Life cycle assessment in the framework of sustainable tourism: a preliminary examination of its effectiveness and challenges

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Abstract: The environmental sustainability of tourism has been increasingly appearing in Local Agenda 21 and in the development policies of many countries. Although several studies have focused on sustainable tourism, only a few of them are based on life cycle assessment (LCA), the main methodology to assess environmental issues from a life cycle perspective. In order to gain a better understanding of the limited application of LCA in the tourism sector, the authors have critically reviewed the international literature and have carried out a case study on an Italian hotel. In this paper, results of such an implementation are concisely presented. From this study, key points for LCA development are envisaged, and the role of LCA in the framework of sustainable tourism is analysed.

Keywords: sustainable tourism; life cycle assessment; LCA; life cycle management; life cycle thinking; accommodation; service; tourism; hospitality; lodging; hotel case study; Italy.

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1 Introduction

The high growth rate seen in the tourism industry over the recent decades has made it one of the most important industries in the world economy and forecasts for the coming years predict a strengthening of this trend (Raggi and Petti, 2006; UNWTO, 2008a).

The European Union (EU) accounts for 55% of total international tourist arrivals worldwide and 51% of international tourism receipts (UNWTO, 2008b). Moreover, no less than 12 of the world's top 20 tourism markets are European (UNWTO, 2008c). Furthermore, total domestic tourism within the EU countries is even much larger than international arrivals (Peeters et al., 2007; UNWTO, 2008b). Also, the global volume of domestic tourism surpasses the international volume by a factor four (UNWTO-UNEP-WMO, 2008). Tourism currently contributes 4% of the EU's gross domestic product (GDP), varying from about 2% in several new EU Member States to circa 12% in Malta (CORDIS-European Commission, 2008).

The increasing role of the tourism industry in the world economy highlights the importance to carefully identify the products of the tourism industry and accurately assess their environmental sustainability using a holistic and integrated approach. For this purpose life cycle assessment (LCA) (ISO, 2006a, 2006b) could be the proper tool. LCA is widely recognised as an objective scientific methodology that can be used to assess the environmental performance of a product/service over its entire life cycle (Raggi et al., 2008a). According to a preliminary survey on the use of LCA in the tourism industry (Raggi et al., 2005), it emerged that LCA is still uncommon for a number of stakeholders of the tourism industry and for researchers in the so called field of sustainable tourism (Bramwell and Lane, 2008; De Camillis et al., 2008; Hunter and Shaw, 2007).

In order to gain a better understanding of the reasons for such a limited dissemination and to evaluate the need of sectorial LCA guidelines, a critical review focused on a comparison of LCA-based case studies in the tourism sector was carried out by the authors (De Camillis et al., 2010a). In addition, an LCA case study was conducted on the services provided by an Italian hotel. In this paper, the findings of such a case study are analysed to help define some improvements that could be made to LCA for the tourism industry, and to identify the role of LCA in the framework of sustainable tourism.

2 Goal and scope definition

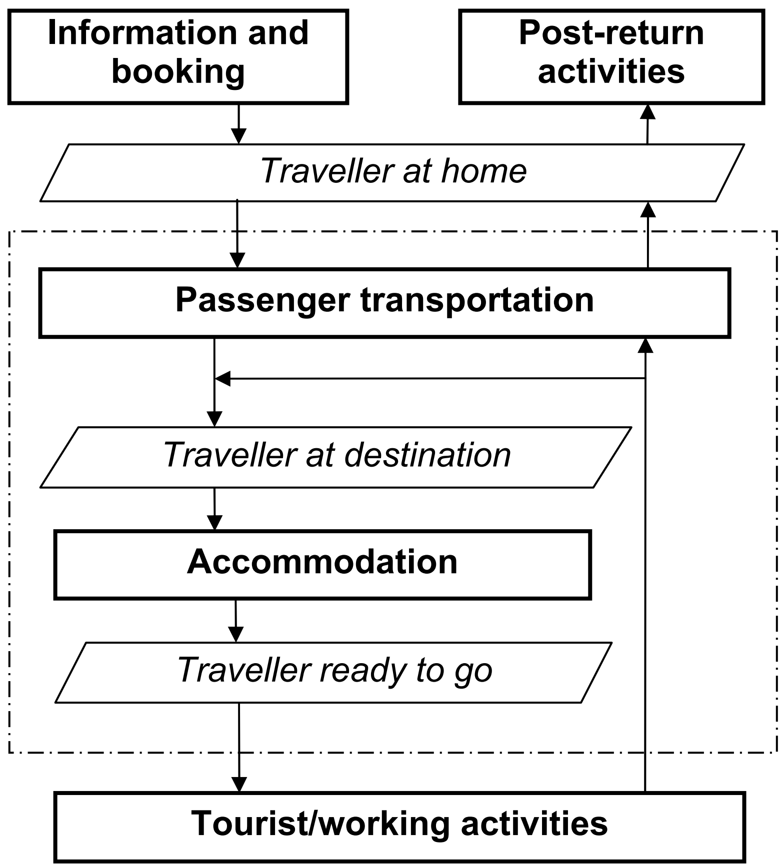
The LCA methodology was implemented to the accommodation services provided by Duca d'Aosta Hotel, a three-star hotel located in Pescara, Italy.

The aim of the study was to assess the environmental performance of accommodation services (i.e., parking, reception and administration, lodging, and breakfast) in order to identify environmentally crucial points. The assessment was carried out for internal use in order to improve the environmental performance of the hotel, in particular of lodging, as this is the most important function for every hotel according to a must-be quality approach (Kano et al., 1984; Xu et al., 2009).

The functional unit was defined as an overnight stay of one guest with breakfast and car-parking services included.

The product system was modelled according to a 'from-door-to-door' perspective (Chambers, 2004), which includes those processes involved over the guest movements from home to home (i.e., departure, stay in the tourist destination and return). In particular, Figure 1 illustrates the life cycle macro-phases: transport to the hotel, accommodation services and transport back home.

Figure 1 System boundaries of hotel services within the life cycle of a travel



Guest transportation was included in the assessment because hoteliers are directly responsible for the location of their structures and could also influence guest choices regarding transport modes (e.g., by offering discounts to guests travelling with a given mean of transportation).

Life cycle inventory (LCI) data on the building were not included in this study, given the impossibility of reducing the environmental burden of structures that already exist, at least as regards the construction phase.

In order to effectively model the accommodation macro-phase, a modular LCA approach (Petti and Tontodonati, 2002; Rebitzer and Buxmann, 2005) was adopted. This approach permits the combination of the main processes of the system (e.g., reception and administration, and lodging services) with additional activities, i.e., those processes that can be added to the main ones in order to broaden and differentiate the supply (e.g., breakfast and parking).

GaBi4 (PE International, 2010) was the LCA software used in this case study and CML 2001 (Guinée et al., 2001a, 2001b) was the impact assessment method chosen by the authors, given the wide range of impact categories it takes into account.

3 LCI analysis

As shown in Figure 1, the whole product system is composed of two main subsystems: passenger transportation and accommodation services.

3.1 Passenger transportation

To model the first subsystem, it was first necessary to calculate the distribution of hotel guest arrivals according to the travellers' place of origin and transport mode (see Table 1). Data from questionnaires submitted to guests (Simboli et al., 2008) and from an interview with the hotel manager were useful for this purpose.

Table 1 Information on guest transport to the hotel

Place of origin	*Guest distribution*	*Transport modes (average distance)*	*Guest sub-distribution*
Northern Italy	45%	Car from home to airport (90 km) + Flight to Pescara (600 km)	50%
		Car (400 km)	50%
Central Italy	27%	Car (250 km)	100%
Southern Italy and major Italian islands	18%	Car from home to airport (90 km) + Flight to Rome (600 km) + Car from Rome to Pescara (230 km)	20%
		Car (370 km)	80%
Europe	10%	Car from home to airport (120 km) + Flight to Rome (1,200 km) + Car from Rome to Pescara (230 km)	100%

Rypdal (2000) was the main source to create a LCI dataset of passenger air transport through a Boeing 737 aircraft. Datasets on car transport (IDEMAT, 2001) were linked to the distribution data of cars according to specific engine types in Italy (ACI, 2010).

A key information to estimate the number of journeys by car was the annual amount of guest groups (*GG*). The following formula was used for this purpose:

$$GG = TG + BG$$

where

TG (tourist groups): overall annual amount of groups of tourist guests

BG (business groups): overall annual amount of groups of worker guests

TG can be calculated as follows:

$$TG = \frac{TA}{AGT}$$

where

TA (tourist arrivals): overall annual arrivals of tourists

AGT (average group of tourists): average number of guests in a group of tourists. This information was estimated by the hotel manager.

BG can be calculated as follows:

$$BG = \frac{WA}{AGW}$$

where

WA (worker arrivals): overall annual arrivals of travellers for work reasons

AGW (average group of workers): average number of guests in a group of work travellers. This information was estimated by the hotel manager.

Although the sensitivity analysis on transport modes revealed a high significance of flights and cars (petrol and diesel engines) over the environmental issues of the life cycle under study, a more accurate data collection was not carried out because this subsystem was not the major focus of the study.

3.2 Accommodation services

The accommodation system can assume different service configurations according to specific requests of guests. In fact, travellers can choose different rooms and specific supporting services (e.g., parking, breakfast and bar). This case study adopted the modular LCA approach because of its effectiveness in taking into account all these diversities. The reference flow selected for this macro-phase was the annual number of overnight stays, which, for the reference year, amounted to 26,027.

Primary data were collected onsite for the following hotel services: parking, administration and hall, lodging and breakfast. Data collection was also performed onsite for the washing of linens (e.g., toilet and bed linens) and the printing of promotion and information material of the hotel.

Given the focus of this study on the lodging service, the LCI dataset of this process (see Table 2) was set up with particular accuracy.

Consumables such as hotel amenities (e.g., dental care set, shaving set, bar of soap, and others) were identified, collected, disassembled, weighted and analysed in order to identify the material composition of each one, where possible. This analysis was necessary because no LCI database was identified on the production processes of these hotel amenities. From the list of materials and their weight, a simplification of the LCA procedure was carried out by considering only those LCI datasets concerning the production of the relevant materials from the GaBi professional database (PE International, 2006).

Table 2 LCI dataset of the lodging process

Inputs		*Outputs*	
Bars of soap	194.739 kg	Overnight stays	26,027.000 units
Bottles of bath foam	199.889 kg	Linen to be washed	71,552.000 kg
Cups	84.024 kg	Aluminium [waste]	125.339 kg
Dental care sets	4.518 kg	Cardboard [waste]	648.495 kg
Clean linens	71,552.000 kg	Glass [waste]	305.174 kg
Packets of paper tissues	174.168 kg	Polyethylene terephthalate (PET) [waste]	279.743 kg
Electricity	295,861.180 kWh	Polypropylene (PP) [waste]	470.477 kg
Shaving sets	8.693 kg	Other plastics [waste]	292.459 kg
Shoe polishers	20.643 kg	Paper [waste]	1,131.688 kg
Shower caps	30.194 kg	Waste water	3,279.402 m^3
Thermal energy	531,451.683 MJ		
Water	3,279.402 m^3		

Table 3 Main electricity consumption items of the lodging service

Electricity consumption items	*kWh*
Treatment unit for air and water	50,778.000
Room lighting	93,359.220
TV sets	2,255.050
Refrigerators	28,304.640
Hairdryers	9,760.130
Lighting of corridors during daytime	55,427.150
Lighting of corridors at night	12,817.900
Lighting of the stairs from the ground floor to the 1st floor	6,709.280
Lighting of common toilets on the 1st floor	725.330
Emergency lighting	2,538.650
Fire fighting service unit	702.660
Treatment unit for air recycling	15,275.250
Elevator no. 1	8,603.960
Elevator no. 2	8,603.960
Total	295,861.180

As electricity bills included all the hotel services, accurate estimations were performed on electricity consumption to outline a detailed overview of each accommodation service. An allocation procedure was mostly avoided in this way. Specifically, these estimations were performed by summing consumption values of equipments involved in each accommodation process (see Table 3 on the lodging service). Time of usage and electric power of equipments and machines were key information to obtain these estimations. However, electricity consumption could not be estimated in some specific cases without carrying out an allocation. For instance, in the case of lighting and cleaning of those areas (corridors, and steps) common to different accommodation services (e.g., lodging and breakfast), the electricity consumption was allocated according to the overall surface used by each service. The accuracy of these estimations was confirmed through a crosscheck with the annual electricity bill of the whole structure.

Water consumption was measured through bills, whilst the waste water amount was assumed to be equal to that consumed because of the lack of measurement systems of waste water.

As no separate collection of waste was settled at the room level at the time of data collection, some samples of waste bins were analysed to identify types and quantities of waste streams.

4 Life cycle impact assessment

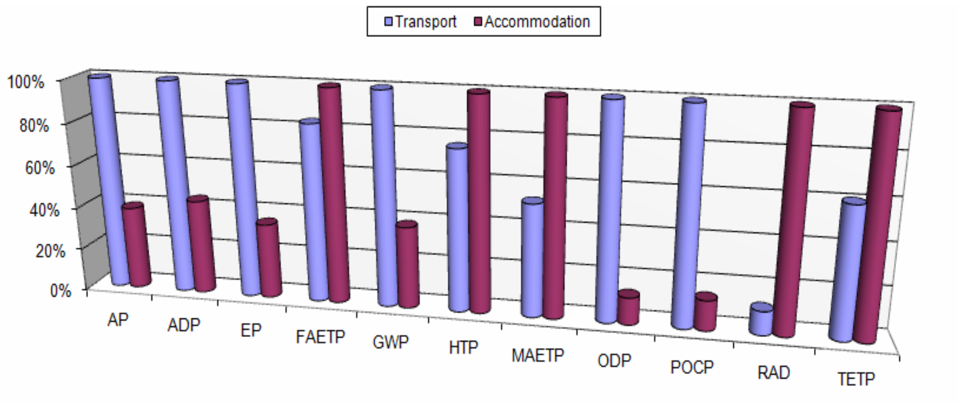
The characterisation results show both the transport system and the accommodation services as crucial environmental points (Figure 2). In fact, the transport system has a higher impact than accommodation services in a number of categories, notably: acidification (AP), abiotic depletion (ADP), eutrophication (EP), global warming (GWP), ozone layer depletion (ODP) and photochemical ozone creation (POCP). On the other hand, accommodation services affect more the three ecotoxicity categories – freshwater (FAETP), marine aquatic (MAETP) and terrestrial (TETP) ecotoxicity – as well as human toxicity (HTP) and radioactivity (RAD).

If the system macro-phases are analysed in detail, it emerges that passenger transport from Northern Italy is the most significant aspect of the transport system (circa 45% of the hotel guests come from Northern Italy).

Focusing on the transport modes used by domestic guests, it emerges that passenger transportations by petrol- and diesel-fuelled cars are the most burdening processes, given also their large shares in the Italian vehicle stock. On the other hand, air transport is the main environmental issue for passenger transportation from Europe.

About the accommodation macro-phase, the characterisation results highlight the ‘lodging’ and ‘reception and administration’ systems as the main crucial points. In particular, the ‘lodging’ system is potentially more responsible than ‘reception and administration’ over all impact categories. Moreover, a deeper analysis of characterisation results has shown that energy production (power and thermal energy) and some disposal processes in landfill are the main burdening processes.

Figure 2 Characterisation result comparison for transport and accommodation macro-phases (see online version for colours)



In addition to classification and characterisation, normalisation and weighting were also implemented within the LCIA, even though these phases are less objective than the previous ones. As shown in Figure 3, normalisation results point out the following impact categories as the most burdening over the whole life cycle: abiotic depletion, global warming, marine aquatic ecotoxicity, photochemical ozone creation and acidification. Finally, the weighting phase (Figure 4), with Southern Europe as spatial reference, has identified global warming and abiotic depletion as the most burdening impact categories.

Figure 3 Normalisation results (see online version for colours)

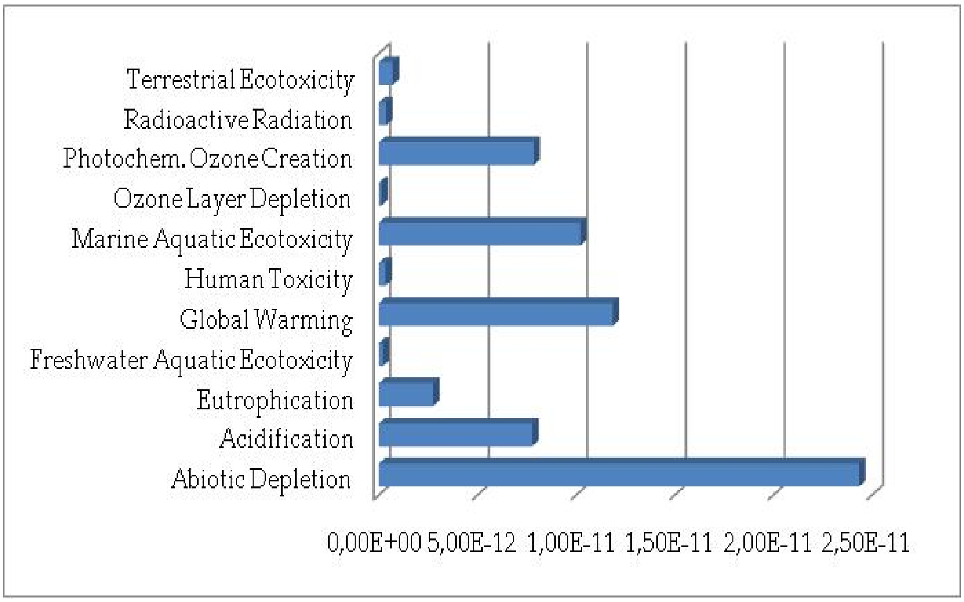
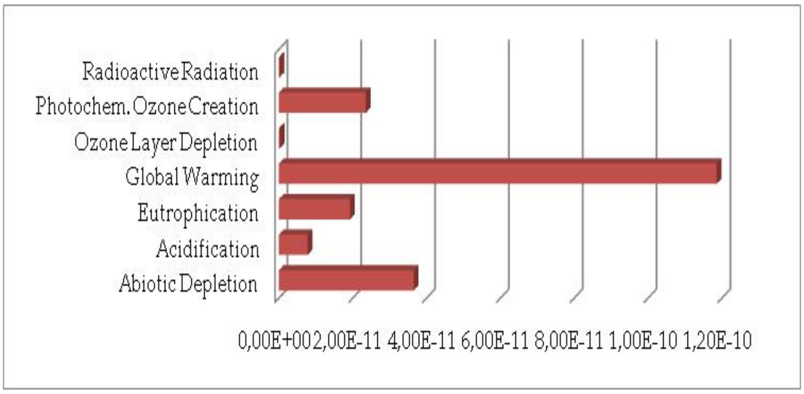


Figure 4 Weighting results (see online version for colours)



5 Life cycle interpretation

5.1 Goal and scope definition

The definition of functional unit and system boundaries has revealed a complicated nature of tourist services. It is therefore crucial that these LCA steps are accurately implemented.

In order to better model the transport system, a specific survey should be carried out: questionnaires or direct interviews focused on transport practices of hotel guests could be used for this purpose.

In outlining the system boundaries, as far as structures (such as the hotel buildings) and durable goods (such as technical equipment, furniture, and others) are concerned, only data on their usage have been included (thus excluding upstream and downstream phases, such as construction/manufacturing and demolition/end-of-life management). Even if this choice is consistent with the assumptions generally taken in LCAs for manufactured goods, where impacts from the production/dismantling of equipment and machinery are usually not included in studies, specific assessments should be carried out to confirm this decision on a case-by-case basis.

In order to better calculate the overall net environmental impacts of the accommodation system, the environmental loads normally generated by hotel guests at home in enjoying the same functions as those provided by hotel accommodation should be considered as avoided loads, and consequently, subtracted from the loads generated by the accommodation service. Even though this procedure was not carried out in this case study because of lacking data on guests' behaviour in their own homes, it might become a norm as it would permit the environmental credits of the missed overnight stay of guests at home to be adequately considered.

5.2 Life cycle inventory

LCI implementation has shown that certain data sets related to travel and tourist industry are missing in the currently available databases. In order to overcome these limitations, the authors made direct measurements, searched and processed literature data, and performed estimations (e.g., regarding air transport and hotel amenities). Further studies should be carried out to review and improve these datasets. For instance, regarding the air transportation system, average fuel consumption and airborne emissions of aircrafts as modelled in this LCA do not adequately consider a few specific parameters (e.g., passenger load factor of the aircraft, meal services on board and technical requirements of engines) which may affect environmental performance. Furthermore, more specific data on kerosene production (extraction, refining and distribution) for aviation should be used (Koroneos et al., 2005). In order to set up a representative aircraft mix for air transportation, the following actions should be carried out: surveys on aircraft models generally used by each airline for passenger transportation; construction of LCA databases and the setting of parameters on aircrafts (Rypdal, 2000). As for air transportation, specific actions on other forms of transport (e.g., car, motorbike, bus, train, and ferry) should be performed in order to improve the accuracy of the LCA model. As regards the accommodation system, the following processes should be included in the study in order to add details to this LCA model: production of hotel amenities and breakfast food.

5.3 Life cycle impact assessment

LCA implementation has mainly pointed out the following processes as crucial points of the system: energy production (power and thermal energy) for hotel and related services, petrol and diesel car transport, air transport, and some disposal processes in landfill.

Therefore, in order to substantially improve the environmental performance of the system analysed, some preliminary actions – to be confirmed through further specific assessments – can be identified. First of all, it should be advisable for hotel and related activities the switching towards supplies of energy from renewable sources. Such an action could also be supported by energy saving policies – e.g., switching to lower consumption lamps and electric appliances, as well as daylighting devices (Simboli et al., 2008; Sanchez Ramirez et al., 2010).

Moreover, hotel guests could be directed towards more environmentally-friendly transport solutions. For instance, train transportation could be promoted through campaigns of environmental marketing like that performed by Trenitalia, the main Italian train company, together with the Hotelier Association of Riccione, Italy (Trenitalia, 2009a). According to this initiative, train tickets are refunded to passengers who spend at least one week in one of the association's hotels during summertime. Another example is the cooperation between Trenitalia and Legambiente, an Italian environmentalist association, in granting discounts to those guests who decide to use the train as transport mean for their holiday, and to lodge in eco-friendly accommodation structures indicated by that association (Legambiente Turismo, 2009; Trenitalia, 2009b).

Regarding road transportation (buses and cars), more environmentally-sound solutions should be promoted (e.g., LPG- and methane-fuelled vehicles, travelling in groups, car pooling, etc.), whereas transport using petrol and diesel engines, or single-passenger car travel should be discouraged.

Finally, appreciable environmental improvements to the product/service system might also be achieved through: separate collection of waste not only in the hall, but also in the hotel rooms; selection of suppliers (i.e., laundry, linen dry, and cleaning company) with a better environmental performance; and the provision of more environmentally-sound food for breakfast. In any case, specific improvement scenarios should be identified and their actual environmental preferability should be carefully assessed before any implementation.

6 Conclusions

This LCA case study has shown the most critical environmental issues over the life cycle of the accommodation services provided by an Italian hotel. LCA was also used to figure out how the environmental performance could be improved.

Even though further LCA case studies should be performed, it can be preliminarily argued that LCA could be an effective instrument to assess the environmental impacts of tourism. More specifically, a number of roles could be assigned to LCA within a sustainable tourism pathway.

LCA, for instance, could support eco-design procedures, if integrated in the framework of methodologies for quality design (e.g., quality function deployment) (De Camillis et al., 2010b; Raggi and Petti, 2006).

LCA implementations could be a milestone to develop: a simplified tool for SMEs capable of assessing and comparing the environmental performance of tourist products in a life cycle perspective; product category rules, as a basis for type III environmental declarations (e.g., environmental product declaration – EPD) according to the ISO 14025:2006 standard (ISO, 2006c).

If integrated with strategic environmental assessment (SEA), environmental impact assessment (EIA) (Bruzzi et al., 2008) and even with geographic information systems (GISs), the life cycle approach could be useful to assess, plan and outline environmental impact scenarios. In particular, such an integration would enable a better planning and management of the environmental performance of tourist destinations and structures.

As LCA could scientifically and objectively support campaigns of environmental communication and education for tourists, it could also be an instrument for a more responsible consumption.

Finally, LCA could be used for analysing and comparing eco-label schemes, which are so widespread in the travel and tourism industry (Buckley, 2002). This activity could indicate the real propensity of all these eco-labels to achieve better environmental performance. In this way criteria to obtain these eco-labels could also be improved. For instance, the LCA study presented in this paper has pointed out a few notable contradictions in the assignment criteria for the European eco-label for tourist accommodation services (European Commission, 2009). In fact, the considerable environmental significance of energy generation clashes with the first criterion of the eco-label scheme which includes the possibility of supplying electricity from non-renewable sources if tourist accommodation has "no access to a market that offers electricity generated from renewable energy sources". This criterion does not take into account the potential of tourist activities in generating energy (i.e., solar or wind energy) by themselves or in cooperation with other organisations. Moreover, guest transportation (from home to home), whose environmental impact is very significant in the LCA of the Duca d'Aosta hotel, was not sufficiently regulated in the framework of the EU eco-label. In fact, guest transportation is mentioned in the 22nd criterion, which deals only with the aspect of information on public transport provided to customers and staff by tourist organisations; in particular, on how to use public transportation to and from the tourist accommodation. Information on environmentally preferable means of transport should be given only where no appropriate public transport exists. More effective actions to promote the most environmentally-sound forms of transport, as well as to discourage the most polluting ones, should be included in the criteria list.

Even though a number of roles have been outlined, this case study has pointed out some weaknesses of LCA in tourism. First, the object of an LCA and its system boundaries cannot be easily identified because tourism is a complicated system in which different typologies of tourist products may be recognised. Moreover, specific LCI databases for the tourism industry do not seem to be available, thus making LCI a hard and slow process. Finally, most common impact assessment methods do not consider all the local issues, to which tourists are usually very sensitive (e.g., landscape disruption, acoustic and olfactory pollution). Nowadays, this deficiency within the framework does not make LCA results comprehensive and so much interesting for tourist operators.

In the light of the above-mentioned limitations, the following topics should be developed and shared within the scientific community in order to disseminate LCA in tourism: methodological approaches of LCA for tourist products; sectorial quality assured LCI databases to support LCA practitioners and save time during implementations; impact assessment methods to better consider local environmental issues.

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