THE ROLE OF HOTELS IN SHAPING A SUSTAINABLE BUILT ENVIRONMENT

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Abstract

Because of its function and nature, tourism sector has the potential to shape cities and citizens. The impact of tourism activities on global CO2 is around 5% and its reduction is both a technically achievable and a socially beneficial target. For instance, in the hotel sector on one side the use of energy efficiency measures and renewable energy is far below its real potential; on the other side, due to the number of guests they host, hotels have the potential to act as an example of energy responsibility for other industries, as well as for individuals. At the European level, the issue of reducing hotels' energy consumption goes along with the aggressive goals set for the next decades for energy use reduction. In this framework, this paper presents the application of the Europe-wide known cost-optimal methodology to an existing hotel. Indeed, taking into account financial aspects is crucial for the market uptake of sustainable good practices in real, business-driven world. A small-medium mountain hotel located nearby Torino was selected as baseline model for the analysis and a number of energy efficiency measures were defined and implemented in a building energy dynamic simulation software. The obtained cost-optimal level of energy performance proved that proper combinations of existing technologies could lead to significant reduction of energy use. However, a critical discussion of the implemented methodology led to the proposal of different evaluation parameters for cost-optimal levels of energy performance for hotels, as a possible solution to catch stakeholders' interest toward green investments.

1 Introduction

Tourism activities, mainly transportation and accommodation, contribute around 5% to global CO2 emissions, of which 1% specifically related to hotel sector (UNWTO-UNEP, 2008). The relatively small footprint is nevertheless an issue that is being addressed by this major sub-sector of the tourism industry. In a world looking for new models of economic growth and development, adopting sustainable management practices is a condition for survival and success. Over the past several years, the world's leading hotel brands have increased their efforts to respond to environmental issues and invested significantly in going green (Kang et al. 2012). Sustainable practices are now pillars of the Corporate Social Responsibility (CSR) programs that the hospitality industry is increasingly implementing and being viewed as a green hotel is often a desired outcome of a hotel's CSR strategy (Gao and Mattila 2014). Indeed, today's customers are more and more sensitive to ecological matters and greening a hotel is inevitable not just to achieve operational cost savings, but also - and mainly - in order to meet hospitality customers' needs and boost their positive intention and behaviour toward the firm (Han and Kim 2010, Han et al. 2011). Moreover, by trying to answer to green costumers' needs, hotels have the potential to spread eco-friendly behaviours to a wider range of guests and to act as an example of energy responsibility for other industries (UNWTO 2011). Due to the number of clients they receive, they can become a channel for social change (Ryan 2002).

Despite these promising premises, at the current stage hotel sector's use of energy efficiency and renewable energy is far below its real potential and energy costs still represent a significant part of the operational costs of a tourist accommodation building (RELACS 2010). Particularly, dealing with the small-medium enterprises (SME) sector, poor energy performances are combined with hesitation in investing in green initiatives: even with the opportunities of business success and cost savings, SME hoteliers remain diffident as they are not convinced of the financial benefits of such investments. Indeed the implementation of green practices requires significant initial investments, for which quantifying returns is often difficult, especially in terms of actual market appreciation (Kang et al. 2012).

In Europe the issue of reducing hotels' energy consumption goes along with the more general goal set by EBPD recast (European Commission 2010), envisaging that from 2021 all buildings newly built or undergoing major renovations will reach the nearly Zero Energy level. Based on the Directive formulation, nearly Zero Energy Buildings (nZEB) are buildings with a very high energy performance and where energy need is covered to a very significant extent by energy from renewable sources. It is task of each EU Member State to define figures for this generic definition, keeping in mind that “energy performance” is the calculated or measured amount of energy needed to meet the energy demand associated with the typical energy use of the building, which include energy use for heating, cooling, ventilation, hot water and lighting. In addition to nZEB policy, EPDB recast specifies that Member States shall set buildings minimum energy performance requirement in view to achieving cost optimal levels, which is the amount of primary energy leading to the minimum life cycle cost. While cost optimality is the current framework regarding the ambition level for renovation of existing buildings and new buildings, the principle of nearly zero-energy buildings will be guiding for new buildings as from 2021. Therefore it is important to secure a smooth and consistent transition of policies and markets from cost optimality to nearly zero-energy buildings (Kurnitski et al. 2011). For the purpose of both nZEB and cost-optimal level calculations, 9 buildings types to be considered are listed by the EPBD recast, including hotels.

In this framework the IEE co-funded EU project “neZEH – nearly Zero Energy Hotels” (neZEH 2013a) has its place. This 3 years project aims at accelerating the refurbishment rate of existing buildings into nZEB in the hospitality sector and promoting front runners, focusing on SME hotels. From the operational point of view, the project’s scope consists of: providing technical advice to committed hotel owners; demonstrating the profitability, feasibility and sustainability of investments towards nearly Zero Energy through the application of deep retrofit measures to 14 hotels across Europe; promoting the 14 frontrunners; undertaking training and capacity building activities. Reaching these goals set up a number of theoretical issues: indeed, the nearly Zero Energy level, as well as the cost-optimal level of energy performance for hotels, is not put into figures in most of Member States and the typical energy use for this building type is not defined. Following EPBD precepts in terms of energy uses in a neZEH, the typical energy use in hotels can be identified as the energy used for “hosting functions”, as proposed by Buso et al. (2014). While different hotels may offer different facilities, entailing a wide gap in the energy needs among buildings with the same general use classification, hosting functions, mainly related to guestrooms, are always present and their energy uses aim at providing comfort conditions to guests and workers. This approach was followed by the neZEH project for setting preliminary benchmark values for hosting functions for new and retrofitted neZEHs in the project partner Member States (neZEH 2013b). Figures, regarding primary energy (PE) use for heating, hot water, cooling, lighting and appliances, are shown in Table 1 and were identified as a result of national legislations and literature review.

Table 1 neZEH benchmarks for hosting functions for new and retrofitted hotels in project partner countries

neZEH partner	Croatia	France	Greece	Italy	Romania	Spain	Sweden
PE indicator – New [kWh/m^{2}y]	77	115	76	71	80	72	134
PE indicator -Refurbished kWh/m^{2}y]	100	150	99	92	104	94	174

Given a general overview, this research aims to present and discuss the results of applying the EPBD recast-prescribed cost-optimal methodology to an Italian existing hotel and to verify whether the neZEH benchmarks are achievable and financially convenient. Energy efficiency measures (EEMs) are applied to the selected hotel and their impact on energy consumption and global cost is evaluated. The analysis aims at finding the cost-optimal EEMs and the cost-optimal level of energy performance, considered as a step toward the nearly Zero Energy Hotel target. The obtained results are then critically discussed, particularly questioning whether cost-optimal methodology can give actual support to define the best retrofit strategies for hotels and can seize the extra-benefits (e.g. market appreciation) that going green entail for this kind of business.

2 Method

In this section the steps undertaken in the present cost-optimal methodology exercise, here listed, are extensively described: (1) description of the baseline hotel building; (2) definition of technically feasible EEMs - single measures and packages of measures; (3) energy evaluation through simulations; (4) economic evaluation of the baseline model and the packages of measures.

2.1 Baseline building

A small-medium mountain hotel located in Piedmont (North of Italy) was selected as the baseline model for the cost-optimal analysis. This existing building, built in 1929, was converted into a hotel in the 80’s. In 1998 partial retrofit measures, such as boilers replacement, were undertaken. It is a seven-storey building (2 basement levels and 5 floors) in which the following functions are located: the lower level basement houses unconditioned technical rooms and deposits and conditioned function-rooms; the upper basement level hosts laboratories and entertainment areas; the ground floor has a hall, offices and food services (kitchen, restaurant and cafè); the upper floors house 73 guest rooms, with 170 beds in total. The building longitudinal axis is in

West-East direction and guestrooms are mainly South oriented, as shown in Figure 1. Coming to figures, total net conditioned area and volume are respectively 5.858 m^2 and 22.669 m^3, the aspect ratio is 0,51 m^{-1} and the floors dimensions vary from 80x18 m to 80x12 m.

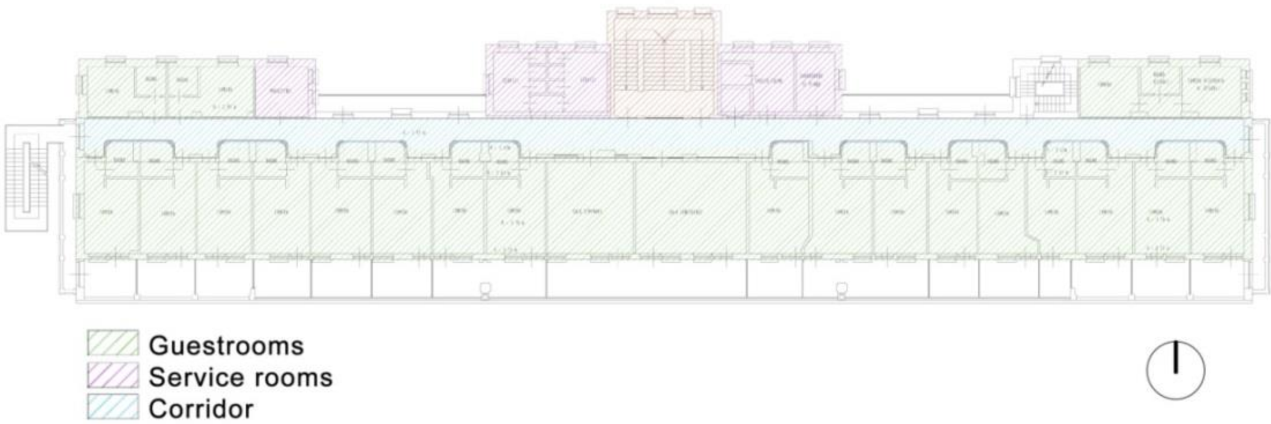

Figure 1 Typical floor plan of the selected existing hotel

Building plants consist of three gas boilers of 500 kW each, serving the heating system for ground and upper floors with radiators and fan coils as heating terminals, the Domestic Hot Water (DHW) production and three Air Handling Units (AHU) for the climatization of the basement, rarely in use. Finally, envelope thermal properties are summarized in Table 2, in comparison with Italian minimum requirements given by D.L.311/2006 (Italy 2006).

Table 2 Envelope thermal properties of the baseline model

	Baseline Building U [W/m²K]	Standard Requirements U [W/m²K]
External wall	1,09	0,33
Roof	0,97	0,29
Windows	1,95	2,00

2.2 Energy Efficiency Measures (EEMs)

Technically feasible retrofit possibilities of the baseline model were defined in order to achieve energy savings through the improvement of the building envelope properties and of the building systems efficiency and through the exploitation of Renewable Energy Sources (RES). As recommended by the European Commission (2012), single EEMs were combined in packages in order to investigate possible synergy effects. Table 3 lists the single Energy Efficiency Measures and in Table 4 the 13 resulting packages of measures are presented.

Table 3. Single Energy Efficiency Measures (EEMs) applied to the baseline model

EEMs type	Code	Intervention	U [W/m²K]
Envelope	EEM1	External walls insulation (from internal side)	0,32
	EEM2	Walls to unheated insulation	0,32
	EEM3	Roof insulation (from internal side)	0,24
	EEM4	Windows substitution	0,90
Plants	EEM5	Substitution of gas boilers with condensing boilers	
	EEM6	Substitution of heating terminals with radiant ceiling	

	EEM7	Installation of mechanical ventilation system
RES	EEM8	Installation of Solar Thermal (ST) Panels (255 m^2, 100% DHW need)
	EEM9	Installation of Solar Photovoltaic (PV) Panels (153 m^2, 19 kWp)

Table 4. Packages of EEMs applied to the baseline model

Code	Intervention
P1	EEM1 + EEM2 + EEM3 + EEM5
P2	EEM1 + EEM2 + EEM3 + EEM5 + EEM6
P3	EEM1 + EEM2 + EEM3 + EEM4
P4	EEM1 + EEM2 + EEM3 + EEM4 + EEM5
P5	EEM1 + EEM2 + EEM3 + EEM4 + EEM5 + EEM6
P6	EEM1 + EEM2 + EEM3 + EEM5 + EEM8
P7	EEM1 + EEM2 + EEM3 + EEM5 + EEM6 + EEM8
P8	EEM1 + EEM2 + EEM3 + EEM7 + EEM9
P9	EEM1 + EEM2 + EEM3 + EEM5 + EEM7 + EEM9
P10	EEM1 + EEM2 + EEM3 + EEM5 + EEM8 + EEM9
P11	EEM1 + EEM2 + EEM3 + EEM4 + EEM5 + EEM8
P12	EEM1 + EEM2 + EEM3 + EEM4 + EEM7
P13	EEM5 + EEM8

2.3 Energy Evaluation

The energy performances under investigation are those prescribed by the Italian D.Lgs 192/2005, that, transposing the EPBD (European Commission, 2002) to the Italian context, asked to calculate the amount of primary energy required for maintain the whole building at the standard comfort condition during the heating season (i.e. t_{indoor}=20°C). Building configurations were modeled in Docet energy simulation software. The Docet version used was based on the Italian standard UNI/TS 11300 1-2 (CTI 2012, 2008) simplified calculation method. Developed by the national research institutions ITC-CNR and ENEA, it was expressly intended to easily provide Primary Energy (EP_{gl}) values to be used in the Italian Energy Performance Certificates (EPCs). At the time of this research, the Italian EP_{gl} only took into account energy uses for heating and DHW, therefore Docet software only provided information about the delivered energy and primary energy used for these functions (electricity uses for lighting, appliances and cooling are not simulated).

Italian regulation for minimum primary energy requirements and EPCs was updated in October 2015 (requisiti minimi e EPC). Now EPCs have to rate, for non-residential buildings, energy uses for lighting, cooling and elevators for all non-residential.

2.4 Economic Evaluation

Aim of the present work is to define the cost-optimal level of energy performance for an existing hotel building. In accordance with EPBD recast, the cost-optimal framework methodology is based on a comparative methodology framework that is based on the global cost (C_G), or net present value, method. Input data for global cost calculation are shown in formula 1:

$$C_G(\tau) = C_I + \sum_j * \left[\sum_{i=1}^{\tau}\left(C_{a,i}(j)*R_d(i)\right) - V_{f,\tau}(j)\right], \quad (1)$$

where $C_G(\tau)$ represents the global cost referred to starting year τ_0, C_I is the initial investment cost, $C_{a,i}(j)$ is the annual cost for component j at the year i (including running costs and periodic or replacement costs), $R_d(i)$ is the discount rate for year i, $V_{f,\tau}(j)$ is the final value of component j at the end of the calculation period (referred to year τ_0). The discount rate R_d is used to refer the costs to the starting year; it is expressed in real terms, hence excluding inflation.

For the baseline model and for each model implementing EEMs all the data were defined and the global cost was calculated. The calculation period was set as 30 years; 4% discount rate was used; investment costs were taken from Piedmont Price List 2011 (Regione Piemonte 2011); replacement and maintenance costs were derived from EN 15459:2007 Appendix A (CEN 2007); energy costs were calculated by applying to Docet simulation results the following energy tariffs: natural gas cost = 0,091 €/kWh; electricity cost = 0,2 €/kWh.

3 Results

3.1 Energy Evaluation

As a first step, the theoretical delivered and primary energy uses of the baseline model were defined through simulation. Results, presented in Table 5, show the building energy performance related to the typical energy use of the building for heating and DHW production.

Table 5. Simulated delivered and primary energy use of the baseline model

Energy source	Energy use	Delivered energy [kWh/m^2]	Primary energy [kWh/m^2]
Gas	Heating	298,8	299,3
Electricity		0,2	
Gas	DHW	20,9	20,9
EP_{gl}			320,2

By applying the defined EEMs and packages of EEMs to the RB, the achievable energy savings are obtained. In Figure 2 the primary energy needs of the several design options are shown in parallel with the related energy savings and with the neZEH benchmark for retrofitted hotels. As expected, single energy efficiency measures were less effective in reducing the building energy use than packages of measures, in which superposition of effects and synergies allowed to reach savings always higher than 40%. The most efficient EEMs (savings > 30%) are related to the plant system (EEM7 and EEM5). Regarding EEM9, PV panels installation, the evaluated savings are the lowest because of the energy uses taken into account in the simulation (no electricity): positive effects of PV panels can be seen in packages where they are coupled with the mechanical ventilation system (P5, P6). It is also worth noting that 7 packages of measures gave primary energy results lower than Italian neZEH benchmark (< 92 kWh/m^{2}y). The highest energy savings (81%, EP_{gl} = 63 kWh/m^{2}y) were obtained by P12, where heat losses are minimized by insulated envelope and windows and ventilation losses are reduced thanks to the mechanical ventilation system. However, neZEH benchmarks consider all energy flows in the primary energy indicator, while the Italian regulation only takes into account energy for heating and DHW production. Therefore, the neZEH benchmark will not be considered in the cost-optimal graph.

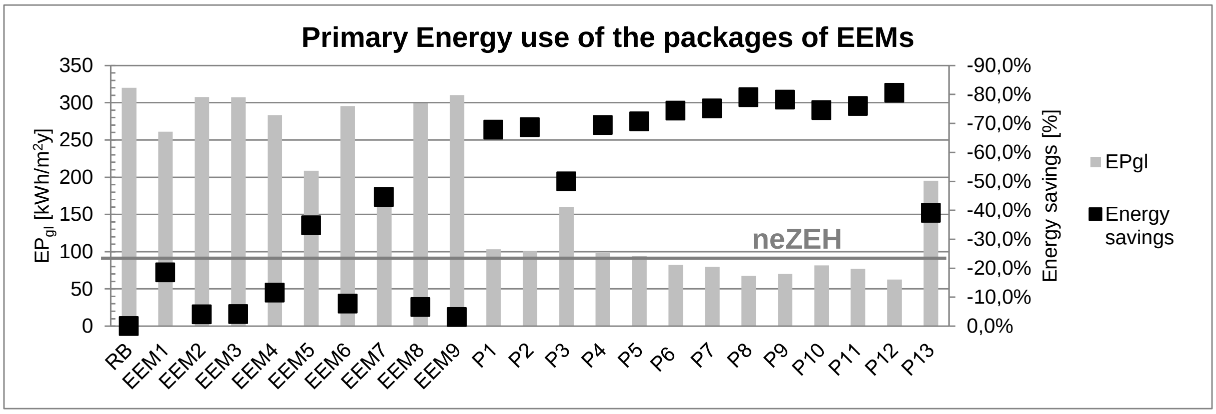

Figure 2. Primary energy use for heating and DHW of the simulated models implementing EEMs and packages of EEMs

3.2 Economic Evaluation

The performed energy analysis was functional to the definition of the cost-optimal level of energy performance of the selected hotel building. Primary energy results for EEMs and packages of measures were plotted versus the calculated global costs, as shown in Figure 3. In the graph, the black vertical line represents the EP_{gl} of the reference building, the dotted black line draws the cost curve and the grey area highlights the cost-optimal level of energy performance, i.e. the primary energy use of the EEMs that minimize the global cost. Results in

Figure 3 highlights that the cost-optimal level for the selected building is reached by 2 options. The lowest global cost is obtained by P1 (235 €/m² and 103 kWh/m²y), implementing to the baseline model opaque envelope thermal insulation and new condensing boilers. P6, where ST panels are added to the features of P1, provides better energy performance (82 kWh/m²y) for a slightly higher global cost (242 €/m²). The graph also provides a rationale for defining the best intervention to invest in. On one hand, packages with similar EP_{gl} may have different global cost (C_G), as exemplified for instance by EMM6 (EP_{gl} = 296 kWh/m²y; C_G = 289 €/m²) and EEM8 (EP_{gl} = 299 kWh/m²y; C_G = 508 €/m²). On the other hand, packages with very similar global cost can differ in energy performances. P5 (EP_{gl} = 94 kWh/m²y; C_G = 300 €/m²) and P13 (EP_{gl} = 195 kWh/m²y; C_G = 297 €/m²) are an example.

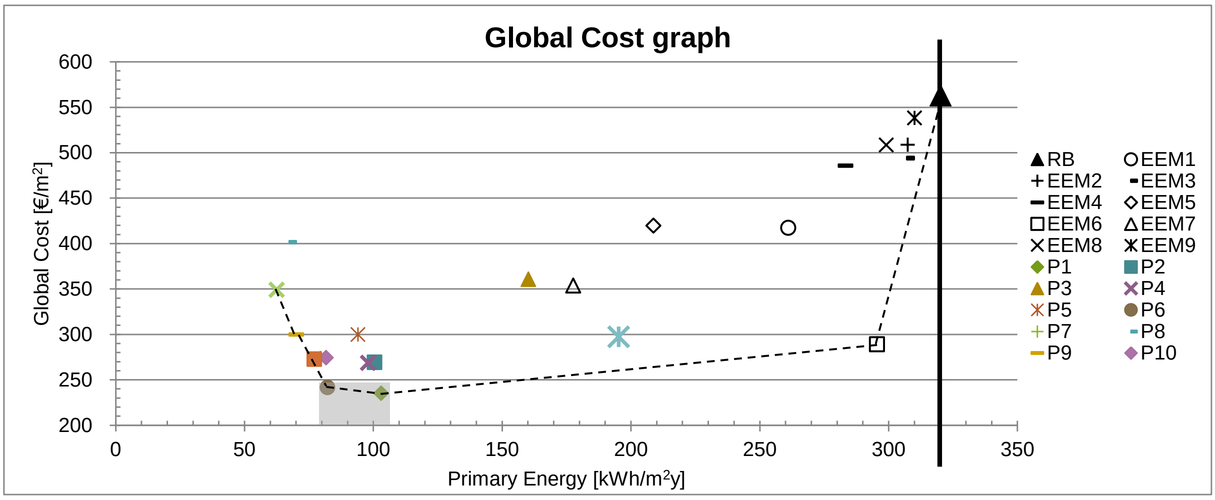

Figure 3. Global Costs of the EEMs and packages of EEMs represented as a function of primary energy consumption

4 Discussion

A cost-optimal exercise was performed for an Italian hotel building in order to test the applicability of general EU disposition regarding nZEB and cost-optimality in a national context and to a specific building type. Results presented above are here interpreted and discussed.

The energy outcomes seem to confirm that also in the case of hotels current technologies related to energy savings, energy efficiency and renewable energies are sufficient to reach, in combination, a suitable target for nearly zero-energy buildings (Ecofys et al. 2013). Nevertheless sound evidences of this statement cannot be presented because of the discrepancy between the energy flows included in primary energy calculation in the neZEH project benchmarks and those considered in the Italian EP_{gl}. This mismatch leads to consider, in the Italian application of neZEH benchmarks, only a fraction of the typical energy use of the building. The issue here raised is consistent with the problem of heterogeneous definitions of nZEB implemented at the national level reported by Jurnitski et al. (2014) and may be partly solved by the new Italian dispositions regarding minimum energy requirements and energy performance certificates. Next steps of the present study should update the method presented in section 2.3 Energy Evaluation.

Another aspect asking for further investigation is whether the typical primary energy use of the building is the proper parameter to be taken into account for energy and cost-optimal evaluation for hotels, and for multipurpose buildings in general. In hotels the energy use for maintaining occupants' comfort is complementary to energy uses for maintaining the quality of offered services. Indeed, for each multipurpose building use, offered services are the characterizing element and their energy consumption is very dependent on the service quality, which in turn is proportional to the economic advantages deriving from them. Therefore, from the private investors standpoint, the whole (typical + extra) building energy use may be considered when economic evaluations of different retrofit design options are compared.

Dealing with the economic evaluation of buildings retrofit, the cost-optimal methodology, used at national level to define the most economically sustainable minimum energy requirements, may not be satisfactory for the private investors' perspective. At the current stage only reduced running cost and higher final value of the building are considered as assets for implementing retrofit measure. For boosting green private investments, extra benefits deriving from the renovation process, such as improved image of the building, new market positioning, increased guest comfort and satisfaction, should be included, with appropriate indicators, in the calculation method. Examples of studies addressing the link between green investments and the quantification of not straight tangible returns flourish in the hotel sector, where, for instances, guests' willingness to pay for sustainable lodging has been deeply investigated (Han et al. 2009, Kang et al. 2012). In the hotel buildings, the impact of benefits on the hoteliers' finances comes from workers and guests' satisfaction and from the building performances, tackling all at once comfort, health, market appreciation and residual value issues.

5 Conclusions

The cost-optimal analysis applied to an Italian existing hotel pointed out that packages of energy efficiency measures have the potential to lead to the energy performance requirements proposed for nearly Zero Energy Hotels and that cost-optimal level of energy performance is able to significantly reduce the building primary energy use (-74%). These findings were critically discussed in view of reaching a realistic and effective energy and economic evaluation for hotel building type: alternatives to the energy use prescribed for calculations by the EPBD recast and to the variables to be included as co-benefits in the global cost methodology are introduced.

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