amounts, units and sources of data are listed in the *user's interface spreadsheet* and used in the other spreadsheets after some further calculations recorded in the *calculation procedure spreadsheet*. Each input flow (the raw amount) is then multiplied by the appropriate intensity factors for each methods (*MIF, EIF, UEVs Characterization Factors*) in the corresponding spreadsheet (respectively *Mass, energy, emergy and emissions spreadsheets*). In this manner, in each *mass, energy, emergy, and emissions spreadsheets* are accounted both direct and indirect inputs and output of the investigated system (or process). The intensity factors are specific according to input flow, method (mass, energy, emergy or emissions analyses), time and location. These values are generally available from scientific literature, database[28] or might be calculated to account for specific features of the investigated process. In effect, such intensities differ according to the technology and resource available and used in certain time, location and specific process. Thus, different intensity factors can be applied to same production process to account for different location or time of production of the investigated system and thus lead to different results time and location specific. Table 8 is an example of the calculations performed in each *mass*, *energy* and *emergy spreadsheets*.

Table 8. Example of environmental accounting calculation tables.

Column 1	**Column 2**	**Column 3**	**Column 4**	**Column 5**	**Column 6**
Numeration	Input flow (i = 1 …n)	Units	Raw amount (fi)	Intensity factor (IF) (ci)	Total amount per input flow (C)
1.	1st flow	g/yr	x	IF (specific for 1st input flow)	= x *IF (1st input flow)
2.	2nd flow	g/yr	y	IF (specific for 2st input flow)	= y *IF (2st input flow)
…	…	…	…	…	…
…	…	…	…	…	…
nth.	nth flow	g/yr	z	IF (specific for nth input flow)	= z *IF (nth input flow)
O.	Output (cumulative)	g/yr			$C = \sum_{i}^{n} f_i * c_i$
Op.	Output per unit of generated product	g/unit	Total generated output (fp)	$c_p = C/f_p$	

Column 1	Item number
Column 2	Lists of input flow items
Column 3	Units of measure per input flow items (either g/yr, J/yr, €/yr …)
Column 4	Raw amount for each input flow items
Column 5	Specific Intensity Factor by input flow items, methods, time and location
Column 6	Cumulative material, energy, environmental cost or emissions associated to the investigated system resulting from the multiplication of column 4 to 5)

Source: own elaboration.

[28] Examples of these type of sources are: the Ecoinvent, the material intensity provided by the Wuppertal Institute, the emissions pollutants provided by the EPA or Corinair (CORINAIR/EEA, 2009; Ecoinvent Centre, 2013; EPA, 1995; Wuppertal Institut, 2014).

This procedure results in C and c_p which are the amount of material, energy, environmental cost or emissions associated respectively to the entire process and to the single output (or product) of that process. Mathematically, this results in the following set of equations:

$$C = \sum_i^n f_i * c_i \quad \text{for } i = 1 \ldots n; \qquad \text{(Equation 1)}$$

where: i = the inputs to the process; C = cumulative material, energy, environmental cost or emissions associated to the investigated system; f_i = raw amount of the i^{th} input flow of the investigated system; c_i = intensity or conversion factor for each material, energy, environmental cost or emissions associated to the i^{th} input flow (from literature or calculated for the study), and

$$c_p = C/f_\mathrm{p} \qquad \text{(Equation 2)}$$

where: p = generated output (or product); c_p = material, energy, environmental cost or emissions per unit of generated output; f_p = total (raw) amount of generated output (or product) in terms of matter or energy content.

The emissions are calculated and the *emissions spreadsheet* contains the aggregation of these emissions according to the selected impact categories which are *climate change*, *particulate matter*, *photochemical oxidation*, *terrestrial acidification*, *fresh water eutrophication*. The *summary spreadsheet* contains both intensive and extensive indicators calculated for each method. These large set of indicators allows performing multiple scale analyses according to the multiple criteria available. The investigated system (or process) can be analyzed entirely or by unit of output and compared with other systems. Indications to policy makers might be provided on the basis of this holistic approach and this comprehensive set of indicators.

3.2.1 System analysis

The implementation of this analysis requires defining goal, scope and boundaries (in time and space) of the system under investigation. The goal determines the purpose of the analysis and how results can be used. The scope defines the system under investigation. Both goal and scope contribute to determine the system boundaries. The boundaries are geographical, temporal and/or technological. System components are affected by location as well as by timeframe usage and technological features. To better frame the analysis, such boundaries should be taken into account and set. Then, a schematic exemplification of the system context might be provided using a system diagram representation. This representation shows all the input and output flows involved in the investigated system. In effect, the system diagram should include all processes (in terms of flows, relations, and interactions) and energy sources (both internal and external to the system) affecting the system under study and included in the system boundaries. This information is converted in a diagram according to specific system symbols (Odum, 1996). The system diagram's symbols are exhibited in Appendix C.

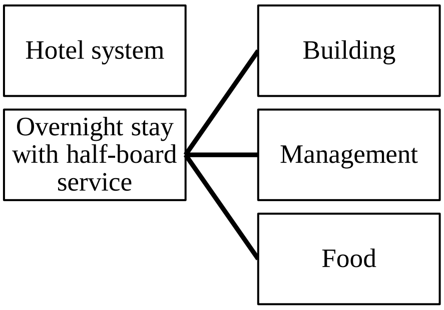
The data collection is performed by accounting for the input and output flows identified as relevant to the investigated system. They are collected according to the goal, scope, and geographical and temporal boundaries selected for the study. Data might be available from database and statistical office or might be directly collected when refer to unexplored systems. Data on input and output flows are included within a common inventory for all the methods. To better understand the information and the type of analysis provided, each methods (Material Flow Accounting, Energy Analysis, Emergy accounting, Emission accounting and impact categories) is presented.

3.2.2 Goal, boundaries and system diagram

The investigated system was a human-driven system in the tourism industry: the hotel system. To this purpose, three hotels in the Province of Trento were selected. The aim was to assess the environmental performance of these hotels. The three hotels were selected according to both hotel-type and number of green technologies implemented. The green technologies taken into account were: implementation of photovoltaic panels and/or solar panels, heat pump, and biomass boiler. Since the implementation of these technologies benefits of public subsidies (because they are considered as less environmental costly and impacting), a comparison between the environmental performance of the three hotels might be a valuable tool not only for managers in deciding whether or not investing in these technologies in their business, but also for policy makers in setting the priorities to public subsidies. Two of the three hotels are four star hotels located in two major winter and summer destinations in Trentino: *Val Rendena* and *Val di Fiemme*. The other hotel is a Garnì-hotel located in *Val di Fiemme*.

The investigated system consisted of three main elements: building (physical construction), management (welcome and overnight stay) and food (breakfast plus another meal). They represent a common basic set of services provided by hotels in the Province of Trento (see Figure 9). The boundaries of the system excluded transportation and waste. The means of transports used by tourists were excluded to simplify calculation even though the transport is an important variable not only from a tourism perspective but also as one of the main source of emissions on air. Waste flows were also excluded but the analysis of the waste flows was performed and presented in paragraph 4.2.3.

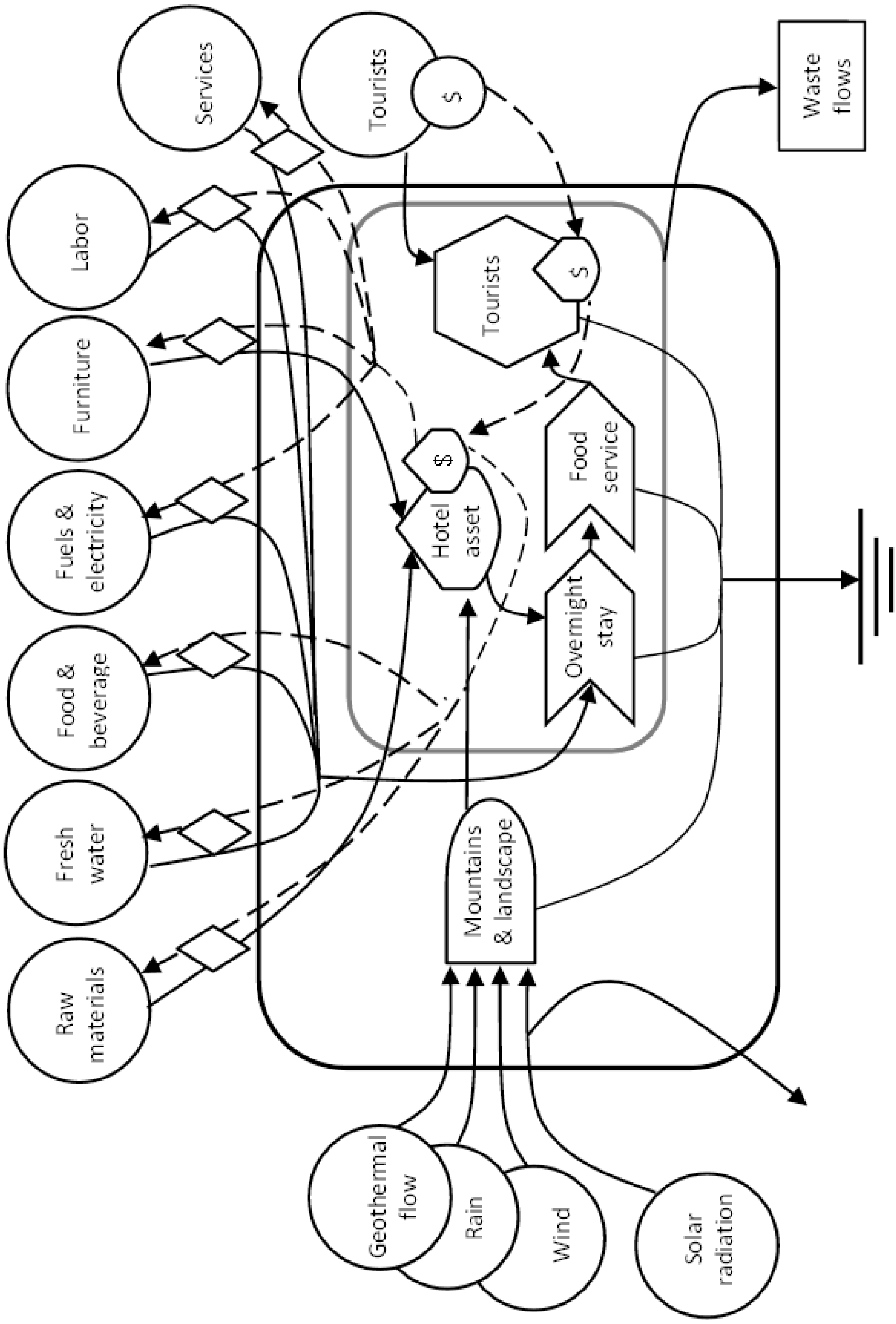
Figure 9. Map of hotel services.



Source: own elaboration.

A common inventory scheme based on system boundaries was used to collect same type of data. In this context, hotel services are mainly three: welcome of the guests, overnight stay, and breakfast. The time boundary of this system is one year. All flows for management and food operations referred to year 2013 (in case of annual flow such as the amount of electricity or wood chips consumed); all data for building constructions were converted into annual flows considering the amount and the lifetime of the inputs. The output of the investigated system was the amount of overnight stay per hotel in a time frame of one year (year 2013). The overnight stays entailed the amount of tourists served assuming a half-board service (accommodation, breakfast and an addition meal). Hereafter both overnight stay and night will be used to indicate the unit of output for each hotel as described above. The system diagram for the investigate system is represented in Figure 10.

Figure 10. Systems diagram of the investigated hotel.



Source: own elaboration.

3.2.3 Characteristics of the selected hotels and data collection

The three hotels are located among 700 and 1000 amsl in the Rendena and Fiemme Valleys in the Province of Trento. The energy mix adopted by the selected hotels is the following: hotel A uses a fossil fuel energy mix based on LPG and oil; hotel B uses oil and wood chip; hotel C uses methane and electricity produced by photovoltaic panels. Other important characteristics of the selected hotels are shown in Table 9 and the adoption of environmental practices is displayed in Table 10.

Table 9. Characteristics of the three hotels selected.

Characteristics	Hotel A	Hotel B	Hotel C
Geographical location	Rendena Valley	Fiemme Valley	Fiemme Valley
Type	Hotel	Hotel	Garnì
Size (number of rooms)	42	50	7
Stars	4	4	3s
Facility age	1981	2004	2007
Affiliation	No	No	No
Number of overnight stays	10320	22672	1500

Source: own elaboration.

Table 10. Adoption of environmental practices by the selected hotels.

Environmental practices	Hotel A	Hotel B	Hotel C
Insulation	No	Yes	Yes
Waste recycling	Yes	Yes	Yes
Green events	Yes	No	No
Green reports	Yes	Yes	No
Green marketing	Yes	Yes	Yes
Environmental monitoring	Yes	Yes	Yes
Environmental objectives	Yes	No	No

Source: own elaboration.

Data collection of the selected hotels was based on face-to-face interviews to hotel owners. Other sources of data were the online survey, scientific literature, and official statistical institutes and reports. Calculation procedures for the three hotels are included in Appendix E. The Material Flow Accounting, Energy Analysis, Emergy Accounting, Emissions Accounting and impact categories for the three hotels are included in Appendix F. The individual methods of the multicriteria assessment framework are also presented in the following paragraphs. The details about the source of data and the typology of data are presented here. The source of raw data for the renewable inputs is the Fondazione Edmund Mach ("Fondazione Edmund Mach," 2015) [29] and the heat flow database ("Global Heat Flow Database," 2015)[30]. The sources of raw data for building construction inputs are face-to-face interviews; the building lifetime was estimated about 50 years (Ghattas et al., 2013)[31]. The sources of raw data for the furniture inputs are face-to-face interviews as well as the furniture lifetime (15 years)[32]. The costs of initial investment (item 14 *Labor and services* in Appendix E) obtained by the face-to-face interviews refer to the initial expenditure for building construction and furniture purchasing. The initial investments are then transformed to annual costs according to their lifetime. The total annual cost for the initial investment refers to the sum of building and furniture annual costs including both labor and services. The source of raw data for the annual management inputs include utilities[33] and cleaning[34] and are obtained by the face-to-face interviews. The services, item 21 in Appendix E, are the total economic costs for the utility during a year. The services, item 24 in Appendix E, are the total economic costs for cleaning materials during a year. Both items (21 and 24) do not include labor (in other words, such economic costs refer to the real amount of money spent to buy them in the market but do not include, for instance, the labor costs for the staff assigned to the cleaning activity). The raw data for annual food[35] and the related economic costs (item 26 in Appendix E) are estimated from literature (Castellani and Sala, 2012; Howarth Bastow

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[29] Such renewable inputs are item 1 (sun insolation), item 2 (wind), and item 3 (rain) in Appendix E.

[30] Such inputs is item 4 (geothermal flow) in Appendix E.

[31] Such inputs are from item 5 to 10 (concrete, sand, stone, wood, clay, and steel) in Appendix E.

[32] Such inputs are from item 11 to 13 in Appendix E.

[33] Such inputs are from item 15 to 20bis in Appendix E.

[34] Such inputs are from item 22 to 23 in Appendix E.

[35] Such input is item 25 (a-f) in Appendix E.

Charleton, 2009). The services, item 26 in Appendix E, are the total economic costs to purchase food during a year (as before, such economic costs do not include, for instance, the labor costs for the staff assigned to the catering activity). The labor data refers to the staff (number of people working in the hotels – including staff for managing and organizational activities as well as staff for catering and cleaning) employed in the hotels. Such data were collected by the interviews and the total annual labor costs were estimated according to such inputs and the national collective labor agreement.

It is important to provide a further explanation about the meaning of labor and services. Labor (L) is referred to the economic costs of human labor (hotel staff dedicated to management, cleaning and catering). Services (S) are referred to the economic costs of utilities, cleaning materials, raw amount of food. For building and furniture it was not possible to disaggregate data quantifying the amount of money spent in materials (services) and human work (labor). Thus, the economic costs for such inputs are grouped together as Labor & Services (L&S).

3.2.4 Material Flow Accounting

"Material Flow Analysis (MFA) is a systematic assessment of the flows and stocks of materials within a system defined in space and time" (Brunner and Rechberger, 2004). Hinterberger and Stiller (1998) defined the Material Flow Accounting as a method which allows accounting for the material directly and indirectly supplied to a process (or a system) and diverted from nature[36]. The resulting Total Material Requirement is an indicator which measure the

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[36] An antecedent of the MFA can be found in medicine and chemistry studies in approaching human metabolism. Recent applications of MFA are large and diversify. They entail environmental management and engineering, industrial ecology, resource management, waste management and anthropogenic metabolism. Most of the recent applications aimed to optimize processes and goods related to the metabolism of the anthroposphere (Baccini and Brunner, 1991; Brunner and Rechberger, 2001). The anthropogenic metabolism approach, considering human needs and their satisfaction, accounts for all inputs and

environmental burden generated by that process (or that system), also called “Ecological Rucksack” (Hinterberger and Stiller, 1998). In short, the MFA procedure consists of: system definition and simplification, assessment of the relevant flows and stocks of materials, production of understandable and transparent results for decision makers about managing resources, environment, or waste. Once all material flows are defined and collected, each input flow is multiplied by the appropriate Material Intensity Factor (MIF). The last update database for MIFs provided by the Wuppertal Institute (Wuppertal Institut, 2014) was used in this study[37]. The material inputs estimated are grouped in four environmental compartments: abiotic matter, biotic matter, water and air. Then, the product between MIF per each gram of material inputs are summed together for each environmental compartment and assigned to the output of the system as Total Material Requirement of that system. Such results are useful in decision making processes about stocking or depletion of resources, setting measures for environmental protection and conservation, or waste management; (re)design appropriate goods, processes, systems to improve their sustainability. The MIFs used in this study are presented in Table 11.

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outputs (stock of materials and energy) necessary to fulfill these needs. Humans progressed from a simple metabolism aiming to satisfy basic needs to a complex metabolism including a heterogeneous array of activities. This is evident observing different signals: the constant demographic and economic growth of human society, the increase depletion of natural resources; the larger anthropogenic flow of substances compared to the geogenic once; the lack of cyclical system in urban material flows (the material flows in urban areas are generally linear, input materials become outputs with limited (re)cycle activity); the increase in material stocks which lack of an appropriate plan to manage them optimally; the larger consumption emissions compared to production emissions (which required more attention on consumer behavior); finally the change in the composition of waste (which required a constant reorganization based on the amount of hazardous substances to be removed). Humans metabolism has been extended to include also terms such as industrial (Ayres, 1989) and societal (Fischer-Kowalski, 1998) metabolism (Hinterberger et al., 2003). The aim is to compare natural metabolic processes to economic processes. In effect, the MFA is an approach capable to stress the relations between the economy and the environment. Natural materials are inputs for economic systems, are consumed to produce goods and services, release outputs to the environment in form of water or air emissions, waste.

[37] However, other qualified databases are available such as the Ecoinvent (http://www.ecoinvent.org/). In cases MIF were not available from the Wuppertal Institut database, MIF from literature or specific calculations for this study (by means of Ecoinvent database) were used.

Table 11. Material Intensity Factors applied in this study.

	Material intensity factors				
#	Item	abiotic	water	unit	Reference
5	Concrete	1.33E+00	3.42E+00	g/g	(Wuppertal Institut, 2014)
6	Sand	1.42E+00	1.43E+00	g/g	(Wuppertal Institut, 2014)
7	Stone	1.42E+00	1.43E+00	g/g	(Wuppertal Institut, 2014)
8	Wood	6.80E-01	9.40E+00	g/g	(Wuppertal Institut, 2014)
9	Clay	3.05E+00	2.46E+00	g/g	(Wuppertal Institut, 2014)
10	Steel	8.05E+00	5.58E+01	g/g	(Wuppertal Institut, 2014)
11	Wood (furniture)	6.80E-01	9.40E+00	g/g	(Wuppertal Institut, 2014)
12	Steel (furniture)	8.05E+00	5.58E+01	g/g	(Wuppertal Institut, 2014)
13	Plastic (furniture)	5.70E+00	1.46E+02	g/g	(Wuppertal Institut, 2011)
15	Electricity	1.58E+03	2.03E+01	g/Kwh	(Ecoinvent 3.1 database)
16	Water	1.00E-02	1.00E+00	g/g	(By definition)
17	Methane	1.22E+00	5.00E-01	g/g	(Wuppertal Institut, 2014)
18	LPG	1.50E+00	1.15E+01	g/g	(Wuppertal Institut, 2014)
19	Oil	1.36E+00	9.70E+00	g/g	(Wuppertal Institut, 2014)
20	Wood chip	3.00E-02	1.30E-01	g/g	(Buonocore et al., 2014)
20 bis	Electricity (hotel PV system)	2.00E+02	3.00E+02	g/Kwh	(Wuppertal Institut, 2014)
22	Soap	1.00E+00	5.32E+02	g/g	(Ecoinvent 3.1 database)
23	Bleach	4.46E+00	2.77E+01	g/g	(Wuppertal Institut, 2014)
25a	Pasta, rice, bread	1.68E+00	4.29E+01	g/g	(Wuppertal Institut, 2014)
25b	Meat	7.76E+00	3.07E+02	g/g	(Wuppertal Institut, 2014)
25c	Milk	8.30E+00	3.29E+02	g/g	(Wuppertal Institut, 2014)
25d	Fruits	1.00E+00	2.00E+01	g/g	(Wuppertal Institut, 2014)
25e	Beverage	1.50E+00	4.69E+01	g/g	(Wuppertal Institut, 2014)
25f	Sugar	3.10E+00	2.40E+01	g/g	(Wuppertal Institut, 2014)

Source: own elaboration from specified reference list.

3.2.5 Energy analysis and Gross Energy Requirement

The interest for energy analysis can be traced back to the 70s when the energy crisis increased the awareness on the dependence of the world economy on fuel and the need to consider new source of energy such as the renewables once. The scarcity of fossil fuel and the rising prices for these materials drew the attention on the energy requirement to generate goods, products, and services.

Several studies attempted to determine the amount of energy necessary to goods and service production and different methods were applied[38] but the related results were not always comparable. To set common guidelines and allow a certain degree of comparability, the International Federation of Institutes for Advanced Study (IFIAS) promoted workshops on energy analysis. In 1974, IFIAS proposed the following definition for energy analysis: "... the determination of the energy sequestered in the process of making a good or a service within the framework of an agreed set of conventions or applying the information so obtained" (IFIAS, 1978).

GER is the acronyms of Gross Energy Requirement: it refers to the energy required directly and indirectly to produce a good or a service[39]. This method was largely applied to perform energy analysis of human-driven systems or processes (Brown and Herendeen, 1996; Franzese et al., 2009; Herendeen, 1998; IFIAS, 1978). Such energy analysis follows the guidelines and standard set by the IFIAS. It analyzes the sum of the fuel energy necessary to drive all phases of a process which involving the production of that good or service plus energy required to make the inputs of that process. In both phases, what is accounted is commercial energy such as fuels and

[38] Actually, an energy analysis can be performed following a technical or an economic approach. The former is a process analysis based on a physical accounting of the processes related to a product or a service. This approach is time consuming but very accurate. The economic approach is based on input-output tables. This method is less accurate than the previous but allows considering all inputs for the whole life cycle of a good, product or service. It is also possible to combine the two approaches in a hybrid method. The economic input-output analysis was developed by Leontief in the 30s (Leontief, 1936). This analysis allows studying the relations between economic sectors. However, Herendeen and Brown stressed some problems with the use of input-output data which related to the lack of up to date data because they are generally old, the dollars unit of measure is not the best to underline embodied energy linkages, generally sectors are not enough disaggregate (Brown and Herendeen, 1996).

[39] Other energy analysis method is Cumulative Energy Demand (CED) that allows accounting for both renewable and non-renewable energy. In this study, the GER was selected because it allows valuating the amount of fossil fuel required to the hospitality system and eventually measure which would have been the portion of green energy needed to substitute the fossil ones.

electricity, machineries or equipment (inputs to the process) are considered in terms of their oil equivalent energy. Human services and labor are generally not accounted nor the environmental support provided to them by the biosphere. Natural processes providing renewable energy such as wind, solar radiation, tides, are not accounted, nor other renewable resources apart from the fossil fuels used to manage them (i.e. harvest is not accounted apart from the eventual fossil fuel of the machinery used to gather it). Thus, to summarize, the energy intensity factors used by the GER are calculated according to this procedure:

- renewable resources are not accounted when their *production* does not require the use of fossil energy (for instance solar radiation, wind, and so on);
- renewable resources are accounted when their production requires the use of fossil energy. Only a GER equivalent to the fossil energy used to such a purpose is accounted;
- non-renewable resources (like oil or coal) are accounted in the GER. Only a GER equivalent to the sum of their actual thermal energy content and the fossil energy used to make the resource available to the final user are accounted;
- human labor and economic services are not accounted.

Practically, given a system with clear boundaries in time and space, energy is assigned to each input of the process. Both direct and indirect consumption of energy is accounted for these inputs.

GER is expressed as energy per physical units. Considering the following elements:

GER_i is the GER of the i^{th} input flow including direct and indirect energy flows; f_i = i^{th} matter flow supporting the process; e_i = energy intensity associated to the i^{th} input flow (usually expressed in MJ/kg), then $\sum_i GER_i = \sum f_i \; * \; e_i$. Thus, the GER of a product p is calculated as follows:

GER $_P = \sum_i \frac{\mathrm{GER}_i}{p}$ for i (1 = 1 … n) (Equation 3)

where i are the input flows of the process. The available energy-based indicators are the following: GER of the process; GER of the product or Energy intensity (this is an energy intensity equivalent); EROI is the energy return on investment and it defined as: EROI$= \frac{E_{out}}{E_{in}}$ (this is the ratio between the energy content of a product to the energy required to produce it). The EIFs used in this study are presented in Table 12.

Table 12. Energy Intensity Factors applied in this study.

	Energy intensity factors			
#	Item	value	unit	Reference
5	Concrete	2.64E-02	g_{oil}/g	(Ecoinvent 3.1 database)
6	Sand	1.09E-03	g_{oil}/g	(Ecoinvent 3.1 database)
7	Stone	1.09E-03	g_{oil} /g	(Ecoinvent 3.1 database)
8	Wood	5.71E-03	g_{oil} /g	(Buonocore et al., 2014)
9	Clay	1.09E-03	g_{oil} /g	(Ecoinvent 3.1 database)
10	Steel	1.45E+00	g_{oil} /g	(Ecoinvent 3.1 database)
11	Wood (furniture)	5.71E-03	g_{oil} /g	(Buonocore et al., 2014)
12	Steel (furniture)	1.45E+00	g_{oil} /g	(Ecoinvent 3.1 database)
13	Plastic (furniture)	3.00E+00	g_{oil} /g	(Biondi et al., 1989)
15	Electricity	1.68E+00	g_{oil} /Kwh	(Ecoinvent 3.1 database)
16	Water	4.49E-05	g_{oil} /g	(Ecoinvent 3.1 database)
17	Methane	1.15E+00	g_{oil} /g	(Ecoinvent 3.1 database)
18	LPG	1.28E+00	g_{oil} /g	(Ecoinvent 3.1 database)
19	Oil	1.23E+00	g_{oil} /g	(Biondi et al., 1989)
20	Wood chip	1.00E-02	g_{oil} /g	(Buonocore et al., 2014)
20 bis	Electricity (hotel PV system)	1.73E+01	g_{oil} /Kwh	(Ecoinvent 3.1 database)
22	Soap	9.79E-02	g_{oil} /g	(Ecoinvent 3.1 database)
23	Bleach	3.08E-01	g_{oil} /g	(Ecoinvent 3.1 database)
25a	Pasta, rice, bread	8.00E-02	g_{oil} /g	(Ecoinvent 3.1 database)
25b	Meat	8.00E-01	g_{oil} /g	(Ecoinvent 3.1 database)
25c	Milk	1.50E-01	g_{oil} /g	(Ecoinvent 3.1 database)
25d	Fruits	7.73E-02	g_{oil} /g	(Ecoinvent 3.1 database)
25e	Beverage	5.00E-01	g_{oil} /g	(Ecoinvent 3.1 database)
25f	Sugar	7.01E-03	g_{oil} /g	(Ecoinvent 3.1 database)

Source: own elaboration from specified reference list.

3.2.6 Emergy Accounting

The emergy analysis is an accounting method with a holistic approach that focuses on the analysis of both natural and economic components of an entire system. It entails a circular rather than a linear causality of phenomena, it recognizes a number of multiple answers to questions, and it acknowledges the importance of externalities. The term *emergy* is a combination of two words – *memory* and *energy* – to underline the energy content contained within a good, or a service across time and transformation processes. This analysis uses the flows of energy, material, and information to measure or assess ecosystem goods and services. Although not all *forms* of energy are equivalent, they can be converted and expressed in energy of the same *form* that is generally calculated in term of solar energy. Given this approach to conversion, the definition of solar emergy is: "the available solar energy used up directly and indirectly to make a service or product" (Odum, 1996).

The units of emergy are solar emergy joules (also called solar emjoules or seJ). The Unit Emergy Values (UEVs) are calculated as the ratio of the total amount of solar emergy required to produce a given product or service to the total amount of mass (grams) or energy (joule) required to produce that given product or service. When the ratio of the total amount of solar emergy to the total amount of energy required is measured in joule, the UEV is called transformity. Transformity is the conversion factor measured as seJ/J. Other specific UVEs are measured in seJ/g (named Specific Emergy) and seJ/$.

To better understand the concept of UEV, consider a simple process based on a single form of energy input A. Given the amount of A, the UEV is the conversion factor in solar energy of a unit of that specific form of energy. Multiplying the total amount of A by the corresponding UEV results in the emergy for the input A.

This calculation, applied to all energy inputs of a system, provides a common basis to evaluate the work[40] done by that system (Hau and Bakshi, 2004) where the common basis is represented by the conversion to all energy flow in term of solar emergy.

Emergy evaluation is considered not only an analysis, but also a synthesis. Considering a process or service within a specific system (or ecosystem), the emergy evaluation accounts for the total emergy (U), and distinguishes it by source and type of energy inputs (purchased or imported inputs F, local nonrenewable inputs N, and local renewable inputs R). This evaluation is an emergy analysis which provides information on quantity, source, and type of energy used in a process or service that can be synthesized by the elaboration of certain emergy indicators. These emergy indicators, combining the emergy flows of a process, allow for the interpretation of information and data collected. The three main indicators are:

- The Emergy yield ratio (EYR) of a process or system is the ratio of the sum of all emergy flows (R+N+F) to the purchased emergy flows (F): EYR= $\frac{R+N+F}{F}$, The EYR, assessing the ability to exploit local resources, measures the system emergy yield with respect to its costs (in term of purchased inputs F) (Brown and Ulgiati, 2001, 1997). Although this indicator does not distinguish renewable from non-renewable energy, it analysis the investment in terms of its emergy yield. Larger is the value of the EYR, greater will be the ability (and the yield) of the system in using use local resources.

- The Environmental Loading Ratio (ELR) of a process or system is the ratio of the sum of all non-renewable and purchased emergy flows (N+F) to the renewable emergy flows

[40] This work can be understood in a comprehensive perspective as the work done by ecosystem, nature and society.

only (R): ELR= $\frac{N+F}{R}$. It measures the potential environmental pressure of that process on the (eco) system, lower is the ELR, and lower is this environmental pressure.

- The Emergy Sustainability Index (ESI) is the ratio of the EYR to the ELR: ESI= $\frac{EYR}{ELR}$. Larger is the ESI, larger is the sustainability of that process; in details lower is the ELR (at the denominator of the ESI ratio), larger is the sustainability of the process.

Other indicators are: the *areal empower intensity* that is the ratio of the total emergy used to the total area employed by a process; the *percent renewable emergy* that is the ratio of renewable emergy to the total emergy; the e*mprice* of a good is the emergy a user receives given the money spent to buy that good; the *emergy exchange ratio* is the ratio of emergy exchange in a transaction; the *emergy per capita* is the ratio of the total emergy used at a regional or national economic level to the total population. It can be used to measure the standard of living of a population (Franzese et al., 2014).

The emergy analysis is based on a donor rather than a receiver value perspective. The former attributes a value to a good based on the costs of all the inputs uses for its production; the latter, based on the utility theory of value, assigns a value determined in the market. Therefore, to apply the donor perspective to ecosystem services entails to account for all the inputs which allow to produce these services. In addition, to base emergy analysis in such a framework entails to evaluate these inputs based on the work done by the biosphere rather than on the value attributed them in satisfying human needs (Brown and Ulgiati, 2004).

The emergy analysis has a multidisciplinary approach given the multiple contributions such as: ecology, biology, thermodynamics, and general system theory. The father of the emergy analysis is Professor H.T. Odum who combined several disciplines. Actually, the emergy analysis is only a part Odum's work. He developed a larger theory about organisation and functioning of systems. He showed the hierarchies' organisation and the strategies adopted to survive. A crucial role in these strategies is played by the degree of efficiency in energy use. The central role of energy in survival and evolution of system as already claimed by Lotka in terms of the fourth law of thermodynamics (Lotka, 1922), Odum emphasized this concept stating that these systems capable to compete and overcome other systems are the ones which will survive and will determine future systems. This is formalized as the Maximum Empower Principle which states that "systems that will prevail in competition with others, develop the most useful work with inflowing emergy sources by reinforcing productive processes and overcoming limitations through system organization" (Brown and Herendeen, 1996).

Moreover, from the general system theory (von Bertalanffy, 1971) which underlines the significance of the whole rather than the sum of its parts, it is reinforced the holistic/systemic approach that contributes to better frame a wide range of fields such as economy, industry, biology, ecology, social science. The role of the energy is framed according to thermodynamics functions and laws, particularly the first and second laws[41]. In accounting for all the energy flows of a system and converting them into solar emergy, the emergy analysis considers also the transformation occurred to energy. The transformity is a very sensitive indicator which depends on the number of transformations occurred in a process in terms of energy. For each transformation, while the amount of energy decreases (according to the second law of thermodynamics), the emergy, which is the amount of energy used for that transformation, increases. In fact, more transformations imply higher level of transformity.

The emergy intensities (or transformity) applied in this study are shown in Table 13.

[41] The first law refers to the conservation of energy while the second to the energy lost during transformation.

Table 13. Emergy Intensities applied in this study.

#	Emergy intensities Item	value	unit	Reference
	Local renewable resources			
1	Solar radiation	1	seJ/J	(By definition)
2	Wind	2.42E+03	seJ/J	After (Odum, 1996)
3	Rain	3.05E+04	seJ/J	After (Odum, 1996)
4	Geothermal flow	2.03E+04	seJ/J	(Brown and Ulgiati, 2010)
11 bis	Wood (building & furniture)	5.16E+08	seJ/g	(Buonocore et al., 2014)
20	Wood chip	5.31E+08	seJ/g	(Buonocore et al., 2014)
	Local non-renewable resources			
15	Electricity	1.01E+05	seJ/J	Calculated from (Brown and Ulgiati, 2002; Buonocore et al., 2012)
16	Water	7.30E+05	seJ/J	After (Buenfil, 2001)
	Imported resources			
5	Concrete	2.49E+09	seJ/g	After (Brown and Buranakarn, 2003)
6	Sand	1.61E+09	seJ/g	After (Odum, 1996)
7	Stone	1.61E+09	seJ/g	After (Odum, 1996)
9	Clay	3.22E+09	seJ/g	After (Odum, 1996)
10	Steel	3.03E+09	seJ/g	(Bargigli and Ulgiati, 2003)
11 bis	Wood (building & furniture)	5.16E+08	seJ/g	(Buonocore et al., 2014)
12	Steel (furniture)	3.03E+09	seJ/g	(Bargigli and Ulgiati, 2003)
13	Plastic (furniture)	9.45E+09	seJ/g	After (Buranakarn, 1998)
14	Services	9.89E+11	seJ/€	After (Pereira et al., 2013)
15	Electricity	1.01E+05	seJ/J	Calculated from (Brown and Ulgiati, 2002; Buonocore et al., 2012)
17	Methane	1.78E+05	seJ/J	(Brown et al., 2011)
18	LPG	1.70E+05	seJ/J	(Brown et al., 2011)
19	Oil	1.81E+05	seJ/J	(Brown et al., 2011)
20	Wood chip	5.31E+08	seJ/g	(Buonocore et al., 2014)
20 bis	Electricity (hotel PV system)	7.93E+04	seJ/J	(Brown et al., 2012)
21	Services	9.89E+11	seJ/€	After (Pereira et al., 2013)
22	Soap	1.82E+12	seJ/g	(Lei et al., 2011)
23	Bleach	1.82E+12	seJ/g	(Lei et al., 2011)
24	Services	9.89E+11	seJ/€	After (Pereira et al., 2013)
25a	Pasta, rice, bread	6.80E+04	seJ/J	(Lei et al., 2011)
25b	Meat	7.92E+05	seJ/J	(Lei et al., 2011)
25c	Milk	7.92E+05	seJ/J	(Lei et al., 2011)
25d	Fruits	5.30E+04	seJ/J	(Lei et al., 2011)
25e	Beverage	6.00E+04	seJ/J	(Lei et al., 2011)
25f	Sugar	8.50E+04	seJ/J	(Lei et al., 2011)
26	Services	9.89E+11	seJ/€	After (Pereira et al., 2013)
27	Labor cost	9.89E+11	seJ/€	After (Pereira et al., 2013)

Source: own elaboration from specified reference list.

3.2.7 Emissions accounting and impact categories

Downstream methods generally evaluate the impact of processes or systems according to amount of emissions (on airborne and waterborne) and waste.

The ReCiPe mid-point method (ReCiPe, 2000) was used to evaluate the impact to environment. It aims at evaluating the potential environmental damage of airborne, waterborne, and solid emissions by appropriate equivalence factors to selected reference compounds for each impact category. In effect, each impact category is associated with a reference compound. The reference compound is associated to an equivalence or characterization factor. The impact generated by a process or a system on a certain impact category is provided by multiplying the amount of emissions to the equivalence factor of each category. Calculating the amount of emissions and assigning them to specific impact categories under the assumption that "less" is better is a mid-point assessment. Calculating the extent to which certain damage may potentially occur is instead an end-point assessment. The end-point assessment is more complex and less reliable than the other one. The impact categories selected in this study were: are Climate Change, Particulate Matter, Photochemical Oxidant Formation, Terrestrial Acidification and Fresh Water Eutrophication. Climate Change is expressed as g CO_2 equivalent and the emissions contributing to this category are: CO_2 (carbon dioxide), NO_2 (nitrogen dioxide), CH_4 (methane). Particulate Matter is expressed as g PM10 equivalent and the emissions contributing to this category are: NOx (mono-nitrogen oxide), SO_2 (sulfur dioxide), PM10 (particulates, smaller than 10 μm). Photochemical Oxidant Formation is expressed as g NMVOC equivalent and the emissions contributing to this category are: CO (carbon monoxide), NOx (mono-nitrogen oxide), SO_2 (sulfur dioxide), CH_4 (methane). Terrestrial Acidification is expressed as g SO_2 equivalent and the emissions contributing to this category are: NOx (mono-nitrogen oxide), SO_2 (sulfur dioxide). Fresh Water Eutrophication is expressed as g PO_4 equivalent and the emissions contributing to this category is NOx (mono-nitrogen oxide).

The Converting factors per impact category and the unit of emissions from indirect use of oil and direct use of wood and natural gas are provided in Table 14, Table 15, Table 16, and Table 17 respectively.

Table 14. Conversion Factors applied in this study.

Converting Factors: baseline (Recipe midpoint)					
	Climate change	Particulate Matter	Photochemical Oxidant Formation	Terrestrial Acidification	Fresh Water Eutrophication
	g CO_2 eq.	g PM10 eq.	g NMVOC eq.	g SO_2 eq.	g PO_4 eq.
CO_2	1.00E+00				
CO			4.50E-02		
NOx		2.20E-01	1.00E+00	5.60E-01	3.89E-01
SO_2		2.00E-01	8.10E-02	1.00E+00	
PM_{10}		1.00E+00			
N_2O	2.98E+02				
CH_4	2.50E+01		1.00E-02		

Source: own elaboration from specified reference list.

Table 15. Emissions from indirect use of oil.

Reference	Unit	CO_2	CO	NOx	SO_2	PM_{10}	N_2O	CH_4
EPA	g/MJ	7.84E+01	1.50E-02	5.10E-02	1.50E-01	5.80E-03	3.40E-04	3.10E-03

Source: own elaboration from specified reference list.

Table 16. Emissions from direct use of wood.

Reference	Unit	CO_2	CO	NOx	SO_2	PM_{10}	N_2O	CH_4
EPA	g/J wood	8.39E-05	2.58E-07	2.11E-07	1.08E-08	1.55E-07	5.59E-09	9.03E-09

Source: own elaboration from specified reference list.

Table 17. Emissions from direct use of natural gas.

Reference	Unit	CO_2	CO	NOx	SO_2	PM_{10}	N_2O	CH_4
CORINAIR	g/MJ	6.42E+01	3.90E-02	8.90E-02	3.00E-04	9.00E-04	6.00E-04	3.00E-03

Source: own elaboration from specified reference list.

4 RESULTS AND DISCUSSION

4.1 Environmental management

4.1.1 Operational, communicational, and organizational practices

The analysis of the environmental practices (operational, communication and organizational ones listed in Table 5) of the final dataset (247 observations) was performed by means of the PCA applied to the polychoric correlation matrix. This PCA reproduced more than 72 percent of the total variance considering the first three principal components. An analysis of the correlation between the variables and the principal components revealed important aspects which lead to identify each of the first three components as being associated with a specific set of practices (see Table 18). This analysis provided evidence that these environmental management practices can be divided into three groups even though there are differences compared to the classification proposed in literature (González-Benito and González-Benito, 2006): communication, organizational and operational practices. According to PCA analysis, the operation practices were associated to either the second or third factor while the communication and organizational practices were associated entirely to the first factor.

Table 18. PCA of environmental management practices.

The variance explained by the first three factors is 72.5 percent; the values (*) identify the maximum correlation between variable and factor.

	Variables	F1	F2	F3
Operational practices	Renewables	0.257	0.207	0.761 (*)
	Insulation	0.321	0.293	0.691 (*)
	Biomass boiler	0.574	0.589 (*)	- 0.084
	Multi-fuel boiler	0.267	0.835 (*)	- 0.310
	Waste	0.892 (*)	0.122	- 0.243
Communication practices	Green events	0.695 (*)	- 0.580	0.091
	Green report	0.831 (*)	- 0.080	- 0.109
	Green marketing	0.770 (*)	0.146	0.057
Organizational practices	EMS	0.818 (*)	0.016	- 0.037
	Environmental monitoring	0.744 (*)	- 0.343	0.084
	Environmental objectives	0.771 (*)	- 0.284	- 0.152
Supplementary variables	Subsidies-No	- 0.165	- 0.092	- 0.248 (*)
	Subsidies-Yes	0.165	0.092	0.248 (*)

Source: own elaboration.

Thus, a first consideration is that there is a distinction between these environmental practices since the classification does not follow the framework proposed: communication, organizational and operational categories. More precisely, communicational and organizational practices include waste management, the promotion of green events, the publicizing of a hotel's sustainable activities, the monitoring of consumption and the setting of environmentally sustainable business objectives. The operation practices splits in two: on one hand the use of biomass or multi-fuel boilers, on the other the insulation of buildings in order and the adoption of solar and photovoltaic panels. The supplementary variable – whether respondents gained accessed (subsidies-Yes) or not (subsidies-No) to provincial subsidies (these subsidies are intended to encourage energy efficiency and energy savings in buildings used for tourist purposes) – revealed that certain activities, which were also the more expensive ones, had a higher correlation with the request of financial support. An analysis of the correlation between variables and factors reinforced this analysis and confirmed by the examination of the square cosines.

A series of chi-squared tests were run to verify if significant differences exist between practices adopted by certain groups of hotels rather than others. The groups of hotels were based on the following characteristics: category, size, ownership of hotel and access to subsidies. The categories were grouped in 1-2 stars and 3-4 stars; the size was defined equal to/ less than 30 rooms and more than 30 rooms; the ownership of the hotel was based on the hotelier ownership of the hotel or not; the access to subsidies was based on receiving or not these subsidies. The association between hotel size and adoption of environmental practices was significant only for the following practices: EMS, green marketing and access to subsidies. Group 2 (> 30 rooms) reported percentage of adoption higher than group 1 (≤ 30 rooms) as well as in the positive access to subsidies. The larger the hotel size the higher was the association with green marketing, EMS adoption, and access to subsidies (see Appendix D, Table A). This same set of practices was also significant for high category hotels (see Appendix D, Table B). The association by access to subsidies and adoption of environmental practices was significant with the respect to the renewables, insulation, biomass boiler, green report, green marketing, EMS. For these practices, group 1 (hotels benefit from provincial subsidies) presented a significance difference in the percentage of adoption compared to group 2 (hotels not benefiting from provincial subsidies). In effect, the majority of these practices – renewables, insulation, biomass boiler – were retrofitting activities eligible for subsidies and those hotels adopting them were those receiving funds (see Appendix D, Table C). The association between hotel ownership and adoption of environmental practices was significant for each practice apart for multi-fuel boiler, green events, green report, EMS, environmental objective (see Appendix D, Table D).

The literature on environmental management suggested that the variables which determine the enterprise's environmental proactivity can be divided into three groups: operations, communication, planning and organization (González-Benito and González-Benito, 2006). These studies, however, focus mainly on the manufacturing sector. Although the manufacturing and service industries may adopt similar environmental management strategies, especially in communication and planning, most strategies, such as those related to operational practices, are necessarily determined by the particular sector of industry. The hotel sector, as a branch of the service industry, naturally has its own unique characteristics, and therefore it generates particular environmental impacts.

The environmental practices analyzed by the present study were organized in a different way with the respect to the framework suggested by González-Benito and González-Benito (2006). Communication practices were grouped with planning and organizational practices, while the operational practices were divided into two subgroups which were renamed as soft infrastructural practices (F2) and infrastructural practices (F3). Therefore, the initial hypothesis was only partially confirmed. The selected variables are significant for the environmental management of SMHEs in the Province of Trento, but they aggregated differently compared to the environmental management framework of corporate enterprises.

These differences can partially be attributed to the abovementioned distinguishing features of the hotel sector generally, and partially to the specific characteristics of these SMHEs.

These characteristics might be enterprise size or managerial capacity. These SMHEs were small; the hotel owner was usually also the owner of the structure itself and the business was run by the family in the majority of cases. In fact, almost half of the sample had less than 30 rooms and human resources were limited. Communications and organizational activities were generally carried out by family members, or even by the hotel owner him/herself. These enterprises had no formal business structure: the owner was also responsible for marketing, supplier relationships, front office activities, and employee training.

The division of operational activities between soft infrastructural and infrastructural highlighted two additional elements: ability to attract investments and the importance of long term managerial planning. Small businesses usually not only had limited access to funds and difficulties in attracting investments, but also limited capacity or inclination to develop innovative, long term management strategies. In the present analysis, the soft infrastructural activities were low-budget medium-term investments while the infrastructural activities entailed higher-budget long-term investments in environmental management. Since these practices were expensive they were highly correlated with access to subsidies to sustain investment over time.

This analysis presented a number of new aspects. As has been mentioned, the study of environmental management has only recently been more widely applied to the service sector, and hotels in particular. In addition, very few studies address small and medium sized hotel enterprises; even fewer examine such firms in mountain areas. The Alpine context is unusual in many ways. The relevance of both natural and economy ecosystems means that the relationship between environmental management and hotel enterprises has to be examined taking this specific context into account. Another important aspect of this study is the collection of such primary data for the case study. Since the Province of Trento is representative of many Alpine destinations, this analysis may help to shed light on the environmental proactivity of Alpine hotels more generally. And lastly, the presence of these three sets of practices intended to improve environmental management in the hotels studied reveals an attitude to environmental management which should be analyzed in more detail in order to better understand not only the types of practices, but also the relationship between such practices and hotels' economic and energy performance and, moreover, the factors determining and affecting these behaviors.

4.1.2 Determinants and commitment

Hotel cluster profiles

The k-means cluster analysis was conducted considering from one to six clusters. This initial analysis suggested that the sixth class (composed by 6 observations) was not consistent because the intraclass variance was the largest compared to the others (see Table 19.a).

Another cluster analysis was performed considering from one to five classes. This analysis suggested that the fifth class (composed by 6 observations) was again not consistent because the intraclass variance was the largest compared to the others and accounted for about 5.3 (in absolute terms) of intraclass variance (see Table 19.b). The inspection of the sixth class of the first cluster analysis and the fifth of the second cluster analysis revealed the same observations identified as outliers and removed from the sample.

Table 19. Intraclass variance for k-means cluster analysis.
Table 19.a. K-means cluster analysis considering from one to six clusters, N=247.

Results by class:

Cluster	1	2	3	4	5	6
Object	44	58	50	33	56	6
Intraclass variance	2.15	0.83	1.07	1.35	1.69	5.27

Table 19.b. K-means cluster analysis considering from one to five clusters, N=247.

Results by class

Cluster	1	2	3	4	5
Object	49	82	70	40	6
Intraclass variance	2.21	1.14	1.87	1.61	5.27

Table 19.c. K-means cluster analysis considering from one to five clusters, N=241.

Results by class

Cluster	1	2	3	4	5
Object	43	64	48	35	51
Intraclass variance	2.23	0.91	1.07	1.34	1.66

Source: own elaboration.

Then, a further cluster analysis (k-means) was run considering from one to five classes on 241 observations (see Table 19.c). The intraclass variances ranged from 0.9 to 2.2 in absolute terms. The analysis of the variance decomposition suggested interclass variance maximization based on the k-means clustering. The variance among the five classes is near 68 percent while the variance within the class is about 32 percent (see Table 20).

Table 20. Variance decomposition for the optimal classification.

	Absolute value	Percentage value
Intraclass	1.39	32.15%
Interclass	2.95	67.85%
Total	4.35	100.00%

Source: own elaboration.

The five classes (or clusters) were obtained by the cluster analysis and using new coordinates of each variables derived from the factors scores of each one of the three groups of environmental practices adopted by hotels and identified through by the PCA. Communication practices were grouped with planning and organizational practices and included the following practices: waste management, the promotion of green events, dissemination of the sustainable activities offered by the hotel, green marketing activities, the introduction of environmental management systems (EMS), the monitoring of consumption and the setting of business objectives aimed at achieving environmental sustainability. The operational practices are divided into two subgroups which were renamed as soft infrastructural practices which included the following practices: use of biomass and multi-fuel boilers; and the infrastructural practices which included retrofitting of building (by building insulation), and the increase usage of renewable energy (solar and photovoltaic panels).

The first cluster grouped 43 observations. More than half of these hotel adopted infrastructural practices (52 percent), while only 10 percent adopted also soft infrastructural practices. However, a large part of them adopted communication, organizational and planning practices (84 percent). The second cluster grouped 64 observations. In this cluster, the infrastructural and soft infrastructural practices are respectively adopted by 34 and 2 percent of the hotels. The communication, organizational and planning practices are adopted by 42 percent of the hotels.

The third cluster grouped 48 observations. In this cluster, the infrastructural and soft infrastructural practices are respectively adopted by 94 and 2 percent of the hotels. The communication, organizational and planning practices are adopted by 31 percent of the hotels. The fourth cluster grouped 35 observations. In this cluster, the infrastructural and soft infrastructural practices are respectively adopted by 89 and 20 percent of the hotels. The communication, organizational and planning practices are adopted by 61 percent of the hotels. The fifth cluster grouped 51 observations. In this cluster, the infrastructural and soft infrastructural practices are respectively adopted by 19 and 4 percent of the hotels. The communication, organizational and planning practices are adopted by 18 percent of the hotels.

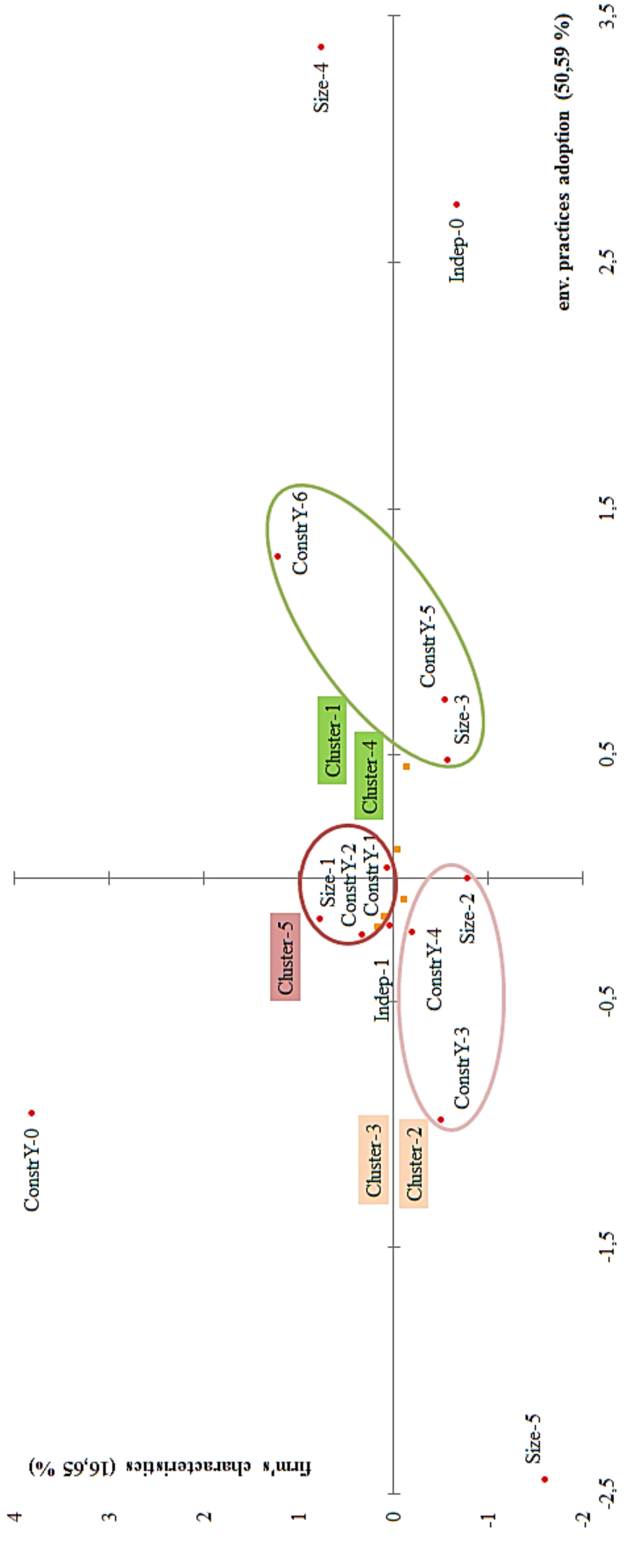
Clusters 1 and 4 were the best performers from an environmental viewpoint since they adopted extensively practices from all the three groups. However, the cluster 1 was more focused on the implementation of communication, organizational and planning practices while cluster 4 was focused on infrastructural and soft infrastructural practices. Cluster 5 was the worst performer from an environmental viewpoint, scoring low in each of the three groups of practices. Cluster 2 performed almost homogenously across the three groups of practices even though large percentages of adoption were not measured in any group of practices. Cluster 3 was completely focused on infrastructural practices and in effect, investigation of age facility showed that hotels grouped in this cluster are older (built on average before 1980) and could require a large number of energy retrofitting activities. This could explain also the low adoption of communication, organizational and planning practices. According to this analysis, an effort of ranking from best to worst performing clusters of hotel could result as cluster 4, cluster 1, cluster 3, cluster 2 and cluster 5.

Later, these clusters were examined to explore the potential role played by the determinants factors. From a descriptive view point, cluster 1 was characterized by large size (on average 39 rooms), the larger number of chain-affiliated hotels (7 on a total of 16 chain-affiliated hotels), and facility age around ’80. Cluster 2 was characterized by smaller size (on average 35 rooms), smaller number of chain-affiliated hotels (4 on a total of 16 chain-affiliated hotels), and facility age around ’80. Cluster 3 was characterized by 31rooms on average, the majority of hotels are independent (there is only 1 chain-affiliated hotel), facility age around ’80. Cluster 4 was characterized by 34 rooms on average, a couple of chain-affiliated hotels, a larger portion of younger facility age hotels (around 1990-2000). Cluster 5 was characterized by smaller-sized hotels (on average 29 rooms), couple of chain-affiliated hotels, older buildings hotel (around ’60).

The MCA was run on determinant factors’ data using clusters data as supplementary variables. The squared cosines, as well as the squared correlations, are a measure of the goodness of data representation performed by the MCA and allow to evaluate the contribution of each factor to the inertia of each modalities. The inspection of such squared cosines suggests a sufficient data quality representation by means of the first two axes. The analysis of the association among determinants and clusters suggested that the axes, horizontal and vertical, could respectively explain the level of adoption of environmental practices and the firm’s characteristics owned by the hotel enterprises. In effect, in accordance with the previous the cluster analysis, the MCA allocated from worst to best performing hotel clusters along the horizontal axis (from left to right). The vertical axis was associated to firm’s characteristics: smaller-sized, older, and independent determinants are positively associated to the vertical axis. Then, there is evidence of association also among hotels’ clusters and determinants. In effect, those clusters best performing from an environmental management viewpoint are associated with certain firms’ characteristics: larger-sized, younger facilities, affiliated to hotel chains (see clusters 1 and 4 in Figure 11). The worst performing clusters are instead associated with smaller-sized, older, and independent-managed facility’s features (see cluster 5 in Figure 11). Then, there are two clusters, 2 and 3, for which these association is evident but less regular.

Figure 11. Association among cluster profiles and hotels' characteristics.

The association is performed through a MCA where the cluster profiles are based on the level of environmental practice adoption and the hotels' characteristics are the determinants for the environmental management (size, age and affiliation to hotel chains).

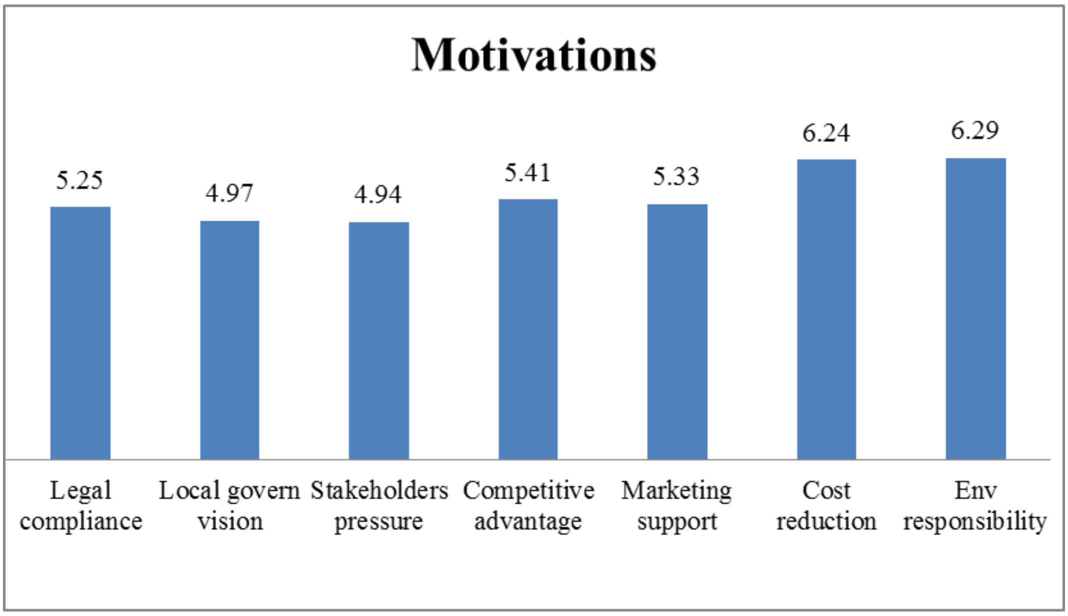


Source: own elaboration.

Environmental commitment: motivations and perceptions

Analyzing the analysis of environmental commitment of this hotel samples, findings were in line with literature. Hotel managers stated that the most important motivations to *going green* are cost reduction and environmental responsibility which scored respectively 6.24 and 6.29 up to 7 points. Legal compliance and opportunity to gain competitive advantage, and marketing support scored around 5 points up to 7. Stakeholders' pressure and local governmental visons obtained lower scores even though they are considered still important (see Figure 12).

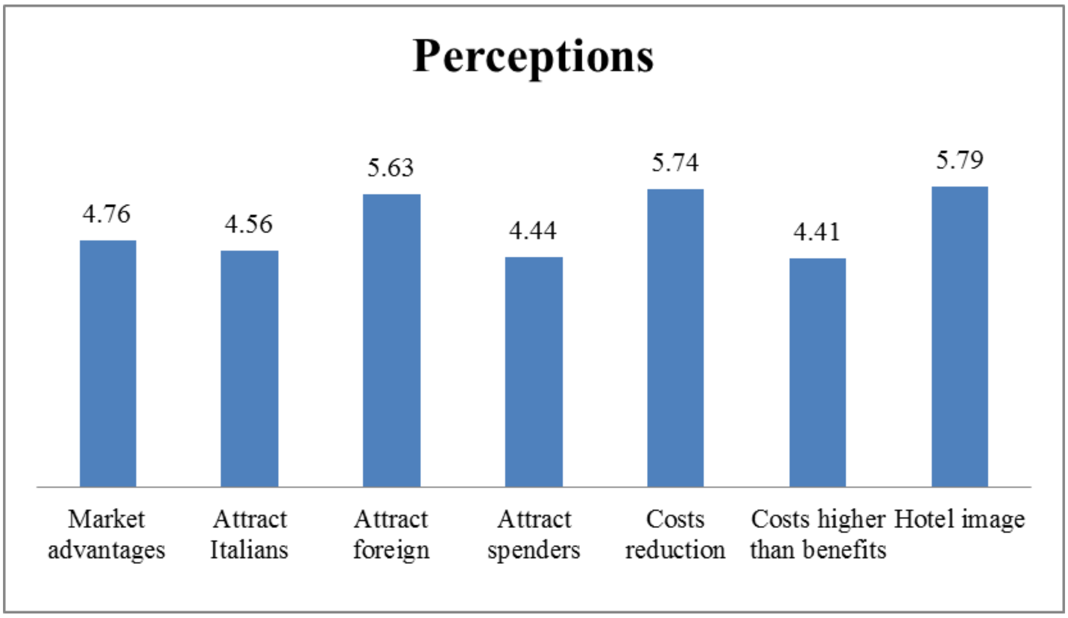
Figure 12. Likert scale on motivations' sentences
N=241.



Source: own elaboration.

The analysis of the perception suggested that hotel managers had the opinion that *to going green* could be important to attract foreign guests which are the most sensitive to green practices compared to Italian ones'. Green practices were perceived beneficial also because they allowed reducing cost of energy. In effect a smaller score was allocated to the control variable (cost higher than benefits). The other perceived benefits were the improvement of hotel image and market advantages (see Figure 13). Hotel managers' answers suggested that there are several motivations *to going green* and almost all of these obtained high scores. However, perception of benefits underlined certain discrepancies between motivations and effective perception and only cost reduction and hotel image for marketing purposes scored similar in both analyses.

Figure 13. Likert scale on perceptions' sentences.
N=241.



Source: own elaboration.

Summarizing, the previous paragraphs analyzed hotels clustering according to the level of adoption of environmental practices, the determinants of environmental management, and the environmental commitment of these hotel enterprises adopting such environmental practices. The general aim was to understand the relationship between adoption of environmental practices and hotel characteristics. The cluster analysis was based on a k-means non-hierarchical. Clusters 1 and 4 were the best performers while cluster 5 was the worst performer from an environmental viewpoint. From a quantitative description, cluster 4 consisted of a small number of hotels which extensively adopted environmental practices across the three sets of practices reorganized by the PCA. They were young-age facility of large size. The MCA supported the evidence of the association between those firm's characteristics and cluster 4. Similar conclusions applied to cluster 1. It is characterized by an extensively adoption of green practices and firm's characteristics are larger-sized, and young facilities mostly affiliated to hotel chains. For cluster 5 applied same reasoning but as worst performed, small-sized, old-aged, and independent hotels. These three clusters best fitted to the initial assumption based on the literature. Thus, there is evidence of alpine small and medium-sized hotel enterprises having similarities in determinant factors for environmental management. However, those evidences are not fully accomplished also for clusters 2 and 3. They represented an intermediate level between the best and the worst performing hotels as far as it concerns the adoption of environmental management practices. The firm's characteristics were similar to these of cluster 5. Thus, there are small hotels, built before '80, almost all independent managed. They represented the 46 percent of the total sample because a large part of hotel sample was assigned to one of the two clusters. The most relevant difference between the two is in the adoption of operational practices (including both infrastructural and soft infrastructural practices). Cluster 2 performed worse than cluster 3 (36 percent against 96 percent). Better is the performance in the adoption of communication, organizational and planning practices in which hotels of cluster 2 reached 42 percent of adoption, while in cluster 3 are 31 percent of adoption.

With the respect of hotel environmental commitment, hotel managers attributed an high importance to the motivations *to going green* submitted to them. Cost reduction and environmental responsibility were evaluated as the most important motivations *to going green*, followed by legal compliance, opportunity to gain competitive advantage and marketing support. Stakeholders' pressure and local governmental were evaluated relatively less important. The importance attributed to the perceptions was similar. The two items for which motivation and perception were agreed with the respect to importance for firm management are cost reduction and hotel image, both in line with the literature.

4.2 Environmental accounting: performance and sustainability assessment

The environmental performance and sustainability of three hotels was investigated calculating both intensive and extensive indicators and considering multiple levels of analysis (the global environmental performance, the operation activities' performance per each hotel; the comparison among hotels' performances). The calculation procedure (the *mass, energy, emergy and emissions spreadsheets*) and the input-output tables per each hotel are displayed in Appendix E, Appendix F, and Appendix G respectively.

Here, the following results are presented:

- single environmental performance of three hotels;
- single environmental performance of three hotels based on the three main operation activities;
- comparison of the environmental performance of the three hotels;
- comparison of the main operation activities' performance of the three hotels;
- analysis of waste flows.

The methods undertaken through the multicriteria assessment are presented in paragraph 3.2: the Material Flow Accounting, the Gross Energy Requirement, the Emergy Accounting, the Emission Accounting and the identification of five relevant impact categories through the ReCiPe Midpoint impact assessment method. The first three methods provides information on the environmental costs of the investigated system in terms of material diverted, commercial energy used (measured in oil equivalent), environmental support of the geobiosphere for all the input flows used by the system (measured in emergy units). The environmental impacts are accounted through the emissions associated to the investigated system and five impacts categories are used: Climate Change, Particulate Matter, Photochemical Oxidation, Terrestrial Acidification and Fresh Water Eutrophication.

4.2.1 Environmental performance of selected SMHEs

The investigation of the individual environmental performance of three hotels was performed by means of both intensive and extensive indicators calculated per each method used within the multicriteria assessment framework. The intensive indicators refer to one unit of output while the extensive indicators refer to the whole output produced by the system in the considered time frame. Applied to the investigated system, the intensive indicators are calculated per single overnight stay assuming breakfast and dinner included (in other words assuming that all guests enjoy, on average, an half board service), hereafter abbreviated with *night*; the extensive indicators are calculated on the total amount of nights provided by each hotel. Quantitative data are exhibited per each hotel in the following tables (Table 22, Table 23 and Table 24):

- The Material Flow Accounting (part a of Table 22, Table 23, Table 24) contains the following intensive indicators: Abiotic Material Intensity, Water Demand; the Global to Local Ratio of abiotic material, Global to Local Ratio of water material; and the following extensive Indicators: Total Abiotic Material Requirement and Total Water Demand. The Abiotic Material Intensity and the Water Demand are the intensity factors of the investigated system respectively for abiotic material and water per unit of output: in other word these are the measure of environmental costs generated by the system from a material flow perspective. Such indicator can be compared with that of other systems to assess which is more expensive according to the material flow perspective. The Global to Local Ratio of abiotic material and water material are the ratios of global to local amount of abiotic material and water respectively associated to the investigated system. The Total Abiotic Material Requirement and Total Water Demand are the sum of all the abiotic material and water flow associate to the whole production output (such amount divided by the total amount of output – in this case the total amount of nights – represent the Abiotic Material Intensity and Water Demand respectively).

- The Gross Energy Requirement (part b of Table 22, Table 23, Table 24) contains the following intensive indicators: Oil Equivalent Intensity; the Global to Local Energy Ratio; and the following extensive indicators: Total GER cost and Total Oil Equivalent. The Oil Equivalent Intensity is the intensity factor of the investigated system per unit of output: in other word, this is the measure of environmental costs in oil equivalent generated by the system from an energy perspective. The Global to Local Energy Ratio is the ratio of global to local amount of energy flows associated to the investigated system. The Total GER cost and the Total Oil Equivalent are the amount of total direct and indirect energy costs associated to the whole production output (such amount divided by the total amount of output – in this case the total amount of nights – represents the Oil Equivalent Intensity).

- The emissions (part c of Table 22, Table 23, Table 24) directly and indirectly associated to the investigated system are the following: CO_2 (carbon dioxide), CO (carbon monoxide), NOx (mono-nitrogen oxide), SO_2 (sulfur dioxide), PM10 (particulates, smaller than 10 μm), NO_2 (nitrogen dioxide), CH_4 (methane).

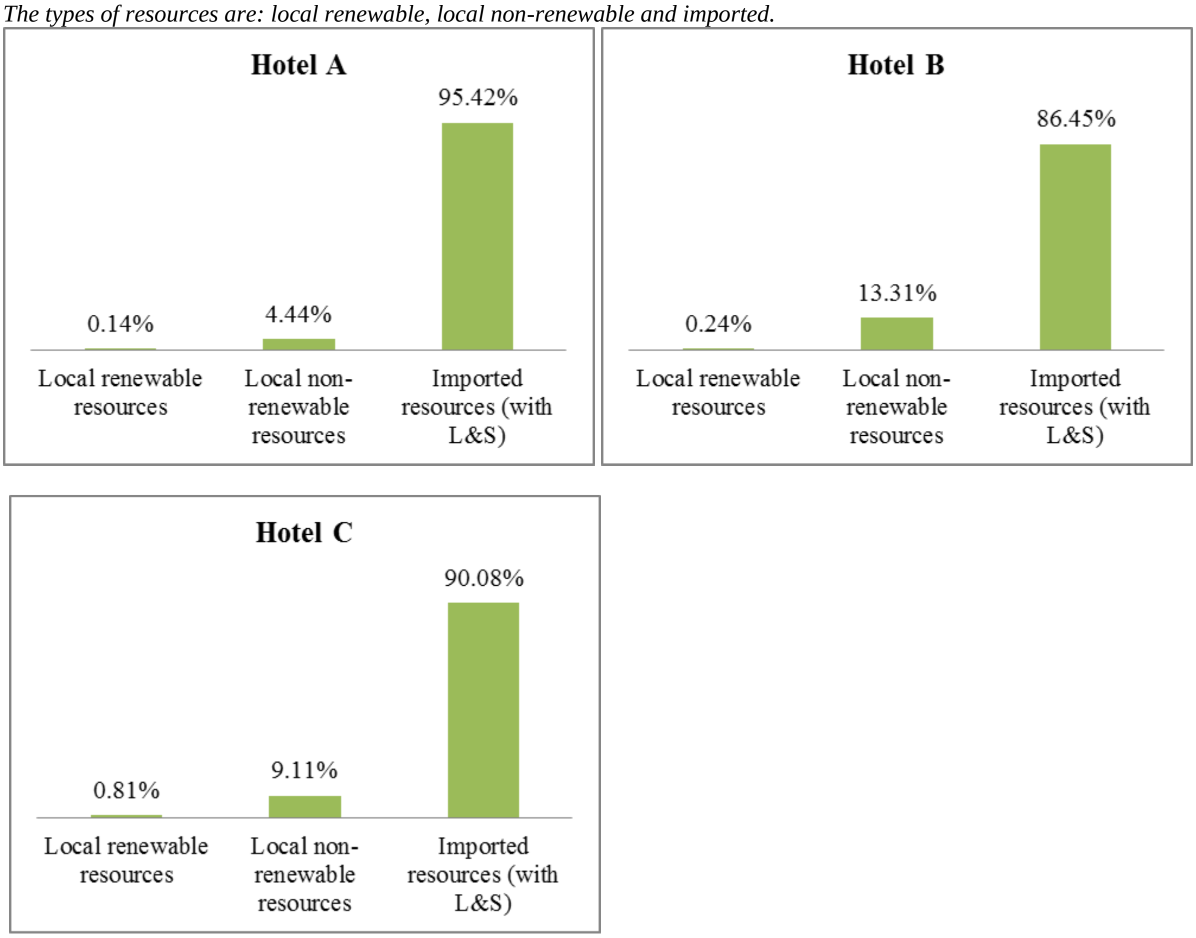
- The emergy accounting (part d of Table 22, Table 23, Table 24) contains the following intensive indicators: UEV, that is the solar transformity calculated with and without including labor and service (L&S); the extensive indicators are the Emergy from local renewable resources (R), the Emergy from local non-renewable resources (N), the Emergy from imported resources (F), the Total Emergy with and without labor and services (U = R+N+F), the Renewable fraction, the Environmental Loading Ratio (ELR = (F+N)/R), the Emergy Yield Ratio (EYR = (R+N+F)/F), the Emergy Sustainability Index (ESI = EYR/ELR) (see Table 21). The UEV corresponds to the intensity factor per unit of output showing the total environmental support converging for the generation of one unit product. Since this method accounts for different type of resources, the amount of emergy demanded by the investigated system can be expressed also according to the type of resources demanded by such system. Figure 14 shown the percentage of emergy used by type of resources per each hotel. All the three hotels are almost entirely dependent on imported resources which are represented by the largest part by labor and services. Local resources both renewables and non-renewables accounted for small percentages. However, differences are registered among the three hotels particularly on the share of local non-renewable resources used.

Table 21. Emergy accounting indicators.

Emergy Accountings	Abbreviation	Details	Unit
Intensive Indicators	**Intensive Indicators**		
UEV (with L&S)	UEV (with L&S)	Solar transformity with L&S	seJ/night
UEV (without L&S)	UEV (without L&S)	Solar transformity without L&S	seJ/night
Extensive Indicators	**Extensive Indicators**	**Extensive Indicators**	
Emergy from local renewable resources (R)	R	R	seJ/yr
Emergy from local non-renewable resources (N)	N	N	seJ/yr
Emergy from imported resources (F)	F	F	seJ/yr
Total Emergy (U, with L&S)	U (with L&S)	U = R+N+F (with L&S)	seJ/yr
Total Emergy (U, without L&S)	U (without L&S)	U = R+N+F (without L&S)	seJ/yr
Renewable emergy fraction	Renewable emergy fraction	Renewable emergy fraction	
Environmental Loading Ratio (ELR)	ELR	ELR = (F+N)/R	
Emergy Yield Ratio (EYR)	EYR	EYR = (R+N+F)/F	
Emergy Sustainability Index (ESI)	ESI	ESI = EYR/ELR	

Source: own elaboration.

Figure 14. Emergy used by each hotel by type of resources.
The types of resources are: local renewable, local non-renewable and imported.



Source: own elaboration.

- The impact Categories (part e of Table 22, Table 23, Table 24) are Climate Change, Particulate Matter, Photochemical Oxidant Formation, Terrestrial Acidification and Fresh Water Eutrophication. Climate Change is expressed as g CO_2 equivalent and the emissions contributing to this category are: CO_2 (carbon dioxide), NO_2 (nitrogen dioxide), CH_4 (methane). Particulate Matter is expressed as g PM10 equivalent and the emissions contributing to this category are: NOx (mono-nitrogen oxide), SO_2 (sulfur dioxide), PM10 (particulates, smaller than 10 μm). Photochemical Oxidant Formation is expressed as g NMVOC equivalent and the emissions contributing to this category are: CO (carbon monoxide), NOx (mono-nitrogen oxide), SO_2 (sulfur dioxide), CH_4 (methane). Terrestrial Acidification is expressed as g SO_2 equivalent and the emissions contributing to this category are: NOx (mono-nitrogen oxide), SO_2 (sulfur dioxide). Fresh Water Eutrophication is expressed as g PO_4 equivalent and the emissions contributing to this category are NOx (mono-nitrogen oxide).

Table 22. Hotel A – Intensive and extensive indicators per method (tables a-e).

Table 22. a

Material Flow Accounting	Value	Unit
Intensive Indicators		
Abiotic Material Intensity	4.45E+04	g/night
Water Demand	2.25E+05	g/night
Global to Local Ratio of abiotic material	6.82E+00	
Global to Local Ratio of water material	499.74	
Extensive Indicators		
Total Abiotic Material Requirement	4.59E+08	g/yr
Total Water Demand	2.32E+09	g/yr

Table 22.b

Gross Energy Requirement	Value	Unit
Intensive Indicators		
Oil Equivalent Intensity	3.82E+03	g_{oil}/night
Oil Equivalent Intensity	1.60E+08	J/night
Global to Local Energy Ratio	1.3	
Extensive Indicators		
Total GER cost	1.65E+12	J/yr
Total Oil Equivalent	3.94E+07	g_{oil}/yr

Table 22.c

Emissions	Value	Unit		Value	Unit
Intensive Indicators			**Extensive Indicators**		
			Global to local CO_2 ratio	1.33E+00	
CO_2	1.28E+04	g CO_2/night	CO_2	1.32E+08	g CO_2/yr
CO	3.33E+00	g CO/night	CO	3.43E+04	g CO/yr
NO_x	8.91E+00	g NO_x/night	NOx	9.19E+04	g NO_x/yr
SO_2	2.40E+01	g SO_2/night	SO_2	2.48E+05	g SO_2/yr
PM10	1.48E+00	g part./night	PM10	1.53E+04	g part./yr
NO_2	7.44E-02	g NO_2/night	NO_2	7.68E+02	g NO_2/yr
CH_4	5.28E-01	g CH_4/night	CH_4	5.45E+03	g CH_4/yr

Table 22.d

Emergy Accountings	Value	Unit
Intensive Indicators		
UEV (with L&S)	1.56E+14	seJ/night
UEV (without L&S)	7.34E+13	seJ/night
Extensive Indicators		
Emergy from local renewable resources (R)	2.27E+15	seJ/yr
Emergy from local non-renewable resources (N)	7.14E+16	seJ/yr
Emergy from imported resources (F)	1.53E+18	seJ/yr
Total Emergy (U, with L&S)	1.61E+18	seJ/yr
Total Emergy (U, without L&S)	7.57E+17	seJ/yr
Renewable emergy fraction	0.1%	
Environmental Loading Ratio (ELR)	708.30	
Emergy Yield Ratio (EYR)	1.05	
Emergy Sustainability Index (ESI)	0.0015	

Table 22.e

Impact Categories (Recipe midpoint)	Value	Unit
Intensive Indicators		
Climate Change	1.29E+04	g CO_2 eq./night
Particulate Matter	8.24E+00	g PM10 eq./night
Photochemical Oxidation	1.10E+01	g NMVOC eq./night
Acidification	2.90E+01	g SO_2 eq./night
Eutrophication	3.46E+00	g PO_4 eq./night
Extensive Indicators		
Climate Change	1.33E+08	g CO_2 eq./yr
Particulate Matter	8.51E+04	g PM10 eq./yr
Photochemical Oxidation	1.14E+05	g NMVOC eq./yr
Acidification	2.99E+05	g SO_2 eq./yr
Eutrophication	3.58E+04	g PO_4 eq./yr

Source: own elaboration.

Table 23. Hotel B – Intensive and extensive indicators per method (tables a-e).

Table 23.a

Material Flow Accounting	Value	Unit
Intensive Indicators		
Abiotic Material Intensity	6.11E+04	g/night
Water Demand	1.92E+05	g/night
Global to Local Ratio of abiotic material	2.33E+01	
Global to Local Ratio of water material	592.98	
Extensive Indicators		
Total Abiotic Material Requirement	1.38E+09	g/yr
Total Water Demand	4.35E+09	g/yr

Table 23.b

Gross Energy Requirement	Value	Unit
Intensive Indicators		
Oil Equivalent Intensity	5.64E+02	g_{oil}/night
Oil Equivalent Intensity	2.36E+07	J/night
Global to Local Energy Ratio	10.1	
Extensive Indicators		
Total GER cost	5.36E+11	J/yr
Total Oil Equivalent	1.28E+07	g_{oil}/yr

Table 23.c

Emissions	Value	Unit		Value	Unit
Intensive Indicators			**Extensive Indicators**		
			Global to local CO2 ratio	1.28E+01	
CO_2	2.35E+03	g CO_2/night	CO2	5.34E+07	g CO_2/yr
CO	1.90E+00	g CO/night	CO	4.30E+04	g CO/yr
NO_x	2.47E+00	g NO_x/night	NOx	5.59E+04	g NO_x/yr
SO_2	3.61E+00	g SO_2/night	SO2	8.18E+04	g SO_2/yr
PM10	1.06E+00	g part./night	PM10	2.41E+04	g part./yr
NO_2	4.15E-02	g NO_2/night	NO2	9.40E+02	g NO_2/yr
CH_4	1.27E-01	g CH_4/night	CH4	2.89E+03	g CH_4/yr

Table 23.d

Emergy indicators	Value	Unit
Intensive Indicators		
UEV (with L&S)	7.50E+13	seJ/night
UEV (without L&S)	4.98E+13	seJ/night
Extensive Indicators		
Emergy from local renewable resources (R)	4.09E+15	seJ/yr
Emergy from local non-renewable resources (N)	2.26E+17	seJ/yr
Emergy from imported resources (F)	1.47E+18	seJ/yr
Total Emergy (U, with L&S)	1.70E+18	seJ/yr
Total Emergy (U, without L&S)	1.13E+18	seJ/yr
Renewable emergy fraction	0.2%	
Environmental Loading Ratio (ELR)	414.94	
Emergy Yield Ratio (EYR)	1.16	
Emergy Sustainability Index (ESI)	0.0028	

Table 23.e

Impact Categories (Recipe midpoint)	Value	Unit
Intensive Indicators		
Climate Change	2.37E+03	g CO_2 eq./night
Particulate Matter	2.33E+00	g PM10 eq./night
Photochemical Oxidation	2.85E+00	g NMVOC eq./night
Acidification	4.99E+00	g SO_2 eq./night
Eutrophication	9.60E-01	g PO_4 eq./night
Extensive Indicators		
Climate Change	5.37E+07	g CO_2 eq./yr
Particulate Matter	5.28E+04	g PM10 eq./yr
Photochemical Oxidation	6.45E+04	g NMVOC eq./yr
Acidification	1.13E+05	g SO_2 eq./yr
Eutrophication	2.18E+04	g PO_4 eq./yr

Source: own elaboration.

Table 24. Hotel C – Intensive and extensive indicators per method (tables a-e).

Table 24.a

Material Flow Accounting	Value	Unit
Intensive Indicators		
Abiotic Material Intensity per night	9.40E+04	g/night
Water Demand per night	2.25E+05	g/night
Global to Local Ratio of abiotic material	1.32E+01	
Global to Local Ratio of water material	782.31	
Extensive Indicators		
Total Abiotic Material Requirement	1.41E+08	g/yr
Total Water Demand	3.37E+08	g/yr

Table 24.b

Gross Energy Requirement	Value	Unit
Intensive Indicators		
Oil Equivalent Intensity per night	1.09E+03	g_{oil}/night
Oil Equivalent Intensity per night	4.56E+07	J/night
Global to Local Energy Ratio	7.3	
Extensive Indicators		
Total GER cost	6.84E+10	J/yr
Total Oil Equivalent	1.63E+06	g_{oil}/yr

Table 24.c

Emissions	Value	Unit		Value	Unit
Intensive Indicators			**Extensive Indicators**		
			Global to local CO_2 ratio	1.06E+01	
CO_2	4.30E+03	g CO_2/night	CO_2	6.45E+06	g CO_2/yr
CO	2.91E+00	g CO/night	CO	4.37E+03	g CO/yr
NO_x	4.15E+00	g NO_x/night	NOx	6.22E+03	g NO_x/yr
SO_2	6.93E+00	g SO_2/night	SO_2	1.04E+04	g SO_2/yr
PM10	1.60E+00	g part./night	PM10	2.40E+03	g part./yr
NO_2	6.38E-02	g NO_2/night	NO_2	9.57E+01	g NO_2/yr
CH_4	2.19E-01	g CH_4/night	CH_4	3.29E+02	g CH_4/yr

Table 24.d

Emergy indicators	Value	Unit
Intensive Indicators		
UEV (with L&S)	1.51E+14	seJ/night
UEV (without L&S)	7.73E+13	seJ/night
Extensive Indicators		
Emergy from local renewable resources (R)	1.83E+15	seJ/yr
Emergy from local non-renewable resources (N)	2.06E+16	seJ/yr
Emergy from imported resources (F)	2.04E+17	seJ/yr
Total Emergy (U, with L&S)	2.26E+17	seJ/yr
Total Emergy (U, without L&S)	1.16E+17	seJ/yr
Renewable emergy fraction	0.8%	
Environmental Loading Ratio (ELR)	122.65	
Emergy Yield Ratio (EYR)	1.11	
Emergy Sustainability Index (ESI)	0.0091	

Table 24.e

Impact Categories (Recipe midpoint)	Value	Unit
Intensive Indicators		
Climate Change	4.32E+03	g CO_2 eq./night
Particulate Matter	3.90E+00	g PM10 eq./night
Photochemical Oxidation	4.84E+00	g NMVOC eq./night
Acidification	9.25E+00	g SO_2 eq./night
Eutrophication	1.61E+00	g PO_4 eq./night
Extensive Indicators		
Climate Change	6.48E+06	g CO_2 eq./yr
Particulate Matter	5.85E+03	g PM10 eq./yr
Photochemical Oxidation	7.26E+03	g NMVOC eq./yr
Acidification	1.39E+04	g SO_2 eq./yr
Eutrophication	2.42E+03	g PO_4 eq./yr

Source: own elaboration.

The main operation activities identified per each hotel were three: building construction, management and food. The building construction includes all the matter, energy, environmental support and emission generated to build the hotel infrastructures. The management includes all matter but above all the energy, environmental support and emission needed to provide the hotel services except for the food that is treated separately. Food consists of the raw amount of food used for meal preparation. Per each hotel, the environmental costs and impacts generated by each operation activities are explored. Generally, the building construction generates the majority of the environmental costs in terms of matter invested; however, management activities require large amount of energy, environmental support and generate large amount of emissions. Food, particularly dairy products and meat, are those generating large environmental impacts.

The indicators considered in this analysis are the MIF, the EIF, Emergy flows and Economic costs[42], Climate Change and Particulate Matter impact categories. The Emergy flows account also for labor and services costs, thus it is possible to compare them with the economic costs supported by the hotels. All calculated indicators are expressed as unit per night.

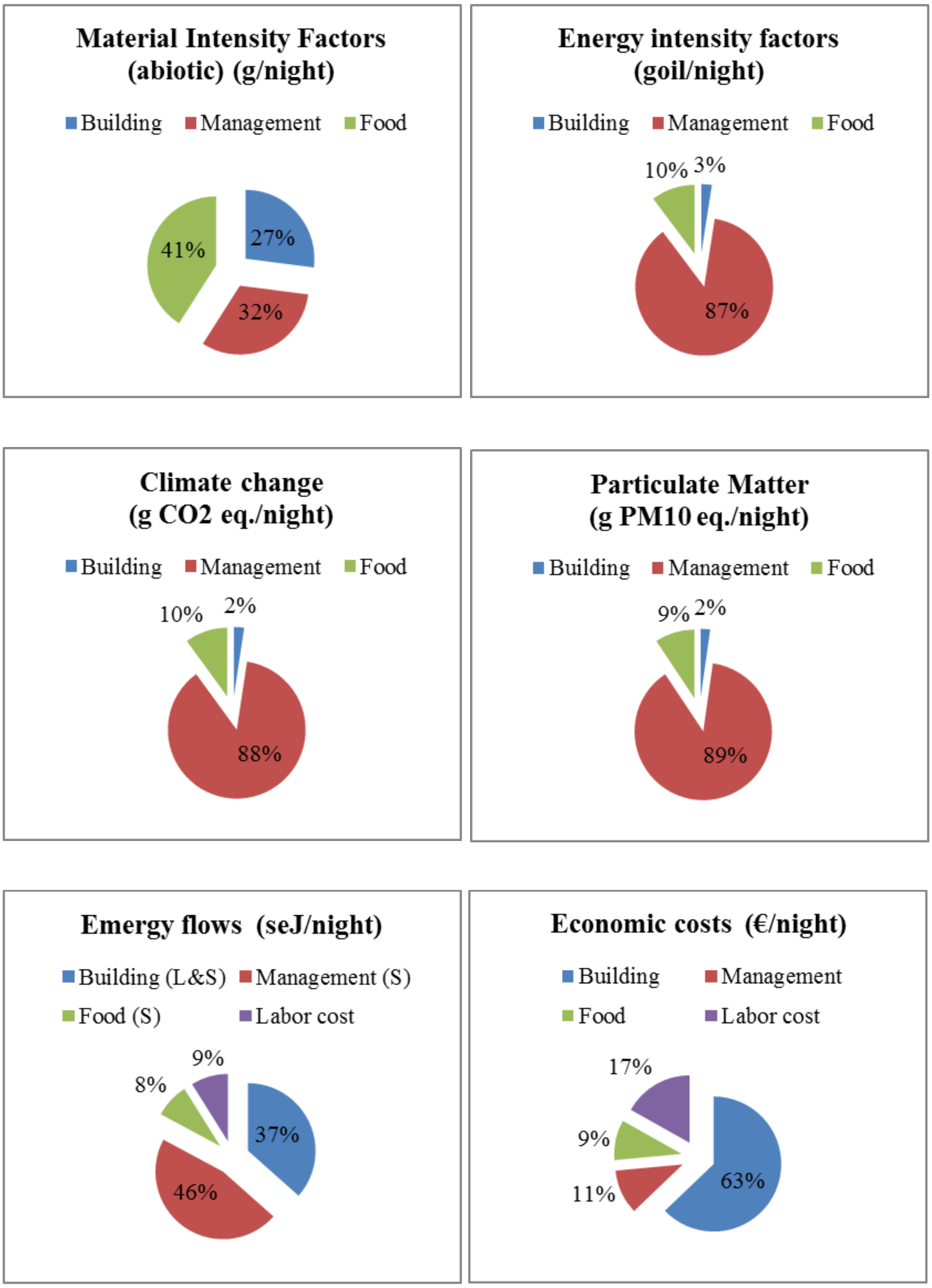
For Hotel A, management is the operation activity generating high environmental impacts, followed by food requirement. Analyzing the emergy flow per night, building construction and management are the two operation activities requiring the most environmental support. However, from an economic viewpoint, such environmental support is overpaid in the case of building construction, but underpaid in the case of management. A reasons for the building construction's overpaid is the service and labor component included in it; in other words what is overpaid are not the material

[42] It is worth to call back the economic costs related to labor and services. Labor (L) is referred to the economic costs of human labor (hotel staff dedicated to management, cleaning and catering). Services (S) are referred to the economic costs of utilities, cleaning materials, raw amount of food. For building and furniture it was not possible to disaggregate data quantifying the amount of money spent in materials (services) and human work (labor). Thus, the economic costs for such inputs are grouped together as Labor & Services (L&S). See also footnote 43.

diverted from nature and the environmental support required to make them available but instead the labor and services invested in it (Figure 15)[43]. The data (without building construction values) underlined the relevant role played by services to this hotel (Figure 16). Similar patterns are shown for Hotels B and C but Food operation activities showed a larger share and a higher environmental impact among the other operations activities for these two hotels. The comparison among emergy flows and economics costs revealed, also in Hotels B and C, the same scheme of hotel A. Certain services are under evaluated in economic terms such as management operation activities; labor costs represent one of the large items of hotel expenditure.

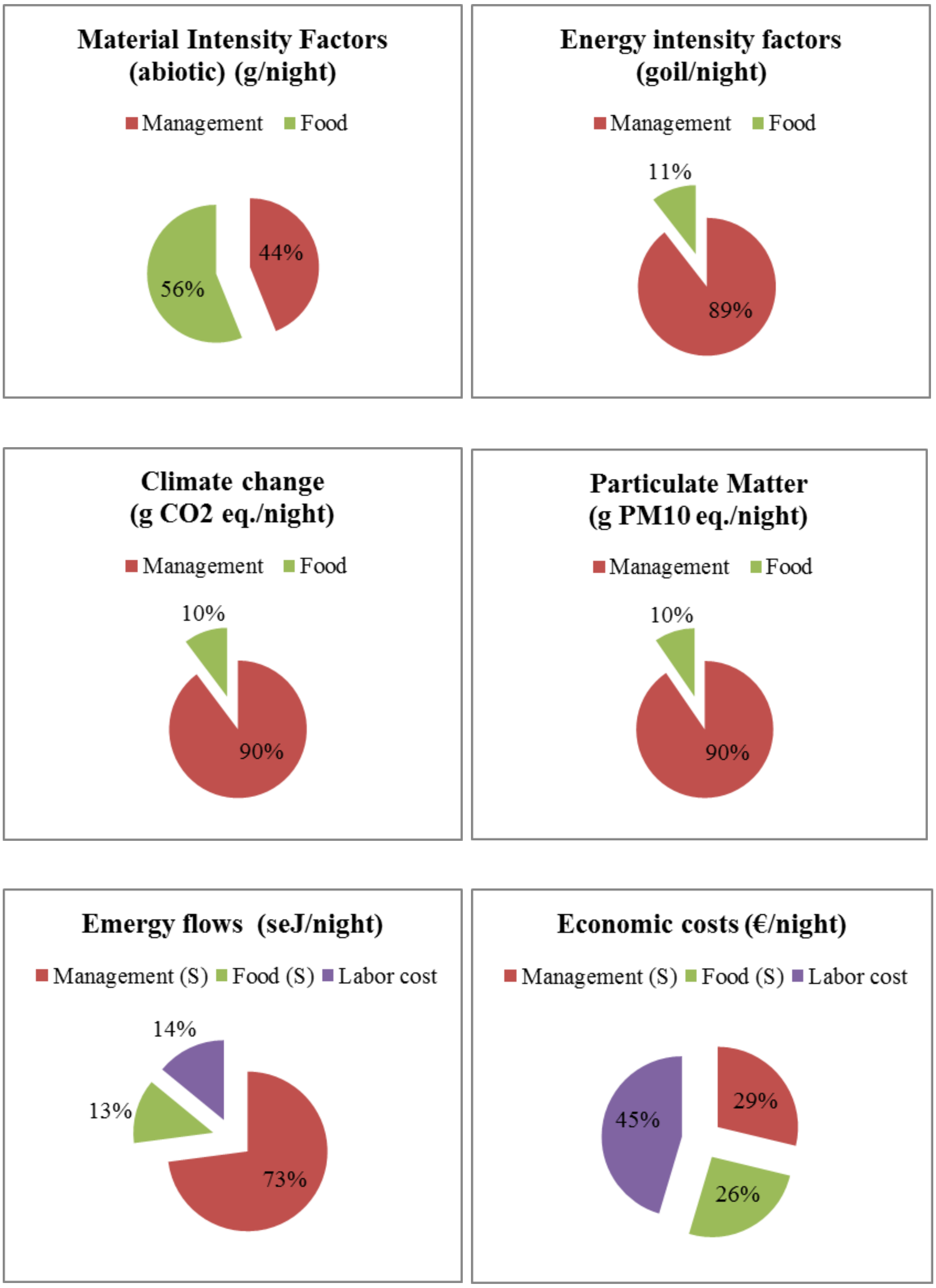
[43] The economic costs refer to the amount of euro per night spent for the operation activities. In Figure 15, the economic costs for building (63%) include both labor and services costs. Management and food activities include only economic costs for services (raw materials and utilities) but not human labor. The economics cost of human labor falls back into the Labor cost category. The emergy analysis allows accounting for labor and services also. In this case, the emergy flows include labor and/or services as shown before. In this way, the last two parts of Figure 15 are comparable. This applies also to Figure 16, Figure 17, Figure 18, Figure 19, and Figure 20.

Figure 15. Operation activities of Hotel A.



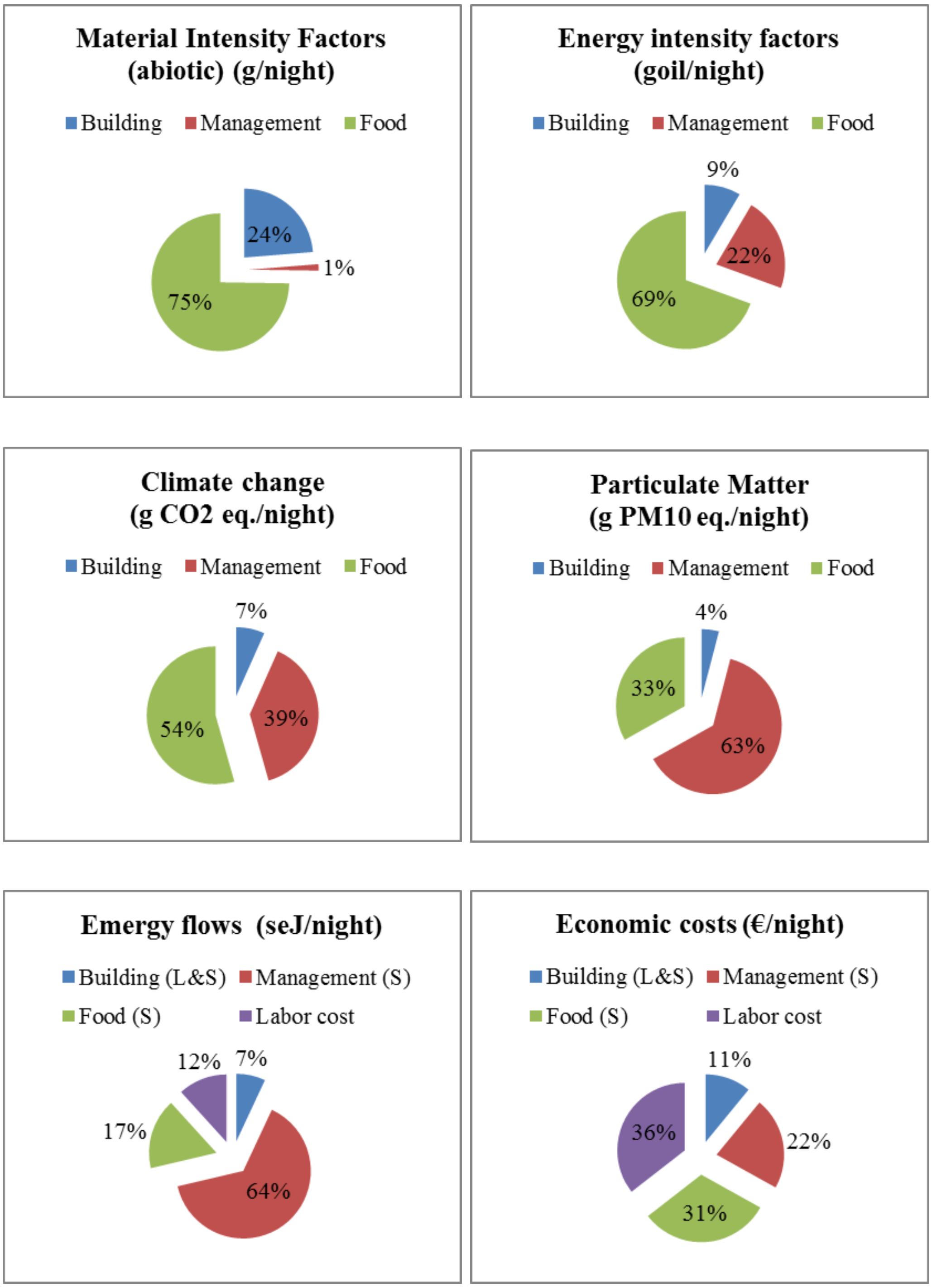
Source: own elaboration.

Figure 16. Management and Food operation activities of Hotel A.



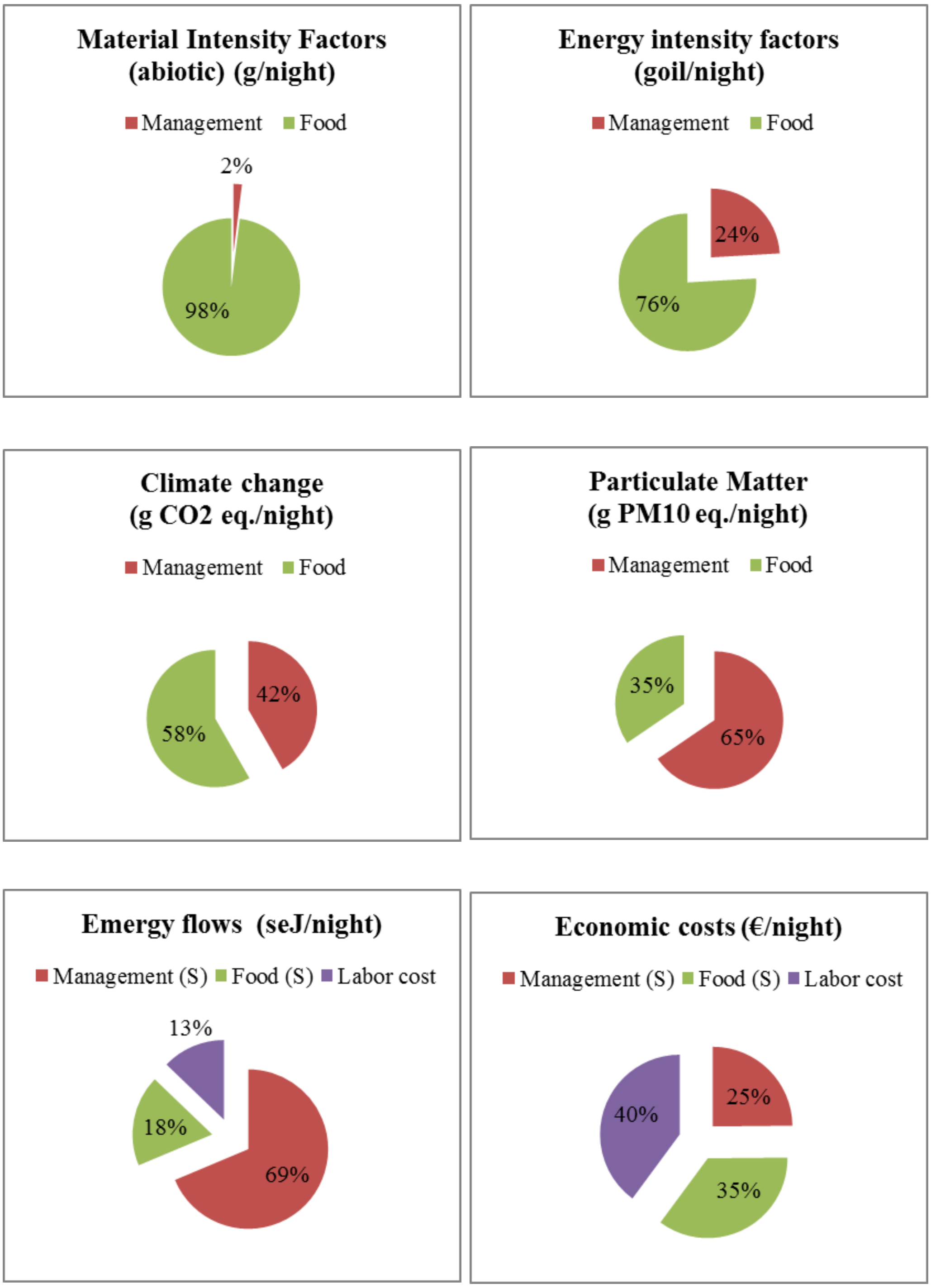
Source: own elaboration.

Figure 17. Operation activities of Hotel B.



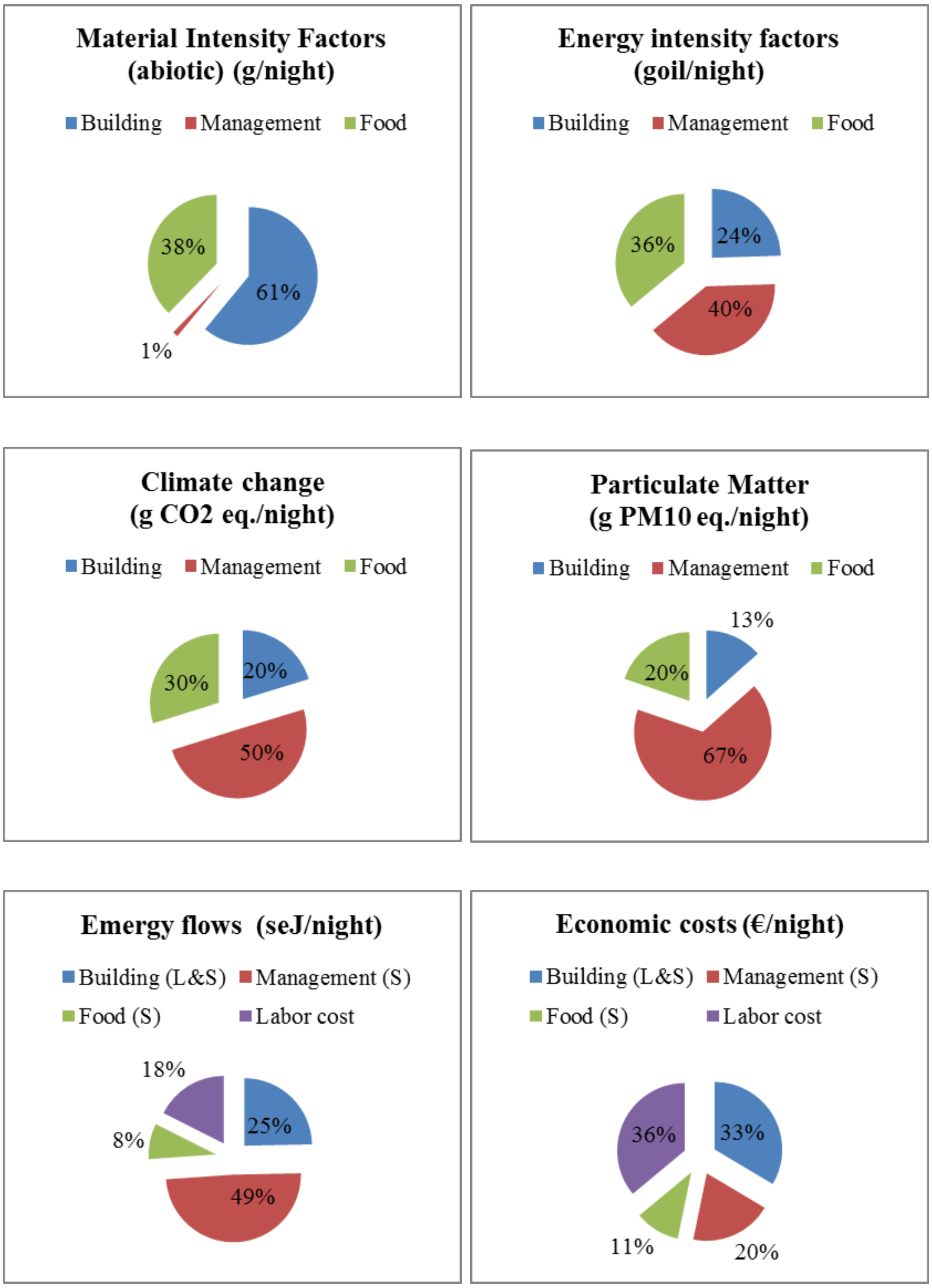
Source: own elaboration.

Figure 18. Management and Food operation activities of Hotel B.



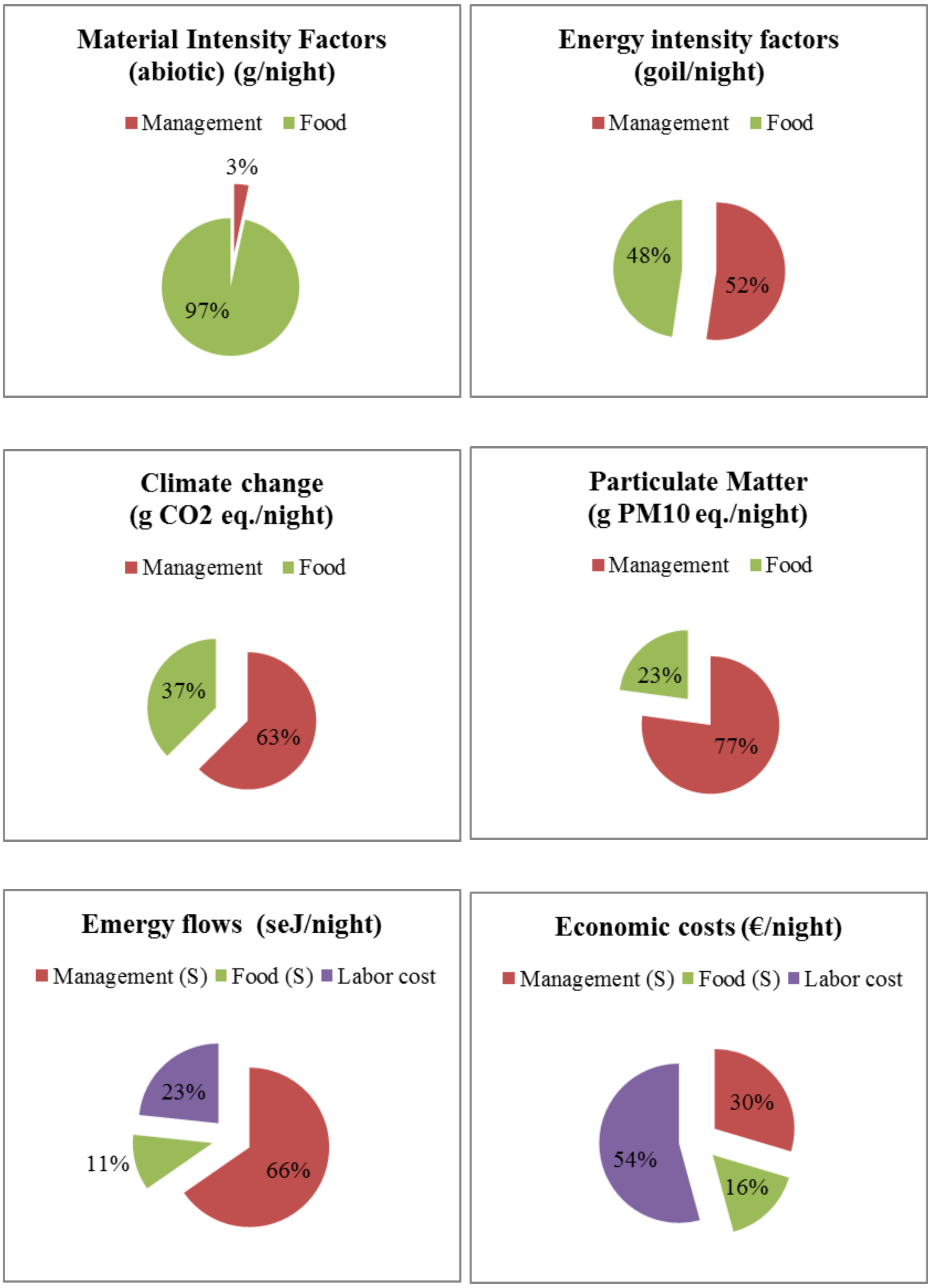
Source: own elaboration.

Figure 19. Operation activities of Hotel C.



Source: own elaboration.

Figure 20. Management and Food operation activities of Hotel C.



Source: own elaboration.

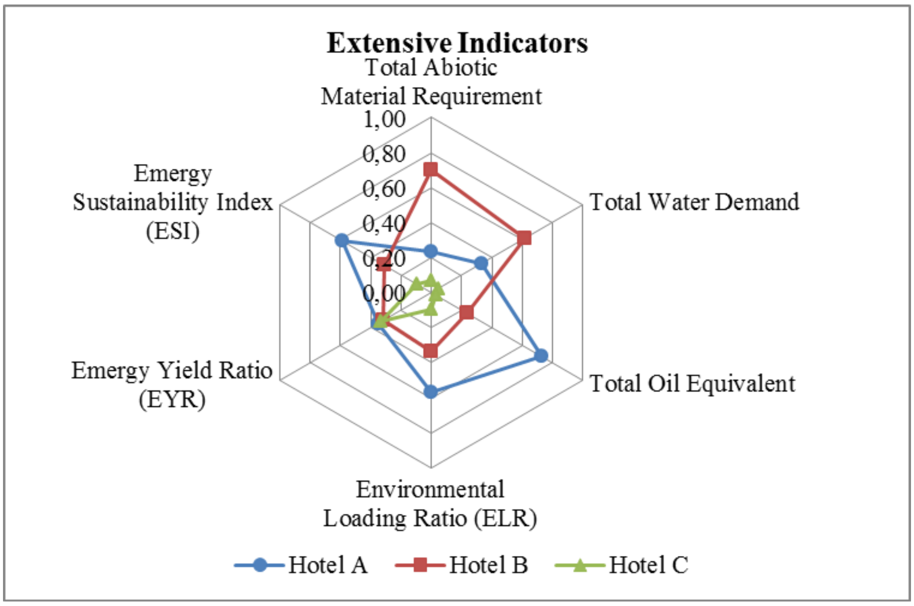
4.2.2 Comparison among three SMHEs

4.2.2.1 The extensive indicators

The extensive indicators provide information about the total amount of output produce by the systems (in other words the total amount of nights per each hotel). Such indicators did not allow comparing the environmental performance of the hotels on a common basis because the three hotels are characterized by different physical dimension and support different amount of overnight stays (assuming breakfast and lunch included). In effect Hotel A supported over 10000 overnight stays, Hotel B supported over 20000 overnight stays, and Hotel C supported 1500 overnight stays. Thus, they required a different environmental support for their activities. In addition to that, another major difference is related to the energy mix of the three hotels. Hotel A uses a fossil fuel energy mix based on LPG and oil; Hotel B uses oil and wood chip; Hotel C uses methane and electricity produced by photovoltaic panels. Other details about the three hotels are reported in Table 9 and Table 10.

The following extensive indicators are presented per each hotel to show the environmental costs and impacts generated by the three hotels but such data are not comparable. The aim is to provide, in a unique figure, more indicators per each hotel and to better understand what determines the environmental performance of each hotel. In the following figures, per each hotel, the smaller is the area of the radar diagram the better is the environmental performance of the entire hotel. Despite hotels had different features, the EYR is similar for the three hotels. In effect, all three hotels had a larger portion of imported resources compared to local renewable and non-renewable resources. Despite of the individual amount per each hotel, the percentages per type of resources are similar, and this results in similar values of the EYR (Figure 21).

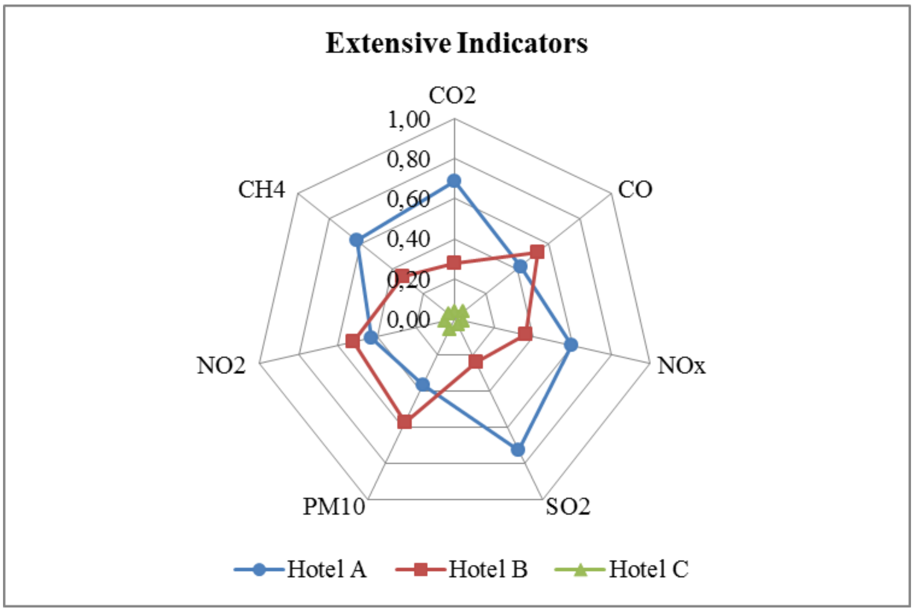
Figure 21. Selected extensive indicators per each hotel.
The indicators are derived from the MFA, GER and Emergy accounting.



Source: own elaboration

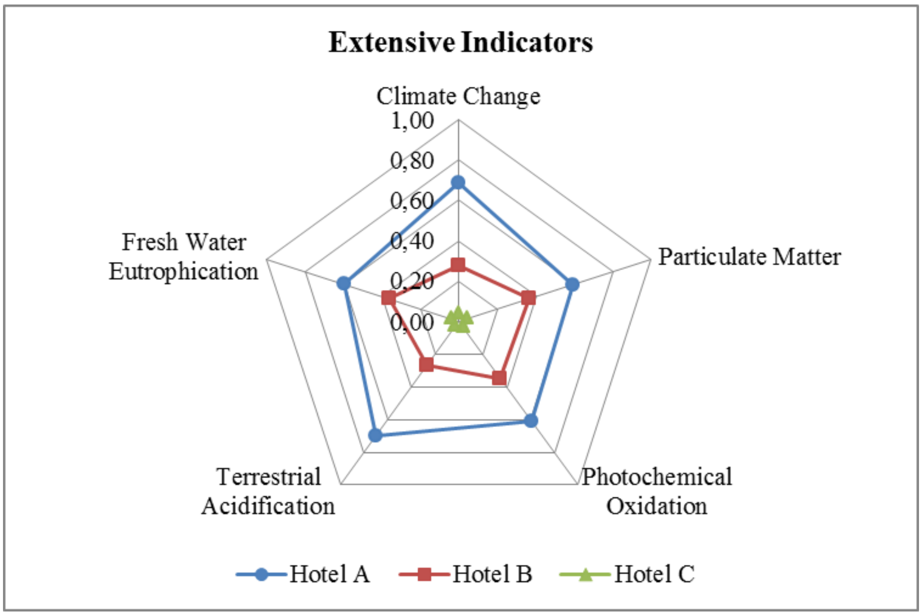
The other indicators in Figure 21 depend on the dimension of each hotel. Hotel C supports the small amount of guests and its environmental costs covers a smaller surface compared to the other two hotels. The differences in the indicators of the other two hotels can be attributed, besides the different amount of guest supported, to the different energies used by Hotel A and B. Hotel A mainly consumes fossil energy while Hotel B uses a mix of fossil and renewable energy. This can explain the difference in the Total Oil Equivalent indicator. The ELR indicator reflects such renewable energy fraction used by the Hotel B. In fact, the ELR is smaller for Hotel B than Hotel A despite the former supports a large quantity of guests than the latter. The ESI, as the ratio of EYR to ELR, reflects support to these considerations. The Total Abiotic Material Requirement is mostly dependent on the construction materials and thus from the physical dimensions of the buildings while the Water Demand depends on the total amount of overnight stays. Hotel A is small in dimensions and supports a smaller amount of overnight stays (compared to hotel B). These aspects are reflected by these two indicators.

Figure 22. Emissions associated to each hotel.



Source: own elaboration

Figure 23. Impact categories per each hotel.



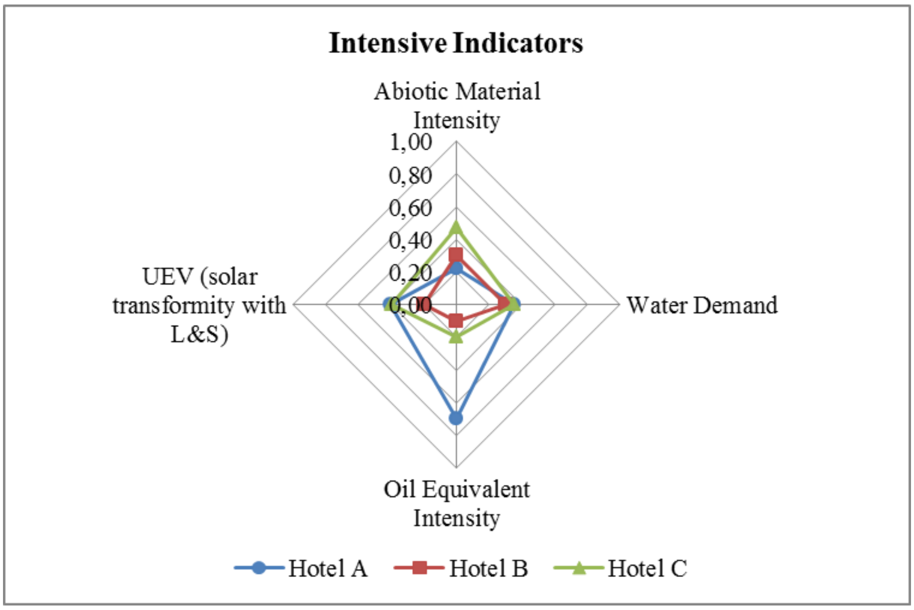
Source: own elaboration

Figure 22 and Figure 23 show the environmental impacts generated by each hotel in terms of total emissions and by impact categories, respectively. Hotel C is the smallest and consequently goes its impact. Hotel A and B, despite the abovementioned differences, suggest environmental impacts not fully associated to the amount of overnight stays only but also to other specific features of each hotel. The emissions associated to Hotel B are generally smaller than those associate to Hotel A (except for CO, NO_2, PM10) particularly for what concern the impact categories, despite the fact that Hotel B has almost the double amount of overnight stays than Hotel A. this can be attribute to the major difference among the two hotels respect to the energy mix. Hotel A uses a fossil fuel energy mix based on LPG and oil while Hotel B uses oil and wood chip. Such differences are explored in detail examining the intensive indicators.

4.2.2.2 The intensive indicators

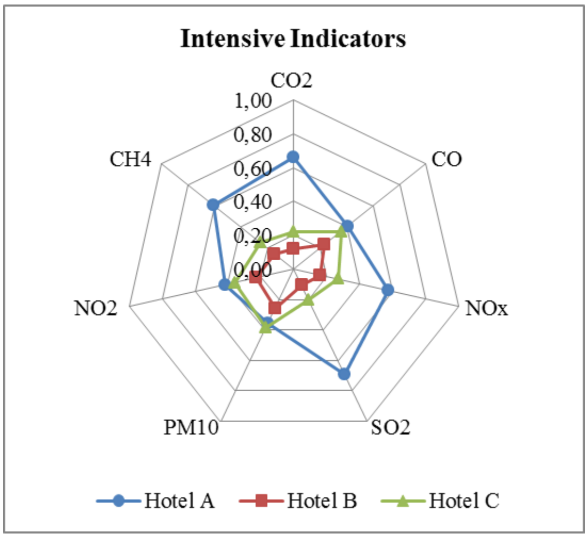
The intensive indicators are calculated per unit of output generated by the investigated hotel systems. The unit of output for the three hotels is the overnight stay. All the intensive indicators are expressed per night and thus the environmental performance of the three hotels can be compared on a common basis that is the unit of output. Hotel C is displayed together with Hotel A and B but it is a Garnì-hotel with a type of tourism different from the other two hotels. Therefore, Hotel C supports a smaller amount of overnight stays. This implies that even in the case of intensive indicators, Hotel C distributes fix costs to a smaller amount of nights, thus resulting in larger impact per night. For instance, this is the case of materials invested in the building construction. In fact, the Abiotic Material Intensity for Hotel C is the largest even if the building is the smallest. The Water Demand (mostly dependent on guests' consumption) shows similar values. This outcome supports the previous reasoning and suggests that there are not different consumption behaviors among the three hotels' guests; such difference may be attributed to individual hotels' characteristics. The UEV indicator of Hotels C is than similar to that of Hotel A and larger than Hotel B despite the larger amount of overnight stays support by Hotel A and B. The UEV is a measure of the environmental supported demanded by each hotel. In effect, Hotel A and C use mainly fossil energy (as shown also by the corresponding Oil Equivalent Intensities' indicators). Fossil energy requires a larger environmental support both in terms of resources and time compared to renewable energies.

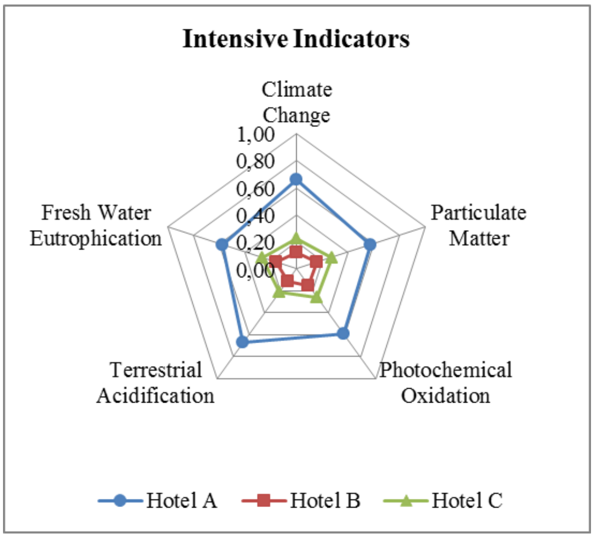
Figure 24. Selected intensive indicators (per night) per each hotel.
The indicators are derived from the MFA, GER and Emergy accounting.



Source: own elaboration

Figure 25. Emissions and impact categories per night per each hotel.
Respectively, the emissions indicators are on the left side of the figure; the impact categories are on the right side.





Source: own elaboration

The comparison between Hotel A and B provides further information. They are two comparable hotels: they have similar physical dimensions, they are located in two of the most touristic municipalities in Trentino, and they have a seasonal tourism flow. The main differences are the number of rooms and the amount of overnight stays per year. Other relevant differences are in the energy consumption: Hotel A uses fossil energy while Hotel B uses a mix of fossil and renewable energies.

The comparison of Hotel A and Hotel B is thus suitable to investigate the performance of these two hotels. The Water Demand indicator shows similar values for the three hotels as mentioned. The Abiotic Material Intensity instead, despite closer is worst for Hotel B than Hotel A and in effect the former is larger than the second. The most relevant differences might be attributed to the different energy mix used and thus to the different environmental support required by the two hotels. The comparison between the emissions and impact categories of the three hotels (Figure 25) suggests similar reasoning.

4.2.2.3 Operation activities

To better understand the differences among the three hotels observed comparing the intensive indicators (Figure 24), the environmental performances of the hotels have been compared according to the three main operation activities. Figure 26 shows the comparison among the three hotels while Figure 27 shows the comparison between Hotel A and Hotel B. As established, the environmental performance of Hotel C is not fully comparable to the other two hotels. However, also in this analysis the higher environmental costs generated by Hotel C are confirmed, particularly those associated to the building operation activity. The comparison between Hotel A and Hotel B (Figure 27) clearly suggests that Hotel B has a better environmental performance than Hotel. Thus, per overnight stay, Hotel B requires a smaller environmental support that Hotel A. The most similar indicators are those related to Food activities. The economic expenditure and the environmental impacts generated by Food operation activity per overnight stay are similar in both hotels. The

Management operation instead is largely different and this might be attributed to the differences in the energy mix of the two hotels.

Figure 26. Comparison among the three hotels by operation activities.

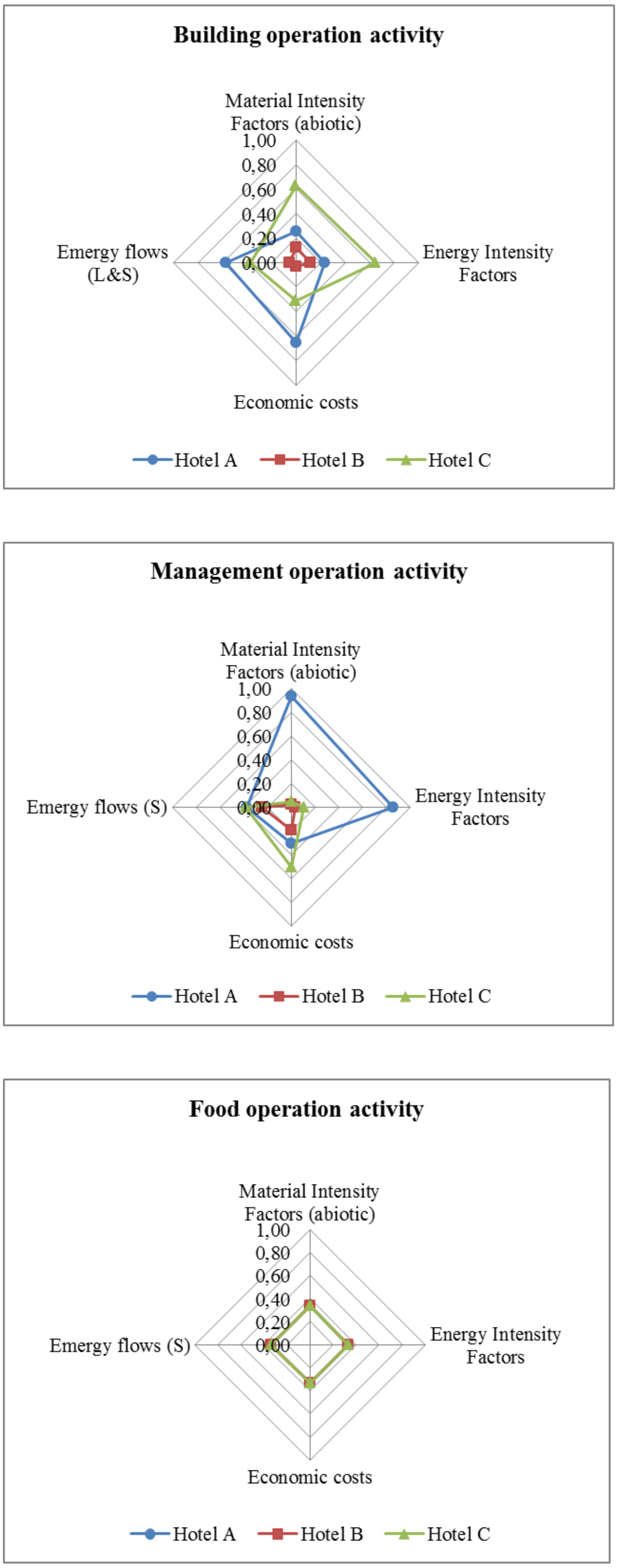
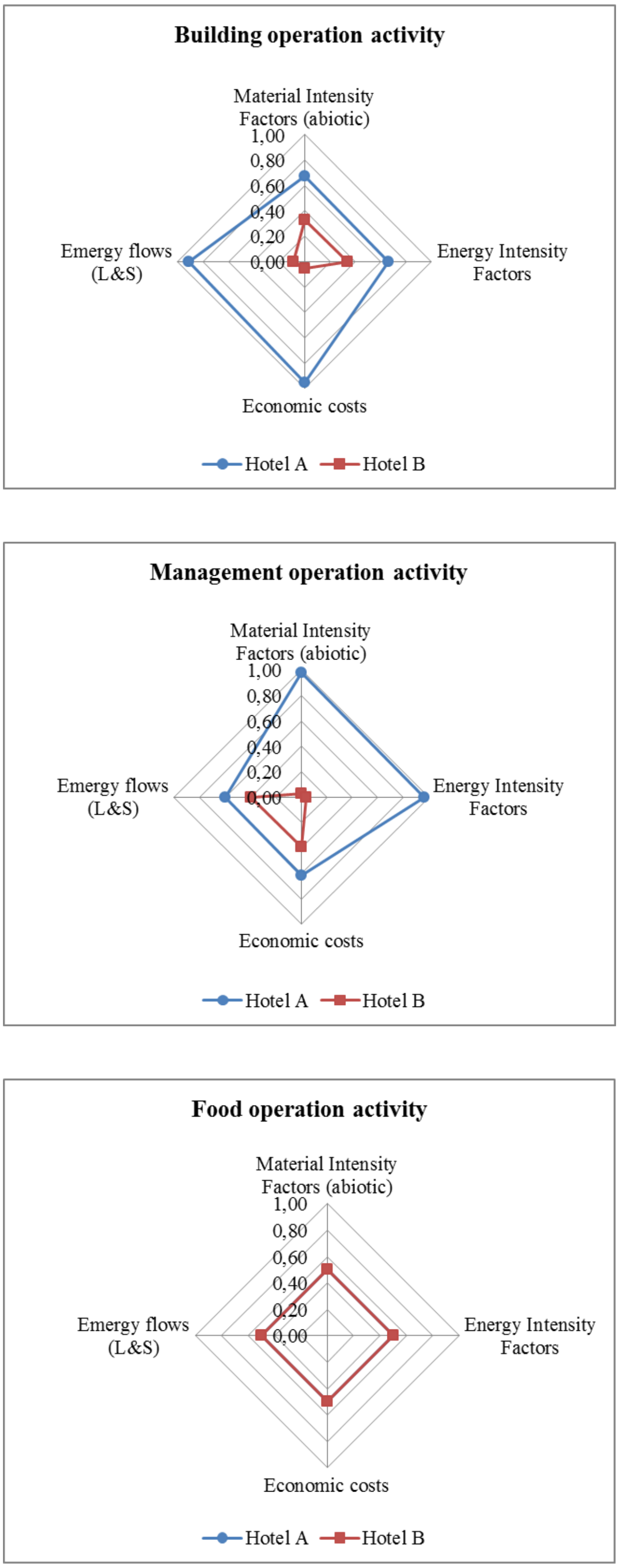


Figure 27. Comparison between Hotel A and B by operation activities.



Source: own elaboration.

4.2.3 Analysis of hotels' waste flows

Waste flows were outside the system boundaries of this analysis. However, tourism activities normally generate large amount of waste. In UK for instance, the waste produced by hotels are estimated about 289700 tons per year, in Ireland, the organic waste produced by hotels (including other commercial business such as restaurants) are estimated about 350000 tons annually (Greenhotelier, 2014). Moreover, the waste flows generated by tourists are generally larger than that of local population. In Venice, the waste generation per inhabitant in 2006 was 756.47 kg/yr while the waste generation per inhabitant equivalent was 699.51 kg/yr. This large discrepancy might be attributed to the tourist pressure on Venice. In effects, this hypothesis is confirmed by analyzing the waste generation of other municipality in Veneto region where the tourist pressure is also high. Municipalities in Garda Lake and mountain areas generate larger amount of waste per inhabitant equivalent than per inhabitant (see Table 25).

Table 25. Waste generated by different municipalities in Veneto region.

Municipality (year 2006)	per inhabitant (kg/yr)	per inhabitant eq. (kg/yr)
A group of urban cities		
Venezia	756.47	699.51
Belluno	383.93	370.98
Verona	551.18	542.64
Vicenza	623.71	617.56
Garda Lake area		
Malcesine	1129.27	672.32
Garda	1129.07	719.67
Mountain area		
Borca di Cadore	578.54	448.38
Cortina d'Ampezzo	1180.96	802.38
Alleghe	631.87	475.27
Falcade	725.66	495.96
Zoldo Alto	794.58	564.17

Source: own elaboration from ARPA Veneto (ARPA Veneto, 2015).

Malcesine, Garda, and Cortina d'Ampezzo exhibite the largest discrepancies and in effect, these municipalities have a high tourist pressure (0.7, 0.62, and 0.52 respectively). The generation of waste per inhabitant equivalent is about 1.84 kg/day for Malcesine, 1.97 kg/per day for Garda, and 2.2 kg/day per Cortina d'Ampezzo (ARPA Veneto, 2015).

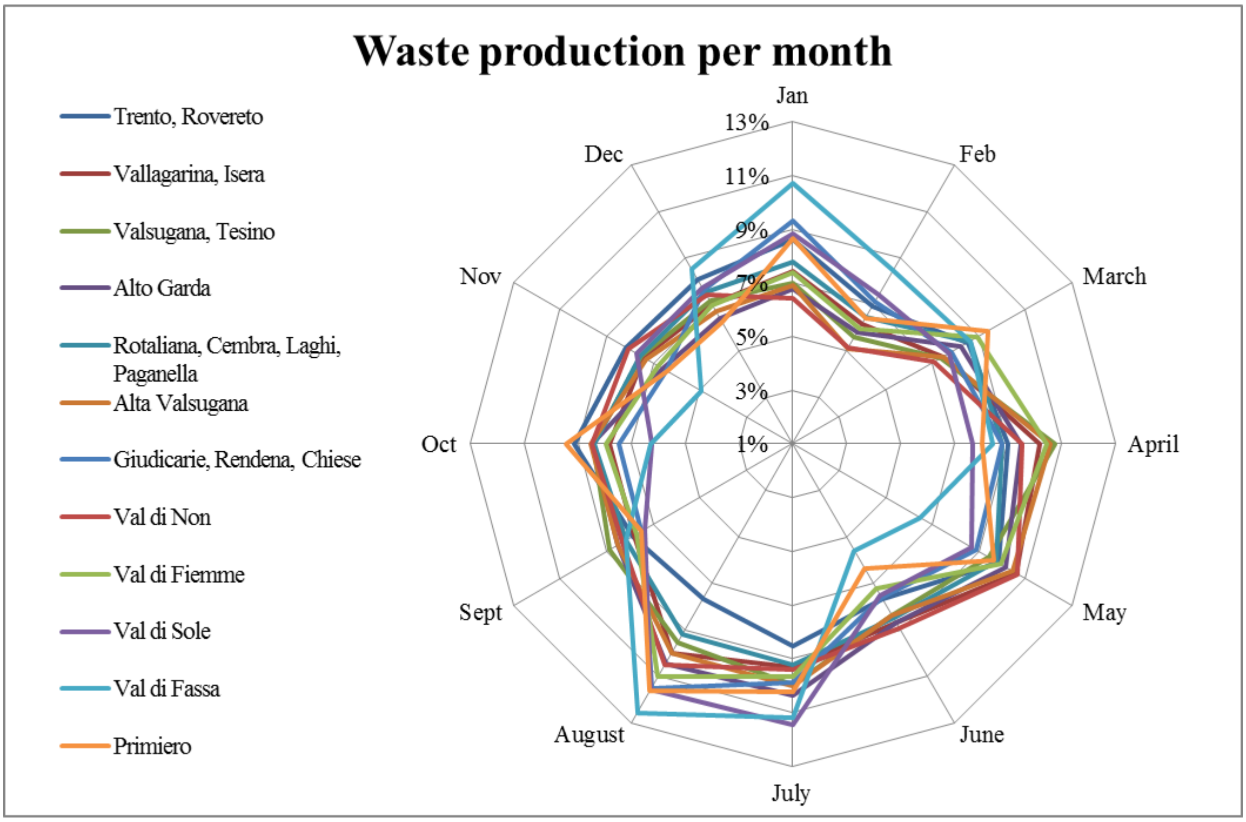
Given the relevance of waste generation to tourism development, the waste flows generated by the three hotels have been analyzed and qualitatively compared with those of the Province of Trento and other Italian regions. The waste flows generated by the Province of Trento are exhibited in Table 26. These flows (expressed per month) suggest a pattern of waste generation according to tourist season. The two main peaks of waste generation are in January and August as showed in Figure 28. Dividing urban areas (Figure 29) from tourist areas (Figure 30) pattern is confirmed. In urban areas with moderate tourist flows (i.e. the Adige Valley which include the city of Trento accounted over 470,000 overnight stay in hotels in 2013 while the Fassa and Fiemme Valley, in the same year, accounted respectively over 2,260,000 and 892,000 hotel overnight stays), the waste flows do not registered such peaks in August and January. The waste flows are almost constant during a year, since there might be a small difference between the amount of inhabitants and inhabitant's equivalent (which instead include also overnight stays). In tourist areas, the peaks of waste flows are concentrated during the tourist season. In effect, the tourist arrivals are concentrated in August and July (summer season), and January, February, March (winter season). The largest amount of waste flows is mainly generated in those peak season's months. On the contrary, low season's months are characterized by smaller amount waste flows such as in September, October, November, or June (Figure 30).

Table 26. Waste flows in the Province of Trento by month.

Waste production per month, year 2013 (%)	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
Province	8	6	8	9	10	8	10	10	8	8	7	7
Trento, Rovereto	9	7	9	9	10	8	9	8	8	9	8	8
Vallagarina, Isera	7	6	7	10	11	9	9	10	8	8	7	7
Valsugana, Tesino	7	6	7	11	9	8	10	10	9	8	8	7
Alto Garda	7	6	8	9	10	9	10	10	9	8	7	6
Rotaliana, Cembra, Laghi, Paganella	8	6	9	9	10	8	9	9	8	8	8	8
Alta Valsugana	7	5	7	11	10	8	10	10	9	9	7	7
Giudicarie, Rendena, Chiese	9	7	8	9	9	8	10	12	8	7	6	8
Val di Non	6	5	7	10	11	9	9	11	8	8	8	7
Val di Fiemme	7	6	9	10	10	7	10	11	8	8	7	7
Val di Sole	9	7	8	8	9	8	11	12	7	6	8	8
Val di Fassa	11	8	9	8	6	6	11	13	8	6	5	9
Primiero	9	6	9	8	10	6	10	12	8	9	6	6

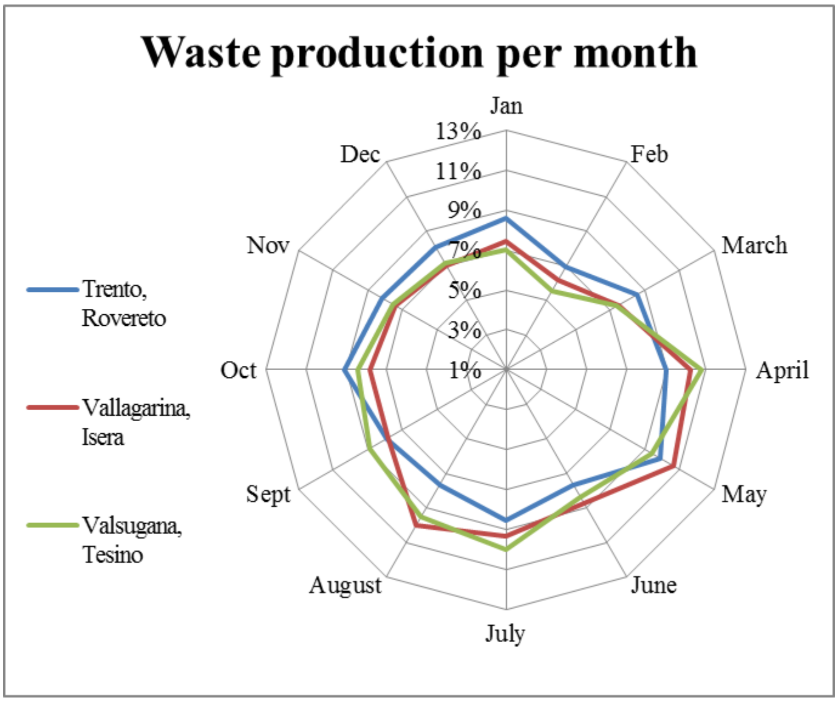
Source: own elaboration from PAT (PAT, 2014).

Figure 28. Waste production per month in the Province of Trento.
Percentage values, year 2013.



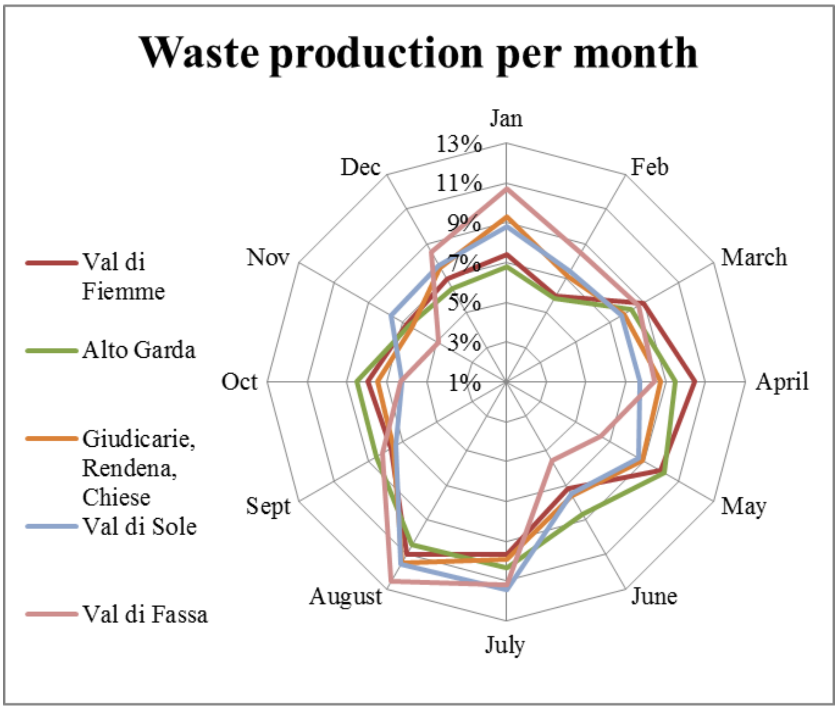
Source: own elaboration from PAT (PAT, 2014).

Figure 29. Waste production per month in main urban areas of the Province of Trento.
Percentage values, year 2013.



Source: own elaboration from PAT (PAT, 2014).

Figure 30. Waste production per month in main tourist areas of the Province of Trento.
Percentage values, year 2013.



Source: own elaboration from PAT (PAT, 2014).

The waste production of the three hotels is showed in absolute values in Table 27.a and in percentage values in Figure 31. Data are related to five main waste categories: plastic, paper, organic, glass, and solid waste. Table 27.b shows the waste production per overnight stay, per working day, and per room per working days. The working days are 200 for hotel A and hotel C and 260 per hotel B.

Table 27. Waste flows of Hotel A, B, C by categories.
Table 27.a. Waste flows by categories, year 2013.

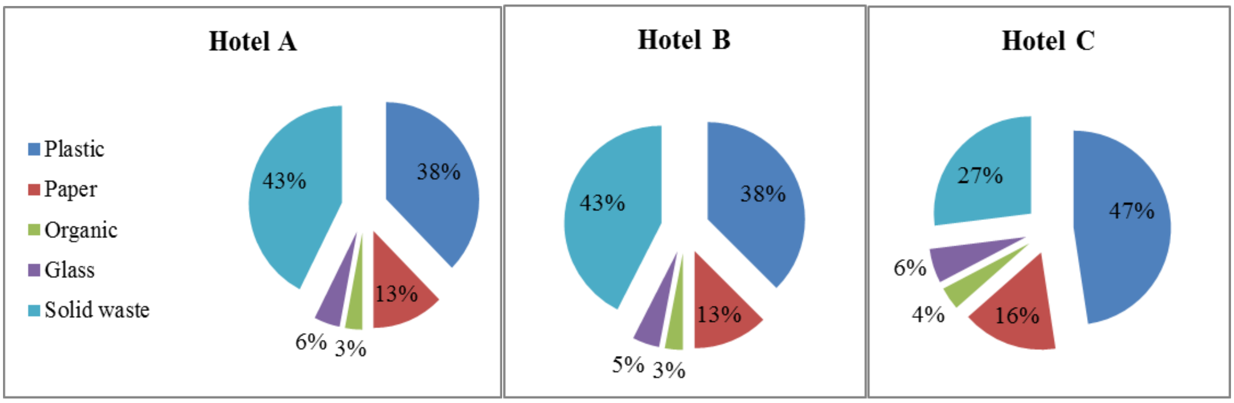
Waste (kg/yr)	Hotel A	Hotel B	Hotel C
Plastic (light packaging)	12000	23400	6000
Paper	4000	7800	2000
Organic	960	1872	480
Glass	1440	2808	720
Solid waste	13600	26520	3400
Total	32000	62400	12600

Source: own elaboration.

Table 27.b. Waste flows by a group of indicators, year 2013.

Waste production (kg)	Hotel A	Hotel B	Hotel C
per overnight stay	3.10	2.75	8.40
per working day	160.00	240.00	63.00
per room/per working day	3.81	4.80	9.00

Figure 31. Waste generated by Hotel A, B, C by category fraction.
Percentage values, year 2013.



Source: own elaboration.

The waste generation in the Province of Trento is in line with other Italian regions. However, it is worth to underline than the population density in Trentino is smaller than that of the other Italian regions considered here. This element, might lead to assume that similar waste generation per inhabitant eq. are due *a compensation* of density population attributed to tourists overnight stays. This reasoning provides an explanation for the waste generation of the hotels of the case study. These hotels generate larger amount of waste compared to the Province of Trento and other Italian regions.

Table 28. Waste generated per inhabitant equivalent in different areas of Italy.
All data are referred to year 2013. Inhab. eq. is the abbreviation for inhabitant equivalent.
In the Province of Trento, Giudicare included Rendena and Chiese areas. The waste referred to Hotel A, B and C are expressed per overnight stay (night).

Table 28.a. Italian regions.

Italian regions	Waste per inhab. eq	
	kg/yr	kg/day
Piemonte	452	1.24
Valle d'Aosta	565	1.55
Lombardia	461	1.26
Trentino Alto Adige	471	1.29
Veneto	449	1.23
Friuli Venezia Giulia	444	1.22
Liguria	559	1.53
Emilia Romagna	625	1.71
Italy	487	1.33

Source: own elaboration from ISPRA (ISPRA, 2014).

Table 28.b. Province of Trento.

Province of Trento	Waste per inhab. eq.	
	kg/yr	kg/day
Val di Fiemme	419.8	1.15
Giudicarie	394.9	1.08
Province	429.4	1.18

Source: own elaboration from PAT (PAT, 2014).

Table 28.c. Hotel A, B, C.

Hotels of the case study	kg per night
Hotel A	3.10
Hotel B	2.75
Hotel C	8.40

Source: own elaboration.

5 SUMMARY AND CONCLUDING REMARKS

This thesis investigated the environmental management, the environmental performance and the environmental sustainability of selected SMHEs located in the Province of Trento. Management theory underlines the key role played by environmental resources as inputs to economic processes. At the same time, the limited availability of these environmental resources sets constrains to firms operations. Despite such relevance, the way firm approaches the environmental management, particularly that of SMEs generally characterized by a weak management, is not fully explored. Traditionally, the environmental management was mostly studied approaching manufacturing industry since they were recognized as responsible for the largest environmental impacts. Recently, such studies applied also to service industry. The recognition of service enterprises as "silent destroyer" (Hutchinson, 1996) of the environment drove the enlargement of such investigations to service enterprises and hotel sectors. However, while corporate firms received the largest attention, SMHEs were under investigated.

Due to their importance in the tourism sector; their economic impact; their energy consumption and their environmental impacts, and the limited number of studies on the Small and Medium-sized Hotel (SMHEs), this study focused on the analysis of such hotel enterprises. The Province of Trento was selected because of the relevance of tourism not only to the local economy, but also to the national and Alpine level. The Province of Trento is one the most important Alpine destinations: local tourism is mainly composed by SMEs, and SMHEs are predominantly compared to hotel-chains. For these reasons, SMHEs in the Province of Trento were selected as case study for this analysis.

The first part of the thesis aimed to answer to the following research questions:

1. To what extent the environmental management of corporate enterprises can be applied to SMHEs?

2. Which are the main environmental practices adopted by SMHEs?
3. Can typology and extent in the adoption of environmental management practices be used as criteria to cluster SMHEs?
4. Which is the role of enterprise characteristics (size, age, affiliation to hotel chains) in the adoption of environmental practices in SMHEs?
5. Which are the perceptions and motivations of SMHEs for implementing environmentally friendly management policy?

Given the lack of data on the environmental management of these SMHEs, primary data were collected through a survey based on an online questionnaire. The main research areas enclosed in the questionnaire were five: the environmental strategy implemented by hotels (considering operational, communicational and organizational practices); the hotel and management profiles; the determinant factors affecting the environmental strategy; the environmental commitment of hotel managers; the access of these SMHEs to local subsidies to finance the implementation of green practices (see Figure 4, page 41). A preliminary description of respondents and the final dataset were presented along with an analysis of the environmental practices implemented by these enterprises. The final dataset consists of 247 hotels. Then, a set of multivariate analyses was performed to answer to the research questions.

The framework applied to analyze the environmental management of these SMHEs was the one proposed in literature for corporate companies (González-Benito and González-Benito, 2006). The Principal Component Analysis was applied to investigate such framework. This analysis revealed only partially suitability of this framework for SMHEs. Such enterprises do adopt practices for the environmental management but a clear division of these practices by firm function – operative, communication and organization – does not exist. The predominant reasons for such results are related to specific characteristics of these enterprises. Thus, the role of these characteristics – size, age, affiliation to hotel chains – in the adoption of environmental practices in SMHEs was investigated. A K-means Cluster Analysis was performed to detect potential clusters in the adoption of environmental practices and a Multiple Correspondence Analysis was carried out to verify the association among the resulting clusters and the potential determinants to the environmental management (size, age, and affiliation to hotel chains). The resulting clusters were five.

Clusters 1 and 4 were the best performers from an environmental management viewpoint since they adopted extensively practices from all the three groups. Cluster 5 was the worst performer scoring low in each of the three groups of practices. Cluster 2 performed almost homogenously across the three groups of practices even though there were not large percentages of adoption in any group of practices. Cluster 3 was completely focused on the implementation of infrastructural practices and in effect, investigation of age facility showed that hotels grouped in this cluster are older (built on average before 1980) and could require a large number of energy retrofitting activities. This could explain also the low adoption of communication, organizational and planning practices. According to this analysis, an effort of ranking from best to worst performing clusters of hotel was the following: cluster 4, cluster 1, cluster 3, cluster 2 and cluster 5. The MCA suggested an association between clusters and determinants according to the level of adoption of environmental practices and the characteristics owned by the hotel enterprises. The graphical representation of the MCA (Figure 11, page 96) allocated from worst to best performing the hotel clusters along the horizontal axis (from left to right). The vertical axis was associated to firm's characteristics: smaller-sized, older, and independent determinants were positively associated to the vertical axis. Then, there was evidence of association also among hotels' clusters and determinants. In effect, the best performing clusters, from an environmental management viewpoint, were associated with certain firms' characteristics: larger-sized, younger facilities, affiliated to chain hotels (see clusters 1 and 4 in Figure 11). Hotels in best performing clusters might have more opportunities to innovate thanks to spreading processes through the hotel chains which act as drivers for such innovative behaviors. The worst performing clusters were instead associated with smaller-sized, older, and independent-managed facility's features (see cluster 5 in Figure 11). Then, there were two clusters, 2 and 3, for which these association was evident but less regular.

Finally, a descriptive analysis of the motivations and perceptions of SMHEs for implementing environmentally-friendly management policy was performed. It revealed no surprised compared to the literature on the topic. Hotel managers stated that the most important motivations to *going green* are cost reduction and environmental responsibility. The analysis of the perceptions suggested that *to going green* is mostly important to attract foreign guests (which are the most sensitive to green practices compared to the Italian ones) and to reduce cost of energy.

The second part of this thesis aimed to explore the environmental performance and sustainability of SMHEs answering to the following research questions:

6. How to account for environmental costs (material, energy, and emergy demands) and impacts (waste and emissions) generated by selected SMHEs?
7. Can environmental management be supported by environmental accounting to provide a more comprehensive understanding of SMHEs' features?

Three hotels (A, B, C) were selected to perform this analysis. As mentioned, the complexity of the multi-method and multicriteria assessment framework, the considerable amount and level of detail needed for the data, and the unavailability of similar studies, made the three hotels a sufficient number of facilities to explore the topic. The analysis was performed by a multicriteria assessment which includes different methods capable of accounting for all flows of materials, energy, resources (both renewables and non-renewables) and money (both labor and economic services). This multicriteria assessment includes Material Flow Accounting, Gross Energy Requirement, Emergy Accounting, Emission Accounting and impact categories.

In effect, since this is a recent field of application and a limited number of studies are available, the results of such environmental performance cannot be compared to other studies relevant to the tourism sector. In addition, such studies do not refer to same type of system. Thus, it is not possible to assess the environmental performance of the three hotels compared to other hotels in neither similar geographical area nor elsewhere. The results of such analyses are original. They represent a contribution to the literature since they provide indicators and intensity factors that can be used in future studies related to hotel systems and tourism sector. Moreover, these results are relevant to decision making processes involving tourism and hospitality development. Policy makers might obtain valuable tools and information in support of medium and long-term planning. This multi-criteria and multi-scale framework provides a comprehensive set of indicators to understand the environmental costs and impacts generated by the investigated hotels.

The extensive indicators, calculated on the entire hotel system, reflect environmental costs and impacts accounting for the total amount of overnight stays per hotel. Hotel C, hosting a smaller amount of tourists compared to Hotel A and B, has a restrained environmental cost compared to other two hotels. However, exploring the environmental performance of Hotel A and B, there are additional considerations. Hotel A and B have different environmental performances. Analyzing the environmental costs and impacts generated per night by Hotel A and B, there are relevant differences particularly to Oil equivalent intensity and UEV indicators. Both indicators are larger in Hotel A than Hotel B. Such differences might be attributed to the fact that Hotel A uses fossil energy which requires a larger environmental support than renewable energies; Hotel B uses a mix of fossil and renewable energies which requires a smaller environmental support. These results suggest that the environmental support required to sustain an overnight stay can be considerably different and thus the related environmental costs and impacts associated. Such information might be taken into account in decision-making processes and development plan involving hotel infrastructures and tourism development. Ensuring smaller environmental costs and impacts per night in major tourist destinations, as it is the Province of Trento, establishes a more long-term sustainability not only in hotel industry management but also in local environmental management. To support the implementation of renewable energy sources is beneficial in term of less environmental costs and impacts: in other words, each overnight stay is cheaper in terms of efforts done by the geobiosphere when using renewable energies compared to fossil energy alternative.

The integration of the analyses related to the environmental management can be supported by the comprehensive set of indicators attained through the environmental accounting. In the first part of the thesis, significant insights on the practices and determinants affecting the environmental management of SMHEs are provided. Such results can be effectively supported by the set of indicators provided by the multicriteria assessment framework used to investigate the environmental performance and sustainability of these SMHEs. In effect, the managerial analysis provided an understanding about the environmental proactivity, the type and extent in the adoption of environmental practices, the determinants of environmental management. However, such analysis did not provide a measure of the environmental performance of these SMHEs. Integrating both analyses, through a multicriteria perspective, allowed obtaining a framework on the managerial approach to environmental practices' implementation along with an assessment of the environmental costs and impacts encompassing all types of inputs invested by the enterprises. The effectiveness of the environmental management of an enterprise can be assessed considering the specific set of environmental practices evaluated through this multicriteria perspective. In this manner, managerial decisions and policy development can take into consideration also environmental costs and impacts. However, such environmental accounting does neither exclude money flows nor renewables resources since the Emergy Accounting allows considering all type of input flows, included money flows. This set of information is crucial both at firm level and policy maker level. The firm's decision makers can take more informative decisions looking at such comprehensive set of indicators complementing socio-economic information. The policy makers can benefit from this information to long-term planning of tourism development strategies. Be aware about the environmental management and the environmental performance of SMHEs can guide policy makers in designing strategies that aim to reduce the environmental costs and impacts of that sector. For instance, recommendations, legal requirements, as well as public subsidies to promote the adoption of green practices can be reviewed to ensure that only those practices generating less costs and impacts for the environment are financed through public funds. In a long-term planning perspective, more environmental efficient systems should be preferred to less efficient alternative to ensure the sustainability and the inter-generational equity in managing the environment. Both analyses, that of the environmental management and the environmental performance and sustainability, are crucial and their integration is largely informative. The environmental management illustrates how firms behave and take decisions on different issues. The environmental performance represents a measure of such behaviors and decisions translated into a supply side qualitative terms. In fact, this multi-method assessment framework, including the Emergy Accounting, allows considering all types of input resources, labor and services, providing a measure of the sustainability of the system. Thus, the question of whether a multicriteria assessment framework integrating environmental management and environmental accounting can effectively support both local managers and policy makers committed to develop sustainable management practices and green economy options, could find an affirmative answer. However, this is a single study, and further research is needed to extensively explore such these important issues related to the industry of tourism and its environmental performance and sustainability.

APPENDICES

Appendix A. Questionnaire

1. Hotel profile

1.1 Please specify the job position of the respondent.

Owner/Manager	
Relatives	
Administrative clerk	
Other	

1.2 Please specify the number of stars of your building.

One	
Two	
Three	
Four	
Five	
Other	

1.3 Please specify the municipality where is located your building. List of the 217 municipalities in the Province of Trento

1.4 Please specify the period the building has been built.

Before 1900	
Between 1900 and 1945	
Between 1946 and 1960	
Between 1961 and 1980	
Between 1981 and 2000	
After 2000	
Don't know/No answer	

1.5 Please specify the energy label assigned to the building.

A+/A	
B+/B	
C+/C	
D	
E	
F	
G	
In acquisition	
Don't know/No answer	

1.6 Please specify the period of the last energy efficient refurbished of the building (i.e. thermal insulation, double glazed windows).

Before 1980	
Between 1980 and 2000	
Between 2001 and 2010	
After 2010	
Never undertaken an energy efficient refurbished of the building	
Don't know/No answer	

1.7 Please shortly specify the type of energy efficient refurbished of the building.

1.8 Please specify the number of rooms in the building. In the box, please do not type any commas and dots.

1.9 Please specify the number of beds in the building. In the box, please do not type any commas and dots.

1.10 Please specify the surface of the building in m2. In the box, please do not type any commas and dots.

1.11 Please specify when the building is closed (closing time for at least 15 days per month).

Never closed (always open)	
January	
February	
March	
April	
May	
June	
July	
August	
September	
October	
November	
December	

1.12 Please specify if these services are available in the building.

	Yes	No
Restaurant		
Indoor swimming-pool		
Outdoor swimming-pool		
Parking		
Wellness center		
Laundry		

Freezer area/stock		

2. Manager profile

2.1 Please specify any possible form of affiliation of the building.

None (Independent)	
Affiliation to hotel chains	
Affiliation to hotel group/brand	
Other	

2.2 The manager is also the owner of the building?

Yes	
No	
Don’t know/No answer	

2.3 Please specify the age group of the building manager.

Less than 30 years old	
Between 30 and 45 years old	
Between 46 and 60 years old	
Between 61 and 75 years old	
More than 75 years old	

2.4 Please specify the level of education of the building manager.

Secondary school	
High school	
Qualification	
Degree	
Other	

2.5 In the last 5 years, the manager attended at least one training course?

Yes	
No	

2.6 Please specify the type of training course attended. Open answer.

2.7 Please specify if the building manager is daughter/son of hotel or accommodation service managers.

Yes	
No	

2.8 Please specify if the building manager is involved in the following activities.

	Yes	No
Management of other hospitality facilities (agritur, B&B, apartments)		
Management of other enterprises (restaurant, bar, ski lift)		
Institutional roles (major, assessor, local council member)		
Other job (member of the tourism board, leisure associations)		

2.9 Please specify if the relatives of the building manager are involved in the following activities.

	Yes	No
Management of other hospitality facilities (agritur, B&B, apartments)		
Management of other enterprises (restaurant, bar, ski lift)		
Institutional roles (major, assessor, local council member)		
Other job (member of the tourism board, leisure associations)		

3. Market trend and target client

3.1 Please specify the dominant target tourist of the building.

Family with children	
Young couple	
Young	
Single tourist	
Mature couple	
Elderly tourists	
Other	

3.2 Please specify the tourist origin.

North of Italy	
Center of Italy	
South of Italy	
Europe	
Russia	
Other	

3.3 Please specify a maximum of three European nations.

Austria	
France/Belgium/Luxembourg/Holland	
Denmark/Scandinavian countries	
Germany	
Poland	
Portugal/Spain	
UK	
Czech Republic/Slovakia	
Other European nations	

3.4 Please specify the type of holiday of the dominant target tourist.

Holiday	
Business tourism	
None in particular	

3.5 Please specify the dominant motivation for holiday.

Snow	
Nature	
Relax	
Thermal	
Rural tourism	

3.6 Please specify if the building subscribes any brand product.

Yes	
No	

3.7 Please specify which type of brand product it is.

Giocovacanza – hotels for families
Adamello Brenta Park Quality Hotels
Trentino Charme
Vita Nova Trentino Wellness Hotel & Resort
Dolomiti Walking Hotel
Motorbike Holidays
Other

4. Staff management

4.1 Please specify, for the summer season, the number of family workers. Please specify zero (0) if there is any family workers during the summer season. In the box, please do not type any commas and dots.

4.2 Please specify, for the summer season, the number of employees. Please specify zero (0) if there is any family workers during the summer season. In the box, please do not type any commas and dots.

4.3 Please specify, for the summer season, the percentage (%) of rooms occupancy rate.

Between 100 and 80%	Between 79 and 60%	Between 59 and 40%	Between 39 and 20%	Between 19 and 0%

4.4 Please specify, for the winter season, the number of family workers. Please specify zero (0) if there is any family workers during the summer season. In the box, please do not type any commas and dots.

4.5 Please specify, for the winter season, the number of employees. Please specify zero (0) if there is any family workers during the summer season. In the box, please do not type any commas and dots.

4.6 Please specify, for the winter season, the percentage (%) of rooms occupancy rate.

Between 100 and 80%	Between 79 and 60%	Between 59 and 40%	Between 39 and 20%	Between 19 and 0%

5. Environmental strategy

5.1 Please specify the amount of rooms equipped with the following devices.

	All	More than half	Half	Less than half	None
Flow restrictor					
Automatic shut-off (timer) for flow					
Heating/conditioning valve (limit control)					
High efficient electric light bulbs					
Automated lighting control					
Room badge for electrical devices					
Green appliances (energy label A)					
Insulated glazing					
Solar shading system					

5.2 Please specify if in the building there are other pro-environmental activities.

	Yes	No
Rainwater harvesting		
Graywater reuse		
Waste management (recycling)		

5.3 Please specify if in the building there are the following devices.

	Yes	No
Photovoltaic panels		
Solar thermal		
Heat pump		
Condensing boiler		
Thermal insulation		
District heating		
Cogeneration		
Methane/LPG boiler		
Biomass boiler		
Multi-fuel boiler		
Fossil fuel boiler		

6. Communication and marketing activities

6.1 Thinking to the communication and marketing activities of the building, please specify if there are the following actions.

	Yes	No
Communication of green activities and/or behavior undertaken by the firm		
Sponsorship/organization of green events		
Report and publications on green activities and/or behavior undertaken by the firm		
Subscription to environmental labelling programme		

6.2 If the firm subscribes any environmental labelling programme, please specify the type.

Ecolabel	
Emas	
Other	

6.3 Are these labels clearly mentioned in the communication and marketing strategy of the building?

Yes	
No	

7. Organizational and planning activities

7.1 Thinking to the services provided in the building rooms, please specify the frequency in the introduction of these activities.

	Always	Often	Sometimes	Never	Don’t know/No answer
Linen change upon guest request					
Soap dispenser					
Courtesy kit					
Environmentally-friendly handbook					

7.2 Thinking to the organizational and planning activities of the building, please specify if these activities are undertaken.

	Yes	No
Monitoring/control of energy consumption		
Set objectives and strategy to environmental		

8. Environmental commitment

8.1 In the choice of implementing green tools and strategy which importance would you allocate, in a scale where 7= very important and 1= not important at all, to the following motivations.

	7	6	5	4	3	2	1	Don't know/No answer
Compliance to legislative requirements								
Institutional vision (mission) sharing								
Pressure from local stakeholders, clients								
Competitive advantage								
Support to marketing strategy								
Cost reduction								
Responsibility toward local environment								

8.2 In the choice of implementing green tools and strategy please specify the degree of accordance in a scale where 7= very important and 1= not important at all, to the following sentences.

	7	6	5	4	3	2	1	Don't know/No answer
Green tools and strategy determine market advantages (with tour operator) and better relations with local stakeholders								
Green tools and strategy are very appreciated by Italian visitors								
Green tools and strategy are very appreciated by foreign visitors								
Green tools and strategy are attractive for high spending power visitors								
Green tools and strategy allow to reduce energy costs								
Green tools and strategy entail costs which do not overcome the benefits produced								
Green tools and strategy contribute to a positive business brand								

9. Subsides

9.1 Did you benefit from subsides from the Autonomous Province of Trento for the energy efficiency refurbish of the building in the last five years?

Yes	
No	

9.2 These incentives were/ are allocated to the implementation of tools and strategy to support energy efficiency and saving? (legislations 14/1980 and 16/2007)?

Yes	
No	

9.3 Please specify the type of investments implemented.

9.4 Please specify the year of subsides request accepted.

9.5 Are there further investment that you would like to perform?

Yes	
No	

9.6 Which are these types of investment?

9.7 If you did receive these subsides, are you willing to ask for them in the future?

Yes	
No	

10. Energy consumption

10.1 Please specify for the 2013 the consumption, in EURO, of the following consumers. Where possible, please refer to 2013 budget. In the box, please do not type any commas and dots (i.e. ten thousand euro=10000).

Electricity € ____________

Water €____________

10.2 Please specify for the 2013 the consumption, in EURO, of the following consumer. Where possible, please refer to 2013 budget. In the box, please do not type any commas and dots (i.e. ten thousand euro=10000).

Methane/LPG (liquefied petroleum gas) € ___________

10.3 Please specify for the 2013 the consumption, in EURO, of the following consumer. Where possible, please refer to 2013 budget. In the box, please do not type any commas and dots (i.e. ten thousand euro=10000).

Fossil fuel (stationary combustion from)/Hydrocarbons(Gas oil, Kerosene) € ___________

10.4 Please specify for the 2013 the consumption, in EURO, of the following consumer. Where possible, please refer to 2013 budget. In the box, please do not type any commas and dots (i.e. ten thousand euro=10000).

Biomass € ____________

10.5 Please specify for the 2013 the auto-production of energy in kwh consumption. In the box, please do not type any commas and dots.

11. Questionnaire evaluation

11.1 Thinking to the present questionnaire, how do you evaluate it according the following adjectives in a scale from 7= very and 1= not at all?

	7	6	5	4	3	2	1	Don't know/No answer
Interesting								
Difficult to understand								
Long								

11.2 Please refer any comments or suggests you would like to express about this questionnaire.

Appendix B. Sample representativeness

Proportionate stratification by type of accommodation on the full set of responses (351 observations).

Type	Sample: 351 obs	PS - ASAT population	PS – OA PAT population	PS – Stat service population
Hotels	297	291	288	257
Garnì-hotel	41	41	45	40
RTA	10	15	16	16
Hotel-village	3	2	2	2
Not Classifiable (NC)		2	0	0
Total	351	351	351	315

Source: own elaboration.

Proportionate stratification by geographical location of accommodation on the full set of responses (351 observations).

Geographical location	Sample: 351 obs	PS - ASAT population	PS – OA PAT population	PS – Stat service population
Fassa valley	71	70	66	59
Alta Valsugana and Bersntol	28	26	28	25
Garda and Ledro	38	44	45	39
Paganella	29	31	29	26
Val di Non	8	11	14	12
Vallagarina	7	8	9	8
Laghi	2	2	2	2
Cembra valley	3	2	2	2
Sole valley	44	35	34	30
Giudicarie	43	44	46	42
Primiero	18	21	21	19
Rotaliana-Kőnigsberg	3	3	4	3
Fiemme valley	31	23	22	20
Valsugana and Tesino	6	5	6	5
Altipiani Cimbri	10	15	17	15
Adige valley	10	9	8	8
NC		2	0	0
Total	351	351	351	315

Source: own elaboration.

Proportionate stratification by tourism board of accommodation on the full set of responses (351 observations).

Tourism board	Sample: 351 obs	PS - ASAT population	PS – OA PAT population	PS – Stat service population
A.P.T. Altipiani Folgaria Lavarone Luserna	10	15	17	15
A.P.T. Ambito Trento, Monte Bondone, Valle dei Laghi	12	10	11	10
A.P.T. Altopiano di Pinè, Valle di Cembra	6	8	8	7
A.P.T. Rovereto, Vallagarina	7	8	9	8
A.P.T. Dolomiti di Brenta, Altopiano Paganella	29	31	29	26
A.P.T. Garda Trentino	34	38	37	33
A.P.T. Madonna di Campiglio, Pinzolo, Val Rendena	29	26	31	28
A.P.T. S. Martino di Castrozza, Primiero	18	21	21	19
A.P.T. Terme Comano, Dolomiti di Brenta	11	8	7	6
A.P.T. Valle di Fassa	71	70	66	59
A.P.T. Valle di Fiemme	31	23	22	20
A.P.T. Valle di Non	8	11	14	12
A.P.T. Valli di Sole, Pejo, Rabbi	44	35	34	30
A.P.T. Valsugana Tesino	29	23	24	21
Other areas	12	24	22	20
Total	351	351	351	315

Source: own elaboration.

Proportionate stratification by mountain level of accommodation on the full set of responses (351 observations).

Mountain level	Sample: 351 obs	PS - ASAT population	PS – OA PAT population	PS – Stat service population
High	2	1	2	Not Available (NA)
Medium	182	185	183	NA
Low	167	163	166	NA
NC		2	0	NA
Total	351	351	351	NA

Source: own elaboration.

Proportionate stratification by type of accommodation on the full set of completed responses (217 observations).

Type	Sample: 217 obs	PS - ASAT population	PS – OA PAT population	PS – Stat service population
Hotels	185	180	178	177
Garnì-hotel	25	25	28	28
RTA	5	9	10	11
Hotel-village	2	1	1	1
NC		1	0	0
Total	217	217	217	217

Source: own elaboration.

Proportionate stratification by geographical location of accommodation on the full set of completed responses (217 observations).

Geographical location	Sample: 217 obs	PS - ASAT population	PS – OA PAT population	PS – Stat service population
Fassa valley	44	43	41	41
Alta Valsugana and Bersntol	20	16	17	17
Garda and Ledro	24	27	28	27
Paganella	17	19	18	18
Val di Non	5	7	9	9
Vallagarina	4	5	6	6
Laghi	1	1	1	2
Cembra valley	2	1	1	1
Sole valley	29	22	21	20
Giudicarie	27	27	28	29
Primiero	9	13	13	13
Rotaliana-Kőnigsberg	1	2	2	2
Fiemme valley	17	14	14	13
Valsugana and Tesino	5	3	3	4
Altipiani Cimbri	3	9	11	11
Adige valley	9	5	5	6
NA		1	0	0
Total	217	217	217	217

Source: own elaboration.

Proportionate stratification by tourism board of the accommodation on the full set of completed responses (217 observations).

Tourism board	Sample: 217 obs	PS - ASAT population	PS – OA PAT population	PS – Stat service population
A.P.T. Altipiani Folgaria Lavarone Luserna	3	9	11	11
A.P.T. Ambito Trento, Monte Bondone, Valle dei Laghi	10	6	7	7
A.P.T. Altopiano di Pinè, Valle di Cembra	5	5	5	5
A.P.T. Rovereto, Vallagarina	4	5	6	6
A.P.T. Dolomiti di Brenta, Altopiano Paganella	17	19	18	18
A.P.T. Garda Trentino	21	23	23	23
A.P.T. Madonna di Campiglio, Pinzolo, Val Rendena	17	16	19	19
A.P.T. S. Martino di Castrozza, Primiero	9	13	13	13
A.P.T. Terme Comano, Dolomiti di Brenta	9	5	4	4
A.P.T. Valle di Fassa	44	43	41	41
A.P.T. Valle di Fiemme	17	14	14	13
A.P.T. Valle di Non	5	7	9	9
A.P.T. Valli di Sole, Pejo, Rabbi	29	22	21	20
A.P.T. Valsugana Tesino	20	14	15	15
Other areas	7	15	14	14
Total	217	217	217	217

Source: own elaboration.

Proportionate stratification by mountain level of accommodation on the full set of completed responses (217 observations).

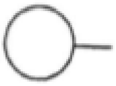
Mountain level	Sample: 217 obs	PS - ASAT population	PS – OA PAT population	PS – Stat service population
High	1	1	1	NA
Medium	108	114	113	NA
Low	108	101	103	NA
ND		1	0	NA
Total	217	217	217	NA

Source: own elaboration.

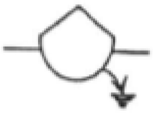
Appendix C. Energy systems symbols

System frame: a rectangular box drawn to represent the boundaries of the system selected.

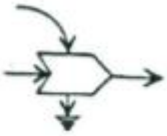
Energy circuit: a flow of energy, often with a flow of materials.



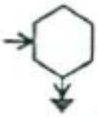
Source: outside source of energy; a forcing function.



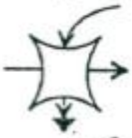
Storage: a component of energy storage within the system storing quantity as the balance of inflows and outflows.



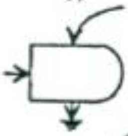
Interaction: process which combines different types of energy flows or material flows to produce an outflow in proportion to a function of the inflows.



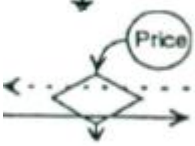
Consumer: unit that transforms energy quality, stores it, and feeds it back auto-catalytically to improve inflow.



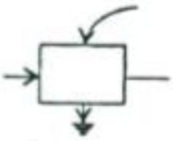
Switching action: symbol that indicates one or more switching functions where flows are interrupted or initiated.



Producer: unit that collects and transforms low-quality energy under control interactions of higher quality flows.



Transaction: a unit that indicates the sale of goods or services (solid line) in exchange for payment of money (dashed line).



Box: miscellaneous symbols for whatever unit or function is labeled.

Source: own elaboration from (Odum, 1996, 1983).

Appendix D. Chi-squared tests

P-values equal to or less than 0.05 are marked with a star (*).

Table A. Values are expressed as percentage value by group:

- G1: Group 1 which includes hotels equal or smaller than 30 rooms;
- G2: Group 2 which includes hotels larger than 30 rooms.

Table B. Values are expressed as percentage value by group:

- G1: Group 1 which includes 1 or 2 star hotels;
- G2: Group 2 which includes 3 or 4 star hotels.

Table C. Values are expressed as percentage value by group:

- G1: Group 1 which includes hotels receiving subsidies;
- G2: Group 2 which includes hotels not receiving subsidies.

Table D. Values are expressed as percentage value by group:

- G1: Group 1 which includes hotels not owned by the hoteliers;
- G2: Group 2 which includes hotels owned by the hoteliers.

A. Chi-square tests for the adoption of practices by hotel size.

	G 1, N=136	G 2, N=111	Chi-square	P-value
Renewables			0.001	0.976
No	55	55		
Yes	45	45		
Insulation			3.046	0.081
No	47	36		
Yes	53	64		
Biomass boiler			1.020	0.312
No	88	84		
Yes	12	16		
Multi-fuel boiler			0.335	0.563
No	97	98		
Yes	3	2		
Waste			0.050	0.823
No	2	2		
Yes	98	98		
Green events			2.488	0.115
No	86	78		
Yes	14	22		
Green report			0.880	0.348
No	83	78		
Yes	17	22		
Green marketing			5.020	0.025*
No	65	51		
Yes	35	49		
EMS			5.044	0.025*
No	87	76		
Yes	13	24		
Environmental monitor			3.286	0.070*
No	26	16		
Yes	74	84		
Environmental objectives			2.780	0.095
No	61	50		
Yes	39	50		
Subsidies			7.526	0.006*
No	68	50		
Yes	32	50		

Source: own elaboration.

B. Chi-square tests for the adoption of practices by hotel stars.

	G 1 N=35	G 2 N=212	Chi-square	P-value
Renewables			1.870	0.171
No	66	53		
Yes	34	47		
Insulation			9.324	0.002*
No	66	38		
Yes	34	62		
Biomass boiler			2.227	0.136
No	94	85		
Yes	6	15		
Multi-fuel boiler			0.032	0.859
No	97	98		
Yes	3	2		
Waste			0.143	0.706
No	3	2		
Yes	97	98		
Green events			3.879	0.049*
No	94	81		
Yes	6	19		
Green report			4.692	0.030*
No	94	79		
Yes	6	21		
Green marketing			11.942	0.001*
No	86	55		
Yes	14	45		
EMS			4.279	0.039*
No	94	80		
Yes	6	20		
Environmental monitor			14.237	0.000*
No	46	17		
Yes	54	83		
Environmental objectives			9.328	0.002*
No	80	52		
Yes	20	48		
Subsidies			8.934	0.003*
No	83	56		
Yes	17	44		

Source: own elaboration.

C. Chi-square tests for the adoption of practices by access to subsidies.

	G 1 N=99	G 2 N=148	Chi-square	P-value
Renewables			18.571	0.000*
No	38	66		
Yes	62	34		
Insulation			7.894	0.005*
No	31	49		
Yes	69	51		
Biomass boiler			5.767	0.016*
No	80	91		
Yes	20	9		
Multi-fuel boiler			0.252	0.616
No	97	98		
Yes	3	2		
Waste			0.857	0.355
No	1	3		
Yes	99	97		
Green events			0.896	0.344
No	80	84		
Yes	20	16		
Green report			4.154	0.042*
No	75	85		
Yes	25	15		
Green marketing			6.319	0.012*
No	49	66		
Yes	51	34		
EMS			4.024	0.045*
No	76	86		
Yes	24	14		
Environmental monitor			1.801	0.180
No	17	24		
Yes	83	76		
Environmental objectives			3.087	0.079
No	49	61		
Yes	51	39		

Source: own elaboration.

D. Chi-square tests for the adoption of practices by ownership of hotel.

	G 1 N=34	G 2 N=213	Chi-square	P-value
Renewables			11.869	0.001*
No	82	51		
Yes	18	49		
Insulation			15.972	0.000*
No	74	37		
Yes	26	63		
Biomass boiler			3.891	0.049*
No	97	85		
Yes	3	15		
Multi-fuel boiler			0.044	0.835
No	97	98		
Yes	3	2		
Waste			9.190	0.002*
No	9	1		
Yes	91	99		
Green events			3.643	0.056
No	94	81		
Yes	6	19		
Green report			2.665	0.103
No	91	79		
Yes	9	21		
Green marketing			6.724	0.010*
No	79	56		
Yes	21	44		
EMS			1.102	0.294
No	88	81		
Yes	12	19		
Environmental monitor			12.013	0.001*
No	44	18		
Yes	56	82		
Environmental objectives			3.283	0.070*
No	71	54		
Yes	29	46		
Subsidies			16.040	0.000*
No	91	55		
Yes	9	45		

Source: own elaboration.

Appendix E. Calculation procedures

Hotel A

	CALCULATION ITEM	VALUE	UNIT
1	Sun insolation		
	Average insolation	4.47E+03	MJ/(m^2*yr)
	Total area (building & garden)	4.95E+03	m^2
	Albedo	0.20	
	Energy of solar radiation	1.77E+07	MJ/yr
	Energy of solar radiation	1.77E+13	J/yr
2	Wind		
	Air density	1.30	kg/m^3
	Wind velocity	0.99	m/s
	Geostrophic wind	1.65	m/s
	Drag coefficient	0.003	
	Seconds per year	3.15E+07	s/yr
	Wind energy on land	2.75E+09	J/yr
3	Rain		
	Amount of total rainfall per year	1.59E+03	mm/yr/m^2
	Amount of total rainfall per year	1.59	m/yr
	Water density	1.00E+06	g/m^3
	Mass of rainfall water	1.59E+06	g/yr
	Fraction of evapotranspired water	0.45	
	Evapotranspired rain water	0.72	m/yr
	Mass of evapotranspired water	7.16E+05	g/yr
	Gibbs free energy	4.94	J/g
	Energy of rain[44]	3.54E+06	J/m^2/yr
	Energy of rain[45]	1.75E+10	J/yr
4	Geothermal flow		
	Heat flow per year	45	mW/m^2
	Heat flow per year	0.045	W/m^2

[44] This results as evapotranspired water (g/m^2/yr) by the Gibbs free energy per gram water (J/g).

[45] This results as evapotranspired water (g/yr) by the Gibbs free energy per gram water (J/g).

	Seconds in one year	3.15E+07	s/yr
	Heat flow per m^2	1.42E+06	J/m^2
	Geothermal flow	7.02E+09	J/yr

Building construction and furniture

	Building construction inputs		
5	Concrete	9.60E+05	kg
	Building lifetime	50.00	yr
	Concrete	1.92E+04	kg/yr
	Concrete	1.92E+07	g/yr
6	Sand	7.20E+02	kg
	Building lifetime	50.00	yr
	Sand	1.44E+01	kg/yr
	Sand	1.44E+04	g/yr
7	Stone	1.38E+03	kg
	Building lifetime	50.00	yr
	Stone	2.76E+01	kg/yr
	Stone	2.76E+04	g/yr
8	Wood	1.91E+05	kg
	Building lifetime	50.00	yr
	Wood	3.81E+03	kg/yr
	Wood	3.81E+06	g/yr
9	Clay	2.76E+04	kg
	Building lifetime	50.00	yr
	Clay	5.52E+02	kg/yr
	Clay	5.52E+05	g/yr
10	Steel	3.18E+03	kg
	Building lifetime	50.00	yr
	Steel	6.37E+01	kg/yr
	Steel	6.37E+04	g/yr

	Furniture inputs		
11	Wood (furniture)		
	Furniture (rooms)	322.00	kg/yr
	Furniture (restaurant)	61.60	kg/yr
	Total weight	383.60	kg/yr

	Fraction of wood (%)	100%	
	Amount of wood	383.60	kg/yr
	Amount of wood	3.84E+05	g/yr
11 bis	Wood (building & furniture)		
	Total wood (building & furniture)	4.19E+06	g/yr
12	Steel (furniture)		
	Furniture (wellness)	45.00	kg/yr
	Oven	20.00	kg/yr
	Dishwasher	7.50	kg/yr
	Fridge	25.00	kg/yr
	Washing machine	85.00	kg/yr
	Dryer	12.86	kg/yr
	Mangle	17.50	kg/yr
	Total weight	212.86	kg/yr
	Fraction of steel (%)	90%	
	Amount of steel	191.57	kg/yr
	Amount of steel	1.92E+05	g/yr
13	Plastic (furniture)		
	Fraction of plastic (%)	10%	
	Amount of plastic	21.29	kg/yr
	Amount of plastic	2.13E+04	g/yr
14	Labor and services		
	Cost of initial investment (building)	2.65E+07	€
	Building lifetime	50.00	yr
	Annual cost of initial investment (building)	5.29E+05	€/yr
	Cost of initial investment (furniture)	1.63E+05	€
	Furniture lifetime	15.00	yr
	Annual cost of initial investment (furniture)	1.08E+04	€/yr
	Total annual cost (L&S) for initial investment[46]	5.40E+05	€/yr
	Management (overnight stays production)		
15	Total amount electricity (Mwh)	2.15E+02	Mwh/yr
	Total amount electricity (Kwh)	2.15E+05	Kwh/yr

[46] This refers to building and furniture inputs depreciated by appropriate lifetime.

	Total amount electricity (J)	7.74E+11	J/yr
16	Total amount water	4.64E+03	m^3/yr
	Total amount water (g)	4.64E+06	g/yr
	Total amount water (J)	2.29E+10	J/yr
18	Total amount LPG	9.15E+03	liter/yr
	Equivalence liter to m^3	9.15	m^3/yr
	D (Density) = 508 kg/ m^3	508.00	kg/m^3
	Mass of LPG (kg)	4.65E+03	kg/yr
	Mass of LPG (g)	4.65E+06	g/yr
	HHV (Higher Heating Value) = 50.1 MJ/kg	50.10	MJ/kg
	Energy of LPG (MJ)	2.33E+05	MJ/yr
	Energy of LPG (J)	2.33E+11	J/yr
19	Total amount oil	2.85E+04	liter/yr
	D (Density) = 0.8 kg/liter	0.80	kg/liter
	Mass of oil (kg)	2.28E+04	kg/yr
	Mass of oil (g)	2.28E+07	g/yr
	HHV (Higher Heating Value) = 45.5 MJ/kg	45.50	MJ/kg
	Energy of oil (MJ)	1.04E+06	MJ/yr
	Energy of oil (J)	1.04E+12	J/yr
21	Services		
	Total amount electricity	2.30E+04	€/yr
	Total amount water	5.40E+03	€/yr
	Total amount LPG	1.50E+04	€/yr
	Total amount oil	4.49E+04	€/yr
	Total management cost	8.83E+04	€/yr
	Cleaning		
22	Total soap	1.77E+02	liter/yr
	D (Density) = 1.1 kg/liter	1.10E+00	kg/liter
	Mass of soap (kg)	1.94E+02	kg/liter
	Mass of soap (g)	1.94E+05	g/yr
	Energy value = 1.8E+07 J/kg	1.80E+07	J/kg
	Energy of soap (J)	3.50E+09	J/yr
23	Bleach	4.55E+00	liter/yr
	D (Density) = 1.1 kg/liter	1.10E+00	kg/liter
	Mass of bleach (kg)	5.01E+00	kg/liter
	Mass of bleach (g)	5.01E+03	g/yr
	Energy value = 1.8E+07 J/kg	1.80E+07	J/kg
	Energy of bleach (J)	9.01E+07	J/yr

24	Services		
	Total cost for cleaning	3.48E+03	€/yr
	Total management cost (cleaning and utilities)	9.18E+04	€/yr
25	Food		
a	Pasta, rice, bread	1.82E+03	kg/yr
	Pasta, rice, bread (g)	1.82E+06	g/yr
	Energy value = 1.54E+07 J/kg	1.54E+07	J/kg
	Pasta, rice, bread (J)	2.81E+10	J/yr
b	Meat	3.87E+03	kg/yr
	Meat (g)	3.87E+06	g/yr
	Energy value = 1.51E+07 J/kg	1.51E+07	J/kg
	Meat (J)	5.84E+10	J/yr
c	Milk	1.36E+03	kg/yr
	Milk (g)	1.36E+06	g/yr
	Energy value = 2.26E+06 J/kg	2.26E+06	J/kg
	Milk (J)	3.07E+09	J/yr
d	Fruits	2.72E+03	kg/yr
	Fruits (g)	2.72E+06	g/yr
	Energy value = 1.92E+06 J/kg	1.92E+06	J/kg
	Fruits (J)	5.23E+09	J/yr
e	Beverage	7.79E+02	kg/yr
	Beverage (g)	7.79E+05	g/yr
	Energy value = 2.72E+06 J/kg	2.72E+06	J/kg
	Beverage (J)	2.12E+09	J/yr
f	Sugar	2.18E+02	kg/yr
	Sugar (g)	2.18E+05	g/yr
	Energy value = 1.67E+07 J/kg	1.67E+07	J/kg
	Sugar (J)	3.64E+09	J/yr
26	Services		
	Total cost for raw amount of food	8.26E+04	€/yr
27	Labor		
	Manager	2	persons/yr
	Duration	12	months
	Salary	1.57E+03	€/month
	Manager	3.76E+04	€/yr
	Employees (summer & winter)	15	persons/yr
	Duration	7	months
	Salary	1.07E+03	€/month
	Total employees (summer & winter)	1.07E+05	€/yr

	Manager	3.76E+04	€/yr
	Employees	1.07E+05	€/yr
	Total labor cost	1.45E+05	€/yr
28	Output	Output Hotel A	
	Overnight stays	10320	nights/yr

Hotel B

	CALCULATION ITEM	VALUE	UNIT
1	Sun insolation		
	Average insolation	3.86E+03	MJ/(m^2*yr)
	Total area (building & garden)	6.40E+03	m2
	Albedo	0.20	
	Energy of solar radiation	1.98E+07	MJ/yr
	Energy of solar radiation	1.98E+13	J/yr
2	Wind		
	Air density	1.30	kg/m^3
	Wind velocity	1.15	m/s
	Geostrophic wind	1.91	m/s
	Drag coefficient	0.003	
	Seconds per year	3.15E+07	s/yr
	Wind energy on land	5.48E+09	J/yr
3	Rain		
	Amount of total rainfall per year	3.85E+03	mm/yr/m^2
	Amount of total rainfall per year	3.85	m/yr
	Water density	1.00E+06	g/m^3
	Mass of rainfall water	3.85E+06	g/yr
	Fraction of evapotranspired water	0.45	
	Evapotranspired rain water	1.73	m/yr
	Mass of evapotranspired water	1.73E+06	g/yr
	Gibbs free energy	4.94	J/g

	Energy of rain[47]	8.57E+06	$J/m^2/yr$
	Energy of rain[48]	5.48E+10	J/yr
4	Geothermal flow		
	Heat flow per year	45	mW/m^2
	Heat flow per year	0.045	W/m2
	Seconds in one year	3.15E+07	s/yr
	Heat flow per m^2	1.42E+06	J/m^2
	Geothermal flow	9.08E+09	J/yr
	Building construction and furniture		
	Building construction inputs		
5	Concrete	9.85E+05	kg
	Building lifetime	50.00	yr
	Concrete	1.97E+04	kg/yr
	Concrete	1.97E+07	g/yr
6	Sand	9.20E+02	kg
	Building lifetime	50.00	yr
	Sand	1.84E+01	kg/yr
	Sand	1.84E+04	g/yr
7	Stone	3.55E+03	kg
	Building lifetime	50.00	yr
	Stone	7.09E+01	kg/yr
	Stone	7.09E+04	g/yr
8	Wood	1.60E+05	kg
	Building lifetime	50.00	yr
	Wood	3.21E+03	kg/yr
	Wood	3.21E+06	g/yr
9	Clay	4.19E+04	kg
	Building lifetime	50.00	yr
	Clay	8.39E+02	kg/yr
	Clay	8.39E+05	g/yr

[47] This results as evapotranspired water ($g/m^2/yr$) by the Gibbs free energy per gram water (J/g).

[48] This results as evapotranspired water (g/yr) by the Gibbs free energy per gram water (J/g).

10	Steel	2.88E+03	kg
	Building lifetime	50.00	yr
	Steel	5.75E+01	kg/yr
	Steel	5.75E+04	g/yr
	Furniture inputs		
11	Wood (furniture)		
	Furniture (rooms)	383.33	kg/yr
	Furniture (restaurant)	74.80	kg/yr
	Total weight	458.13	kg/yr
	Fraction of wood (%)	100%	
	Amount of wood	458.13	kg/yr
	Amount of wood	4.58E+05	g/yr
11 bis	Wood (building & furniture)		
	Total wood (building & furniture)	3.67E+06	g/yr
12	Steel (furniture)		
	Furniture (wellness)	53.57	kg/yr
	Oven	20.00	kg/yr
	Dishwasher	7.50	kg/yr
	Fridge	50.00	kg/yr
	Washing machine	127.50	kg/yr
	Dryer	12.86	kg/yr
	Mangle	17.50	kg/yr
	Total weight	288.93	kg/yr
	Fraction of steel (%)	90%	
	Amount of steel	260.04	kg/yr
	Amount of steel	2.60E+05	g/yr
13	Plastic (furniture)		
	Fraction of plastic (%)	10%	
	Amount of plastic	28.89	kg/yr
	Amount of plastic	2.89E+04	g/yr
14	Labor and services		
	Cost of initial investment (building)	2.50E+06	€
	Building lifetime	50.00	yr

	Annual cost of initial investment (building)	5.00E+04	€/yr
	Cost of initial investment (furniture)	1.99E+05	€
	Furniture lifetime	15.00	yr
	Annual cost of initial investment (furniture)	1.32E+04	€/yr
	Total annual cost (L&S) for initial investment[49]	6.32E+04	€/yr
	Management (overnight stays production)		
15	Total amount electricity (Mwh)	7.85E+02	Mwh/yr
	Total amount electricity (Kwh)	7.85E+05	Kwh/yr
	Total amount electricity (J)	2.83E+12	J/yr
16	Total amount water	7.33E+03	m^3/yr
	Total amount water (g)	7.33E+06	g/yr
	Total amount water (J)	3.62E+10	J/yr
19	Total amount oil	1.46E+03	liter/yr
	D (Density) = 0.8 kg/liter	0.80	kg/liter
	Mass of oil (kg)	1.17E+03	kg/yr
	Mass of oil (g)	1.17E+06	g/yr
	HHV (Higher Heating Value) = 45.5 MJ/kg	45.50	MJ/kg
	Energy of oil (MJ)	5.31E+04	MJ/yr
	Energy of oil (J)	5.31E+10	J/yr
20	Total amount wood chip	2.12E+03	kg/yr
	Total amount wood chip (g)	2.12E+06	g/yr
	Energy content of wood chips	12.4	MJ/kg
	Energy of wood chip (MJ)	2.62E+04	MJ/yr
	Energy of wood chip (J)	2.62E+10	J/yr
21	Services		
	Total amount electricity	8.40E+04	€/yr
	Total amount water	8.50E+03	€/yr
	Total amount oil	2.30E+03	€/yr
	Total amount wood chip	2.58E+04	€/yr
	Total management cost	1.21E+05	€/yr
	Cleaning		

[49] This refers to building and furniture inputs depreciated by appropriate lifetime.

22	Total soap	3.60E+02	liter/yr
	D (Density) = 1.1 kg/liter	1.10E+00	kg/liter
	Mass of soap (kg)	3.96E+02	kg/liter
	Mass of soap (g)	3.96E+05	g/yr
	Energy value = 1.8E+07 J/kg	1.80E+07	J/kg
	Energy of soap (J)	7.13E+09	J/yr
23	Bleach	1.00E+01	liter/yr
	D (Density) = 1.1 kg/liter	1.10E+00	kg/liter
	Mass of bleach (kg)	1.10E+01	kg/liter
	Mass of bleach (g)	1.10E+04	g/yr
	Energy value = 1.8E+07 J/kg	1.80E+07	J/kg
	Energy of bleach (J)	1.98E+08	J/yr
24	Services		
	Total cost for cleaning	7.18E+03	€/yr
	Total management cost (cleaning and utilities)	1.28E+05	€/yr
25	Food		
a	Pasta, rice, bread	4.01E+03	kg/yr
	Pasta, rice, bread (g)	4.01E+06	g/yr
	Energy value = 1.54E+07 J/kg	1.54E+07	J/kg
	Pasta, rice, bread (J)	6.17E+10	J/yr
b	Meat	8.50E+03	kg/yr
	Meat (g)	8.50E+06	g/yr
	Energy value = 1.51E+07 J/kg	1.51E+07	J/kg
	Meat (J)	1.28E+11	J/yr
c	Milk	2.99E+03	kg/yr
	Milk (g)	2.99E+06	g/yr
	Energy value = 2.26E+06 J/kg	2.26E+06	J/kg
	Milk (J)	6.75E+09	J/yr
d	Fruits	5.99E+03	kg/yr
	Fruits (g)	5.99E+06	g/yr
	Energy value = 1.92E+06 J/kg	1.92E+06	J/kg
	Fruits (J)	1.15E+10	J/yr
e	Beverage	1.71E+03	kg/yr
	Beverage (g)	1.71E+06	g/yr
	Energy value = 2.72E+06 J/kg	2.72E+06	J/kg
	Beverage (J)	4.65E+09	J/yr
f	Sugar	4.78E+02	kg/yr
	Sugar (g)	4.78E+05	g/yr
	Energy value = 1.67E+07 J/kg	1.67E+07	J/kg
	Sugar (J)	7.99E+09	J/yr
26	Services		

	Total cost for raw amount of food	1.81E+05	€/yr
27	Labor		
	Manager	2	persons/yr
	Duration	12	months
	Salary	1.57E+03	€/month
	Manager	3.76E+04	€/yr
	Employees (summer & winter)	18	persons/yr
	Duration	9	months
	Salary	1.07E+03	€/month
	Total employees (summer & winter)	1.67E+05	€/yr
	Manager	3.76E+04	€/yr
	Employees	1.67E+05	€/yr
	Total labor cost	2.05E+05	€/yr
28	Output	Output Hotel B	
	Overnight stays	22672	nights/yr

Hotel C

	CALCULATION ITEM	VALUE	UNIT
1	Sun insolation		
	Average insolation	3.86E+03	MJ/(m^2*yr)
	Total area (building & garden)	4.00E+03	m2
	Albedo	0.20	
	Energy of solar radiation	1.23E+07	MJ/yr
	Energy of solar radiation	1.23E+13	J/yr
2	Wind		
	Air density	1.30	kg/m^3
	Wind velocity	1.15	m/s
	Geostrophic wind	1.91	m/s
	Drag coefficient	0.003	
	Seconds per year	3.15E+07	s/yr
	Wind energy on land	3.45E+09	J/yr

3	Rain		
	Amount of total rainfall per year	3.85E+03	$mm/yr/m^2$
	Amount of total rainfall per year	3.85	m/yr
	Water density	1.00E+06	g/m^3
	Mass of rainfall water	3.85E+06	g/yr
	Fraction of evapotranspired water	0.45	
	Evapotranspired rain water	1.73	m/yr
	Mass of evapotranspired water	1.73E+06	g/yr
	Gibbs free energy	4.94	J/g
	Energy of rain[50]	8.57E+06	$J/m^2/yr$
	Energy of rain[51]	3.43E+10	J/yr
4	Geothermal flow		
	Heat flow per year	45	mW/m^2
	Heat flow per year	0.045	W/m^2
	Seconds in one year	3.15E+07	s/yr
	Heat flow per m^2	1.42E+06	J/m^2
	Geothermal flow	5.68E+09	J/yr
	Building construction and furniture		
	Building construction inputs		
5	Concrete	3.04E+05	kg
	Building lifetime	50.00	yr
	Concrete	6.09E+03	kg/yr
	Concrete	6.09E+06	g/yr
6	Sand	7.61E+02	kg
	Building lifetime	50.00	yr
	Sand	1.52E+01	kg/yr
	Sand	1.52E+04	g/yr
7	Stone	1.10E+03	kg
	Building lifetime	50.00	yr
	Stone	2.19E+01	kg/yr
	Stone	2.19E+04	g/yr

[50] This results as evapotranspired water (g/m2/yr) by the Gibbs free energy per gram water (J/g).

[51] This results as evapotranspired water (g/yr) by the Gibbs free energy per gram water (J/g).

8	Wood	9.28E+04	kg
	Building lifetime	50.00	yr
	Wood	1.86E+03	kg/yr
	Wood	1.86E+06	g/yr
9	Clay	1.49E+04	kg
	Building lifetime	50.00	yr
	Clay	2.97E+02	kg/yr
	Clay	2.97E+05	g/yr
10	Steel	1.71E+03	kg
	Building lifetime	50.00	yr
	Steel	3.43E+01	kg/yr
	Steel	3.43E+04	g/yr
	Furniture inputs		
11	Wood (furniture)		
	Furniture (rooms)	40.25	kg/yr
	Furniture (restaurant)	6.60	kg/yr
	Total weight	46.85	kg/yr
	Fraction of wood (%)	100%	
	Amount of wood	46.85	kg/yr
	Amount of wood	4.69E+04	g/yr
11 bis	Wood (building & furniture)		
	Total wood (building & furniture)	1.90E+06	g/yr
12	Steel (furniture)		
	Furniture (wellness)	7.50	kg/yr
	Oven	8.33	kg/yr
	Dishwasher	6.00	kg/yr
	Fridge	25.00	kg/yr
	Washing machine	34.00	kg/yr
	Dryer	12.86	kg/yr
	Mangle	17.50	kg/yr
	Total weight	111.19	kg/yr
	Fraction of steel (%)	90%	
	Amount of steel	100.07	kg/yr
	Amount of steel	1.00E+05	g/yr
13	Plastic (furniture)		
	Fraction of plastic (%)	10%	
	Amount of plastic	11.12	kg/yr

	Amount of plastic	1.11E+04	g/yr
14	Labor and services		
	Cost of initial investment (building)	1.69E+06	€
	Building lifetime	50.00	yr
	Annual cost of initial investment (building)	3.38E+04	€/yr
	Cost of initial investment (furniture)	5.52E+04	€
	Furniture lifetime	15.00	yr
	Annual cost of initial investment (furniture)	3.68E+03	€/yr
	Total annual cost (L&S) for initial investment[52]	3.75E+04	€/yr
	Management (overnight stays production)		
15	Total amount electricity (Mwh)	9.35E+01	Mwh/yr
	Avoided electricity (Mwh)	1.85E+01	Mwh/yr
	Total amount electricity (Kwh)	7.50E+04	Kwh/yr
	Total amount electricity (J)	2.70E+11	J/yr
16	Total amount water	4.31E+02	m^3/yr
	Total amount water (g)	4.31E+05	g/yr
	Total amount water (J)	2.13E+09	J/yr
17	Total amount methane	2.50E+02	m^3/yr
	D (Density) = 0.68 kg/m^3	0.68	kg/m^3
	Mass of methane (kg/yr)	1.70E+02	kg/yr
	Mass of methane (g/yr)	1.70E+05	g/yr
	HHV (Higher Heating Value) = 37.72 MJ/m^3	37.72	MJ/m^3
	Energy of methane (MJ)	9.43E+03	MJ/yr
	Energy of methane (J)	9.43E+09	J/yr
20 bis	Electricity (hotel PV system) (Kwh)	1.85E+04	Kwh/yr
	Electricity (hotel PV system) (Mwh)	1.85E+01	Mwh/yr
	Electricity (hotel PV system) (J)	6.66E+10	J/yr
21	Services		
	Total amount electricity	1.00E+04	€/yr
	Total amount water	5.00E+02	€/yr

[52] This refers to building and furniture inputs depreciated by appropriate lifetime.

	Total amount methane	1.10E+04	€/yr
	Total amount LPG	0.00E+00	€/yr
	Total amount oil	0.00E+00	€/yr
	Total amount wood chip	0.00E+00	€/yr
	Total management cost	2.15E+04	€/yr
	Cleaning		
22	Total soap	3.10E+01	liter/yr
	D (Density) = 1.1 kg/liter	1.10E+00	kg/liter
	Mass of soap (kg)	3.41E+01	kg/liter
	Mass of soap (g)	3.41E+04	g/yr
	Energy value = 1.8E+07 J/kg	1.80E+07	J/kg
	Energy of soap (J)	6.13E+08	J/yr
23	Bleach	8.60E-01	liter/yr
	D (Density) = 1.1 kg/liter	1.10E+00	kg/liter
	Mass of bleach (kg)	9.46E-01	kg/liter
	Mass of bleach (g)	9.46E+02	g/yr
	Energy value = 1.8E+07 J/kg	1.80E+07	J/kg
	Energy of bleach (J)	1.70E+07	J/yr
24	Services		
	Total cost for cleaning	4.83E+02	€/yr
	Total management cost (cleaning and utilities)	2.20E+04	€/yr
25	Food		
a	Pasta, rice, bread	2.65E+02	kg/yr
	Pasta, rice, bread (g)	2.65E+05	g/yr
	Energy value = 1.54E+07 J/kg	1.54E+07	J/kg
	Pasta, rice, bread (J)	4.08E+09	J/yr
b	Meat	5.62E+02	kg/yr
	Meat (g)	5.62E+05	g/yr
	Energy value = 1.51E+07 J/kg	1.51E+07	J/kg
	Meat (J)	8.49E+09	J/yr
c	Milk	1.98E+02	kg/yr
	Milk (g)	1.98E+05	g/yr
	Energy value = 2.26E+06 J/kg	2.26E+06	J/kg
	Milk (J)	4.47E+08	J/yr
d	Fruits	3.96E+02	kg/yr
	Fruits (g)	3.96E+05	g/yr
	Energy value = 1.92E+06 J/kg	1.92E+06	J/kg
	Fruits (J)	7.60E+08	J/yr
e	Beverage	1.13E+02	kg/yr
	Beverage (g)	1.13E+05	g/yr
	Energy value = 2.72E+06 J/kg	2.72E+06	J/kg

	Beverage (J)	3.08E+08	J/yr
f	Sugar	3.17E+01	kg/yr
	Sugar (g)	3.17E+04	g/yr
	Energy value = 1.67E+07 J/kg	1.67E+07	J/kg
	Sugar (J)	5.29E+08	J/yr
26	Services		
	Total cost for raw amount of food	1.20E+04	€/yr
27	Labor		
	Manager	1	persons/yr
	Duration	12	months
	Salary	1.57E+03	€/month
	Manager	1.88E+04	€/yr
	Family workers (summer & winter)	1	persons/yr
	Duration	7	months
	Salary	1.07E+03	€/month
	Total family workers (summer & winter)	7.16E+03	€/yr
	Employees (summer & winter)	2	persons/yr
	Duration	7	months
	Salary	1.07E+03	€/month
	Total employees (summer & winter)	1.43E+04	€/yr
	Manager	1.88E+04	€/yr
	Family workers	7.16E+03	€/yr
	Employees	1.43E+04	€/yr
	Total labor cost	4.03E+04	€/yr
28	Output	Output Hotel C	
	Overnight stays	1500	nights/yr

Appendix F. Mass, energy, emergy, emissions accounting

Hotel A

Mass balance (local scale)				MFA - Material Flow Accounting (global scale)	
#	Description of flow	Units	Mass	Mass abiotic g/unit	Mass water (g/yr)
5	Concrete	g/yr	1.92E+07	2.55E+07	6.56E+07
6	Sand	g/yr	1.44E+04	2.04E+04	2.06E+04
7	Stone	g/yr	2.76E+04	3.92E+04	3.95E+04
8	Wood	g/yr	3.81E+06	2.59E+06	3.58E+07
9	Clay	g/yr	5.52E+05	1.68E+06	1.36E+06
10	Steel	g/yr	6.37E+04	5.13E+05	3.55E+06
11	Wood (furniture)	g/yr	3.84E+05	2.61E+05	3.61E+06
12	Steel (furniture)	g/yr	1.92E+05	1.54E+06	1.07E+07
13	Plastic (furniture)	g/yr	2.13E+04	1.21E+05	3.11E+06
15	Electricity	Kwh/yr	2.15E+05	3.40E+08	4.36E+06
16	Water	g/yr	4.64E+06	4.64E+04	4.64E+06
18	LPG	g/yr	4.65E+06	6.97E+06	5.32E+07
19	Oil	g/yr	2.28E+07	3.10E+07	2.21E+08
22	Soap	g/yr	1.94E+05	1.94E+05	1.03E+08
23	Bleach	g/yr	5.01E+03	2.23E+04	1.39E+05
25a	Pasta, rice, bread	g/yr	1.82E+06	3.07E+06	7.82E+07
25b	Meat	g/yr	3.87E+06	3.00E+07	1.19E+09
25c	Milk	g/yr	1.36E+06	1.13E+07	4.47E+08
25d	Fruits	g/yr	2.72E+06	2.72E+06	5.45E+07
25e	Beverage	g/yr	7.79E+05	1.17E+06	3.65E+07
25f	Sugar	g/yr	2.18E+05	6.75E+05	5.23E+06

	Energy Analysis					Global emission flows						
#	Description of flow	Units	Raw amount	Oil equiv. demand (g oil eq)	Energy demand (J)	Global CO_2 (**) (g CO_2)	Global CO (**) (g CO)	Global NO_x (**) (g NOx)	Global SO_2 (**) (g SO_2)	Global PM10 (g PM10)	Global N_2O (g N2O)	Global CH4 (g CH4)
5	Concrete	g/yr	1.92E+07	5.07E+05	2.12E+10	1.66E+06	3.18E+02	1.08E+03	3.18E+03	1.23E+02	7.22E+00	6.58E+01
6	Sand	g/yr	1.44E+04	1.57E+01	6.57E+05	5.15E+01	9.85E-03	3.35E-02	9.85E-02	3.81E-03	2.23E-04	2.04E-03
7	Stone	g/yr	2.76E+04	3.01E+01	1.26E+06	9.89E+01	1.89E-02	6.43E-02	1.89E-01	7.31E-03	4.29E-04	3.91E-03
8	Wood	g/yr	3.81E+06	2.18E+04	9.11E+08	7.14E+04	1.37E+01	4.65E+01	1.37E+02	5.28E+00	3.10E-01	2.82E+00
9	Clay	g/yr	5.52E+05	6.02E+02	2.52E+07	1.98E+03	3.78E-01	1.29E+00	3.78E+00	1.46E-01	8.57E-03	7.81E-02
10	Steel	g/yr	6.37E+04	9.23E+04	3.87E+09	3.03E+05	5.80E+01	1.97E+02	5.80E+02	2.24E+01	1.31E+00	1.20E+01
11	Wood (furniture)	g/yr	3.84E+05	2.19E+03	9.17E+07	7.19E+03	1.38E+00	4.68E+00	1.38E+01	5.32E-01	3.12E-02	2.84E-01
12	Steel (furniture)	g/yr	1.92E+05	2.78E+05	1.16E+10	9.12E+05	1.74E+02	5.93E+02	1.74E+03	6.74E+01	3.95E+00	3.60E+01
13	Plastic (furniture)	g/yr	2.13E+04	6.39E+04	2.67E+09	2.10E+05	4.01E+01	1.36E+02	4.01E+02	1.55E+01	9.09E-01	8.29E+00
15	Electricity (Trento mix)	Kwh/yr	2.15E+05	3.61E+05	1.51E+10	1.19E+06	2.27E+02	7.71E+02	2.27E+03	8.77E+01	5.14E+00	4.69E+01
	Electricity (wood)	Kwh/yr	8.60E+03		3.71E+10	3.12E+06	9.58E+03	7.84E+03	4.01E+02	5.76E+03	2.08E+02	3.35E+02
16	Water	g/yr	4.64E+06	2.08E+02	8.72E+06	6.84E+02	1.31E-01	4.45E-01	1.31E+00	5.06E-02	2.97E-03	2.70E-02
18	LPG	g/yr	4.65E+06	5.95E+06	2.49E+11	1.95E+07	3.74E+03	1.27E+04	3.74E+04	1.44E+03	8.47E+01	7.72E+02
	LPG (direct)	MJ/yr	2.33E+05			1.83E+07	3.49E+03	1.19E+04	3.49E+04	1.35E+03	7.92E+01	7.22E+02
19	Oil	g/yr	2.28E+07	2.80E+07	1.17E+12	9.20E+07	1.76E+04	5.99E+04	1.76E+05	6.81E+03	3.99E+02	3.64E+03
	Oil (direct)	MJ/yr	1.04E+06			8.13E+07	1.56E+04	5.29E+04	1.56E+05	6.02E+03	3.53E+02	3.22E+03
22	Soap	g/yr	1.94E+05	19010.47699	7.96E+08	6.24E+04	1.19E+01	4.06E+01	1.19E+02	4.62E+00	2.71E-01	2.47E+00
23	Bleach	g/yr	5.01E+03	1540.170783	6.45E+07	5.05E+03	9.67E-01	3.29E+00	9.67E+00	3.74E-01	2.19E-02	2.00E-01
25a	Pasta, rice, bread	g/yr	1.82E+06	1.46E+05	6.11E+09	4.79E+05	9.17E+01	3.12E+02	9.17E+02	3.54E+01	2.08E+00	1.89E+01
25b	Meat	g/yr	3.87E+06	3093523.2	1.29E+11	1.02E+07	1.94E+03	6.60E+03	1.94E+04	7.51E+02	4.40E+01	4.01E+02
25c	Milk	g/yr	1.36E+06	2.04E+05	8.54E+09	6.69E+05	1.28E+02	4.36E+02	1.28E+03	4.95E+01	2.90E+00	2.65E+01
25d	Fruits	g/yr	2.72E+06	210466.08	8.81E+09	6.91E+05	1.32E+02	4.49E+02	1.32E+03	5.11E+01	3.00E+00	2.73E+01
25e	Beverage	g/yr	7.79E+05	389270.4	1.63E+10	1.28E+06	2.44E+02	8.31E+02	2.44E+03	9.45E+01	5.54E+00	5.05E+01
25f	Sugar	g/yr	2.18E+05	1526.44152	6.39E+07	5.01E+03	9.58E-01	3.26E+00	9.58E+00	3.71E-01	2.17E-02	1.98E-01

#	Emergy analysis Description of flow	Unit	Flows per year	Emergy (seJ)	%R	%N
	Local renewable resources					
1	Solar radiation	J/yr	1.77E+13	1.77E+13		
2	Wind	J/yr	2.75E+09	6.64E+12		
3	Rain	J/yr	1.75E+10	5.34E+14		
4	Geothermal flow	J/yr	7.02E+09	1.43E+14		
11 bis	Wood (building & furniture)	g/yr	3.36E+06	1.73E+15	0.8	0.2
	Local non-renewable resources					
15	Electricity	J/yr	5.42E+11	5.47E+16	0.7	0.3
16	Water	J/yr	2.29E+10	1.67E+16		
	Imported resources					
5	Concrete	g/yr	1.92E+07	4.77E+16		
6	Sand	g/yr	1.44E+04	2.32E+13		
7	Stone	g/yr	2.76E+04	4.45E+13		
9	Clay	g/yr	5.52E+05	1.78E+15		
10	Steel	g/yr	6.37E+04	1.93E+14		
11 bis	Wood (building & furniture)	g/yr	8.39E+05	4.33E+14	0.8	0.2
12	Steel (furniture)	g/yr	1.92E+05	5.80E+14		
13	Plastic (furniture)	g/yr	2.13E+04	2.01E+14		
14	Labor and services	€/yr	5.40E+05	5.34E+17		
15	Electricity	J/yr	2.32E+11	5.62E+14	0.7	0.3
18	LPG	J/yr	2.33E+11	3.96E+16		
19	Oil	J/yr	1.04E+12	1.88E+17		
21	Services	€/yr	8.83E+04	8.73E+16		
22	Soap	g/yr	1.94E+05	3.54E+17		
23	Bleach	g/yr	5.01E+00	9.11E+12		
24	Services	€/yr	3.48E+03	3.44E+15		
25a	Pasta, rice, bread	J/yr	2.81E+10	1.91E+15		
25b	Meat	J/yr	5.84E+10	4.62E+16		
25c	Milk	J/yr	3.07E+09	2.43E+15		
25d	Fruits	J/yr	5.23E+09	2.77E+14		
25e	Beverage	J/yr	2.12E+09	1.27E+14		
25f	Sugar	J/yr	3.64E+09	3.09E+14		
26	Services	€/yr	8.26E+04	8.16E+16		
27	Labor cost	€/yr	1.45E+05	1.43E+17		

	Climate change g CO2 eq.	Particulate Matter g PM10 eq.	Photochemical Oxidant Formation g NMVOC eq.	Terrestrial Acidification g SO2 eq.	Fresh Water Eutrophication g PO4 eq.
Total global emissions	1.33E+08	8.51E+04	1.14E+05	2.99E+05	3.58E+04
Global emissions per night	1.29E+04	8.24E+00	1.10E+01	2.90E+01	3.46E+00

Hotel B

	Mass balance (local scale)			MFA - Material Flow Accounting (global scale)	
#	Description of flow	Units	Mass	Mass abiotic g/unit	Mass water (g/yr)
5	Concrete	g/yr	1.97E+07	2.62E+07	6.74E+07
6	Sand	g/yr	1.84E+04	2.61E+04	2.63E+04
7	Stone	g/yr	7.09E+04	1.01E+05	1.01E+05
8	Wood	g/yr	3.21E+06	2.18E+06	3.02E+07
9	Clay	g/yr	8.39E+05	2.56E+06	2.06E+06
10	Steel	g/yr	5.75E+04	4.63E+05	3.21E+06
11	Wood (furniture)	g/yr	4.58E+05	3.12E+05	4.31E+06
12	Steel (furniture)	g/yr	2.60E+05	2.09E+06	1.45E+07
13	Plastic (furniture)	g/yr	2.89E+04	1.65E+05	4.22E+06
15	Electricity	Kwh/yr	7.85E+05	1.24E+09	1.59E+07
16	Water	g/yr	7.33E+06	7.33E+04	7.33E+06
19	Oil	g/yr	1.17E+06	1.59E+06	1.13E+07
20	Wood chip	g/yr	2.12E+06	6.35E+04	2.75E+05
22	Soap	g/yr	3.96E+05	3.96E+05	2.11E+08
23	Bleach	g/yr	1.10E+04	4.91E+04	3.05E+05
25a	Pasta, rice, bread	g/yr	4.01E+06	6.73E+06	1.72E+08
25b	Meat	g/yr	8.50E+06	6.59E+07	2.61E+09
25c	Milk	g/yr	2.99E+06	2.48E+07	9.82E+08
25d	Fruits	g/yr	5.99E+06	5.99E+06	1.20E+08
25e	Beverage	g/yr	1.71E+06	2.57E+06	8.02E+07
25f	Sugar	g/yr	4.78E+05	1.48E+06	1.15E+07

	Energy Analysis					Global emission flows						
#	Description of flow	Units	Raw amount	Oil equiv. demand (g oil eq)	Energy demand (J)	Global CO_2 (**) (g CO_2)	Global CO (**) (g CO)	Global NO_x (**) (g NOx)	Global SO_2 (**) (g SO_2)	Global PM10 (g PM10)	Global N_2O (g N2O)	Global CH4 (g CH4)
5	Concrete	g/yr	1.97E+07	5.21E+05	2.18E+10	1.71E+06	3.27E+02	1.11E+03	3.27E+03	1.26E+02	7.41E+00	6.76E+01
6	Sand	g/yr	1.84E+04	2.00E+01	8.39E+05	6.58E+01	1.26E-02	4.28E-02	1.26E-01	4.87E-03	2.85E-04	2.60E-03
7	Stone	g/yr	7.09E+04	7.73E+01	3.24E+06	2.54E+02	4.86E-02	1.65E-01	4.86E-01	1.88E-02	1.10E-03	1.00E-02
8	Wood	g/yr	3.21E+06	1.83E+04	7.67E+08	6.02E+04	1.15E+01	3.91E+01	1.15E+02	4.45E+00	2.61E-01	2.38E+00
9	Clay	g/yr	8.39E+05	9.14E+02	3.83E+07	3.00E+03	5.74E-01	1.95E+00	5.74E+00	2.22E-01	1.30E-02	1.19E-01
10	Steel	g/yr	5.75E+04	8.34E+04	3.49E+09	2.74E+05	5.24E+01	1.78E+02	5.24E+02	2.02E+01	1.19E+00	1.08E+01
11	Wood (furniture)	g/yr	4.58E+05	2.62E+03	1.10E+08	8.59E+03	1.64E+00	5.59E+00	1.64E+01	6.35E-01	3.72E-02	3.40E-01
12	Steel (furniture)	g/yr	2.60E+05	3.77E+05	1.58E+10	1.24E+06	2.37E+02	8.05E+02	2.37E+03	9.15E+01	5.37E+00	4.89E+01
13	Plastic (furniture)	g/yr	2.89E+04	8.67E+04	3.63E+09	2.84E+05	5.44E+01	1.85E+02	5.44E+02	2.10E+01	1.23E+00	1.12E+01
15	Electricity (Trento mix)	Kwh/yr	7.85E+05	1.32E+06	5.52E+10	4.33E+06	8.28E+02	2.82E+03	8.28E+03	3.20E+02	1.88E+01	1.71E+02
	Electricity (wood)	Kwh/yr	3.14E+04		1.36E+11	1.14E+07	3.50E+04	2.86E+04	1.47E+03	2.10E+04	7.58E+02	1.23E+03
16	Water	g/yr	7.33E+06	3.29E+02	1.38E+07	1.08E+03	2.07E-01	7.02E-01	2.07E+00	7.99E-02	4.68E-03	4.27E-02
19	Oil	g/yr	1.17E+06	1.44E+06	6.01E+10	4.71E+06	9.02E+02	3.07E+03	9.02E+03	3.49E+02	2.04E+01	1.86E+02
	Oil (direct)	MJ/yr	5.31E+04			4.17E+06	7.97E+02	2.71E+03	7.97E+03	3.08E+02	1.81E+01	1.65E+02
20	Wood chip	g/yr	2.12E+06	2.12E+04	8.86E+08	6.95E+04	1.33E+01	4.52E+01	1.33E+02	5.14E+00	3.01E-01	2.75E+00
	Wood chip	MJ/yr	2.62E+04			2.20E+00	6.77E-03	5.54E-03	2.83E-04	4.07E-03	1.47E-04	2.37E-04
22	Soap	g/yr	3.96E+05	38748.6	1.62E+09	1.27E+05	2.43E+01	8.27E+01	2.43E+02	9.41E+00	5.51E-01	5.03E+00
23	Bleach	g/yr	1.10E+04	3383.6	1.42E+08	1.11E+04	2.12E+00	7.22E+00	2.12E+01	8.21E-01	4.82E-02	4.39E-01
25a	Pasta, rice, bread	g/yr	4.01E+06	3.21E+05	1.34E+10	1.05E+06	2.01E+02	6.85E+02	2.01E+03	7.79E+01	4.56E+00	4.16E+01
25b	Meat	g/yr	8.50E+06	6796158.72	2.84E+11	2.23E+07	4.27E+03	1.45E+04	4.27E+04	1.65E+03	9.67E+01	8.82E+02
25c	Milk	g/yr	2.99E+06	4.48E+05	1.88E+10	1.47E+06	2.81E+02	9.57E+02	2.81E+03	1.09E+02	6.38E+00	5.82E+01
25d	Fruits	g/yr	5.99E+06	462372.768	1.94E+10	1.52E+06	2.90E+02	9.87E+02	2.90E+03	1.12E+02	6.58E+00	6.00E+01
25e	Beverage	g/yr	1.71E+06	855187.84	3.58E+10	2.81E+06	5.37E+02	1.83E+03	5.37E+03	2.08E+02	1.22E+01	1.11E+02
25f	Sugar	g/yr	4.78E+05	3353.438192	1.40E+08	1.10E+04	2.11E+00	7.16E+00	2.11E+01	8.14E-01	4.77E-02	4.35E-01

#	Emergy analysis Description of flow	Unit	Flows per year	Emergy (seJ)	%R	%N
	Local renewable resources					
1	Solar radiation	J/yr	1.98E+13	1.98E+13		
2	Wind	J/yr	5.48E+09	1.33E+13		
3	Rain	J/yr	5.48E+10	1.67E+15		
4	Geothermal flow	J/yr	9.08E+09	1.84E+14		
11 bis	Wood (building & furniture)	g/yr	2.93E+06	1.52E+15	0.8	0.2
20	Wood chip	g/yr	1.69E+06	8.99E+14	0.8	0.2
	Local non-renewable resources					
15	Electricity	J/yr	1.98E+12	2.00E+17	0.7	0.3
16	Water	J/yr	3.62E+10	2.64E+16		
	Imported resources					
5	Concrete	g/yr	1.97E+07	4.90E+16		
6	Sand	g/yr	1.84E+04	2.96E+13		
7	Stone	g/yr	7.09E+04	1.14E+14		
9	Clay	g/yr	8.39E+05	2.70E+15		
10	Steel	g/yr	5.75E+04	1.74E+14		
11 bis	Wood (building & furniture)	g/yr	7.34E+05	3.79E+14	0.8	0.2
12	Steel (furniture)	g/yr	2.60E+05	7.88E+14		
13	Plastic (furniture)	g/yr	2.89E+04	2.73E+14		
14	Labor and services	€/yr	6.32E+04	6.25E+16		
15	Electricity	J/yr	8.48E+11	2.05E+15	0.7	0.3
19	Oil	J/yr	5.31E+10	9.62E+15		
20	Wood chip	g/yr	4.23E+05	1.02E+09	0.8	0.2
21	Services	€/yr	1.21E+05	1.19E+17		
22	Soap	g/yr	3.96E+05	7.21E+17		
23	Bleach	g/yr	1.10E+01	2.00E+13		
24	Services	€/yr	7.18E+03	7.10E+15		
25a	Pasta, rice, bread	J/yr	6.17E+10	4.20E+15		
25b	Meat	J/yr	1.28E+11	1.02E+17		
25c	Milk	J/yr	6.75E+09	5.35E+15		
25d	Fruits	J/yr	1.15E+10	6.09E+14		
25e	Beverage	J/yr	4.65E+09	2.79E+14		
25f	Sugar	J/yr	7.99E+09	6.79E+14		
26	Services	€/yr	1.81E+05	1.79E+17		
27	Labor cost	€/yr	2.05E+05	2.03E+17		

	Climate change g CO2 eq.	Particulate Matter g PM10 eq.	Photochemical Oxidant Formation g NMVOC eq.	Terrestrial Acidification g SO2 eq.	Fresh Water Eutrophication g PO4 eq.
Total global emissions	5.37E+07	5.28E+04	6.45E+04	1.13E+05	2.18E+04
Global emissions per night	2.37E+03	2.33E+00	2.85E+00	4.99E+00	9.60E-01

Hotel C

	Mass balance (local scale)			MFA - Material Flow Accounting (global scale)	
#	Description of flow	Units	Mass	Mass abiotic g/unit	Mass water (g/yr)
5	Concrete	g/yr	6.09E+06	8.10E+06	2.08E+07
6	Sand	g/yr	1.52E+04	2.16E+04	2.18E+04
7	Stone	g/yr	2.19E+04	3.11E+04	3.13E+04
8	Wood	g/yr	1.86E+06	1.26E+06	1.74E+07
9	Clay	g/yr	2.97E+05	9.07E+05	7.32E+05
10	Steel	g/yr	3.43E+04	2.76E+05	1.91E+06
11	Wood (furniture)	g/yr	4.69E+04	3.19E+04	4.40E+05
12	Steel (furniture)	g/yr	1.00E+05	8.06E+05	5.58E+06
13	Plastic (furniture)	g/yr	1.11E+04	6.34E+04	1.62E+06
15	Electricity	Kwh/yr	7.50E+04	1.18E+08	1.52E+06
16	Water	g/yr	4.31E+05	4.31E+03	4.31E+05
17	Methane	g/yr	1.70E+05	2.07E+05	8.50E+04
20 bis	Electricity (hotel PV system)	Kwh/yr	1.85E+04	3.70E+06	5.55E+06
22	Soap	g/yr	3.41E+04	3.41E+04	1.81E+07
23	Bleach	g/yr	9.46E+02	4.22E+03	2.62E+04
25a	Pasta, rice, bread	g/yr	2.65E+05	4.46E+05	1.14E+07
25b	Meat	g/yr	5.62E+05	4.36E+06	1.73E+08
25c	Milk	g/yr	1.98E+05	1.64E+06	6.50E+07
25d	Fruits	g/yr	3.96E+05	3.96E+05	7.92E+06
25e	Beverage	g/yr	1.13E+05	1.70E+05	5.31E+06
25f	Sugar	g/yr	3.17E+04	9.81E+04	7.60E+05

Energy Analysis						Global emission flows						
				Oil equiv.	Energy	Global	Global	Global	Global	Global	Global	Global
#	Description of flow	Units	Raw amount	demand (g oil eq)	demand (J)	CO_2 (**) ($g\ CO_2$)	CO (**) (g CO)	NO_x (**) (g NOx)	SO_2 (**) ($g\ SO_2$)	PM10 (g PM10)	N_2O (g N2O)	CH4 (g CH4)
5	Concrete	g/yr	6.09E+06	1.61E+05	6.73E+09	5.28E+05	1.01E+02	3.43E+02	1.01E+03	3.90E+01	2.29E+00	2.09E+01
6	Sand	g/yr	1.52E+04	1.66E+01	6.94E+05	5.44E+01	1.04E-02	3.54E-02	1.04E-01	4.03E-03	2.36E-04	2.15E-03
7	Stone	g/yr	2.19E+04	2.39E+01	1.00E+06	7.84E+01	1.50E-02	5.10E-02	1.50E-01	5.80E-03	3.40E-04	3.10E-03
8	Wood	g/yr	1.86E+06	1.06E+04	4.43E+08	3.48E+04	6.65E+00	2.26E+01	6.65E+01	2.57E+00	1.51E-01	1.37E+00
9	Clay	g/yr	2.97E+05	3.24E+02	1.36E+07	1.06E+03	2.04E-01	6.92E-01	2.04E+00	7.87E-02	4.61E-03	4.21E-02
10	Steel	g/yr	3.43E+04	4.97E+04	2.08E+09	1.63E+05	3.12E+01	1.06E+02	3.12E+02	1.21E+01	7.08E-01	6.45E+00
11	Wood (furniture)	g/yr	4.69E+04	2.68E+02	1.12E+07	8.78E+02	1.68E-01	5.71E-01	1.68E+00	6.50E-02	3.81E-03	3.47E-02
12	Steel (furniture)	g/yr	1.00E+05	1.45E+05	6.07E+09	4.76E+05	9.11E+01	3.10E+02	9.11E+02	3.52E+01	2.07E+00	1.88E+01
13	Plastic (furniture)	g/yr	1.11E+04	3.34E+04	1.40E+09	1.09E+05	2.09E+01	7.12E+01	2.09E+02	8.10E+00	4.75E-01	4.33E+00
15	Electricity (Trento mix)	Kwh/yr	7.50E+04	1.26E+05	5.27E+09	4.13E+05	7.91E+01	2.69E+02	7.91E+02	3.06E+01	1.79E+00	1.63E+01
	Electricity (wood)	Kwh/yr	3.00E+03		1.30E+10	1.09E+06	3.34E+03	2.73E+03	1.40E+02	2.01E+03	7.24E+01	1.17E+02
16	Water	g/yr	4.31E+05	1.94E+01	8.10E+05	6.35E+01	1.22E-02	4.13E-02	1.22E-01	4.70E-03	2.75E-04	2.51E-03
17	Methane	g/yr	1.70E+05	1.96E+05	8.18E+09	6.42E+05	1.23E+02	4.17E+02	1.23E+03	4.75E+01	2.78E+00	2.54E+01
	Methane	MJ/yr	9.43E+03			6.05E+05	3.68E+02	8.39E+02	2.83E+00	8.49E+00	5.66E+00	2.83E+01
20 bis	Electricity (hotel PV system)	Kwh/yr	1.85E+04	3.20E+05	1.34E+10	1.05E+06	2.01E+02	6.84E+02	2.01E+03	7.77E+01	4.56E+00	4.16E+01
22	Soap	g/yr	3.41E+04	3332.735092	1.40E+08	1.09E+04	2.09E+00	7.11E+00	2.09E+01	8.09E-01	4.74E-02	4.32E-01
23	Bleach	g/yr	9.46E+02	291.0206422	1.22E+07	9.55E+02	1.83E-01	6.21E-01	1.83E+00	7.07E-02	4.14E-03	3.78E-02
25a	Pasta, rice, bread	g/yr	2.65E+05	2.12E+04	8.88E+08	6.96E+04	1.33E+01	4.53E+01	1.33E+02	5.15E+00	3.02E-01	2.75E+00
25b	Meat	g/yr	5.62E+05	449640	1.88E+10	1.48E+06	2.82E+02	9.60E+02	2.82E+03	1.09E+02	6.40E+00	5.83E+01
25c	Milk	g/yr	1.98E+05	2.97E+04	1.24E+09	9.73E+04	1.86E+01	6.33E+01	1.86E+02	7.20E+00	4.22E-01	3.85E+00
25d	Fruits	g/yr	3.96E+05	30591	1.28E+09	1.00E+05	1.92E+01	6.53E+01	1.92E+02	7.43E+00	4.35E-01	3.97E+00
25e	Beverage	g/yr	1.13E+05	56580	2.37E+09	1.86E+05	3.55E+01	1.21E+02	3.55E+02	1.37E+01	8.05E-01	7.34E+00
25f	Sugar	g/yr	3.17E+04	221.8665	9.29E+06	7.28E+02	1.39E-01	4.74E-01	1.39E+00	5.39E-02	3.16E-03	2.88E-02

#	Emergy analysis Description of flow	Unit	Flows per year	Emergy (seJ)	%R	%N
	Local renewable resources					
1	Solar radiation	J/yr	1.23E+13	1.23E+13		
2	Wind	J/yr	3.45E+09	8.35E+12		
3	Rain	J/yr	3.43E+10	1.05E+15		
4	Geothermal flow	J/yr	5.68E+09	1.15E+14		
11 bis	Wood (building & furniture)	g/yr	1.52E+06	7.86E+14	0.8	0.2
	Local non-renewable resources					
15	Electricity	J/yr	1.89E+11	1.91E+16	0.7	0.3
16	Water	J/yr	2.13E+09	1.55E+15		
	Imported resources					
5	Concrete	g/yr	6.09E+06	1.51E+16		
6	Sand	g/yr	1.52E+04	2.45E+13		
7	Stone	g/yr	2.19E+04	3.53E+13		
9	Clay	g/yr	2.97E+05	9.57E+14		
10	Steel	g/yr	3.43E+04	1.04E+14		
11 bis	Wood (building & furniture)	g/yr	3.80E+05	1.96E+14	0.8	0.2
12	Steel (furniture)	g/yr	1.00E+05	3.03E+14		
13	Plastic (furniture)	g/yr	1.11E+04	1.05E+14		
14	Labor and services	€/yr	3.75E+04	3.71E+16		
15	Electricity	J/yr	8.10E+10	1.96E+14	0.7	0.3
17	Methane	J/yr	9.43E+09	1.68E+15		
20 bis	Electricity (hotel PV system)	J/yr	6.66E+10	5.28E+15		
21	Services	€/yr	2.15E+04	2.13E+16		
22	Soap	g/yr	3.41E+04	6.20E+16		
23	Bleach	g/yr	9.46E-01	1.72E+12		
24	Services	€/yr	4.83E+02	4.78E+14		
25a	Pasta, rice, bread	J/yr	4.08E+09	2.78E+14		
25b	Meat	J/yr	8.49E+09	6.72E+15		
25c	Milk	J/yr	4.47E+08	3.54E+14		
25d	Fruits	J/yr	7.60E+08	4.03E+13		
25e	Beverage	J/yr	3.08E+08	1.85E+13		
25f	Sugar	J/yr	5.29E+08	4.49E+13		
26	Services	€/yr	1.20E+04	1.19E+16		
27	Labor cost	€/yr	4.03E+04	3.98E+16		

	Climate change g CO2 eq.	Particulate Matter g PM10 eq.	Photochemical Oxidant Formation g NMVOC eq.	Terrestrial Acidification g SO2 eq.	Fresh Water Eutrophication g PO4 eq.
Total global emissions	6.48E+06	5.85E+03	7.26E+03	1.39E+04	2.42E+03
Global emissions per night	4.32E+03	3.90E+00	4.84E+00	9.25E+00	1.61E+00

Appendix G. Input-output tables

Hotel A

Input	Unit	Amount
Local renewable resources		
Solar radiation	J/yr	1.77E+13
Wind	J/yr	2.75E+09
Rain	J/yr	1.75E+10
Geothermal flow	J/yr	7.02E+09
Wood	g/yr	3.36E+06
Local non-renewable resources		
Electricity	J/yr	5.42E+11
Water	J/yr	2.29E+10
Imported resources		
Building construction and furniture		
Concrete	g/yr	1.92E+07
Sand	g/yr	1.44E+04
Stone	g/yr	2.76E+04
Wood	g/yr	8.39E+05
Clay	g/yr	5.52E+05
Steel	g/yr	2.55E+05
Plastic	g/yr	2.13E+04
Management		
Electricity	J/yr	2.32E+11
LPG	J/yr	2.33E+11
Oil	J/yr	1.04E+12
Main cleaning items		
Soap	g/yr	1.94E+05
Bleach	g/yr	5.01E+00
Main food items		
Pasta, rice, bread	J/yr	2.81E+10
Meat	J/yr	5.84E+10
Milk	J/yr	3.07E+09
Fruits	J/yr	5.23E+09
Beverage	J/yr	2.12E+09
Sugar	J/yr	3.64E+09
Labor and services	€/yr	8.60E+05
Output		
Overnight stays	night/yr	1.03E+04

Hotel B

Input	Unit	Amount
Local renewable resources		
Solar radiation	J/yr	1.98E+13
Wind	J/yr	5.48E+09
Rain	J/yr	5.48E+10
Geothermal flow	J/yr	9.08E+09
Wood	g/yr	2.93E+06
Wood chip	g/yr	1.69E+06
Local non-renewable resources		
Electricity	J/yr	1.98E+12
Water	J/yr	3.62E+10
Imported resources		
Building construction and furniture		
Concrete	g/yr	1.97E+07
Sand	g/yr	1.84E+04
Stone	g/yr	7.09E+04
Wood	g/yr	7.34E+05
Clay	g/yr	8.39E+05
Steel	g/yr	3.18E+05
Plastic	g/yr	2.89E+04
Management		
Electricity	J/yr	8.48E+11
Oil	J/yr	5.31E+10
Wood chip	g/yr	4.23E+05
Main cleaning items		
Soap	g/yr	3.96E+05
Bleach	g/yr	1.10E+01
Main food items		
Pasta, rice, bread	J/yr	6.17E+10
Meat	J/yr	1.28E+11
Milk	J/yr	6.75E+09
Fruits	J/yr	1.15E+10
Beverage	J/yr	4.65E+09
Sugar	J/yr	7.99E+09
Labor and services	€/yr	5.77E+05
Output		
Overnight stays	night/yr	2.27E+04

Hotel C

Input	Unit	Amount
Local renewable resources		
Solar radiation	J/yr	1.23E+13
Wind	J/yr	3.45E+09
Rain	J/yr	3.43E+10
Geothermal flow	J/yr	5.68E+09
Wood	g/yr	1.52E+06
Local non-renewable resources		
Electricity	J/yr	1.89E+11
Water	J/yr	2.13E+09
Imported resources		
Building construction and furniture		
Concrete	g/yr	6.09E+06
Sand	g/yr	1.52E+04
Stone	g/yr	2.19E+04
Wood	g/yr	3.80E+05
Clay	g/yr	2.97E+05
Steel	g/yr	1.34E+05
Plastic	g/yr	1.11E+04
Management		
Electricity	J/yr	8.10E+10
Methane	J/yr	9.43E+09
Electricity (hotel PV system)	J/yr	6.66E+10
Main cleaning items		
Soap	g/yr	3.41E+04
Bleach	g/yr	9.46E-01
Main food items		
Pasta, rice, bread	J/yr	4.08E+09
Meat	J/yr	8.49E+09
Milk	J/yr	4.47E+08
Fruits	J/yr	7.60E+08
Beverage	J/yr	3.08E+08
Sugar	J/yr	5.29E+08
Labor and services	€/yr	1.12E+05
Output		
Overnight stays	night/yr	1.50E+03

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