Guide to building designers & lift owners on how to improve energy efficiency in lift & escalator installation & upgrading

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ENERGY EFFICIENCY IN LIFTS

LOW HANGING FRUIT FIRST

FOREWORD

Lifts are efficient and don't consume much, in comparison with other building services. They only represent some 3% of the energy costs of a typical administrative or large residential building. The use of a counterweight and traction sheave in most applications, results in a very low electricity need to move the lift up or down.

Still, the lift industry has carefully analyzed the ways to further reduce the energy consumption and has published the E4 Report (2010), Energy Efficiency of Elevators & Escalators, with the European Commission and several other partners: Fraunhofer, the Polish and Italian energy agencies and the University of Coïmbra in Portugal. The study measured the energy consumption and patterns of a large number of lifts & escalators in Europe, and analysed the results. The first conclusion is that the consumption of the lift in standby is very important for its total idleness. Therefore, many improvements were thought out, that can be brought to most lifts and will mainly reduce the consumption when the lift is in standby. The components and lifts manufacturers are working at developing new controllers, new motors, new "sleep modes" that will shut all consumption, while keeping the lifts seconds away at most from functioning with all its features.

This Guide gives the building owner, or developer the basic information on "where to look first" in order to reduce the energy consumption of a lift. There are "low hanging fruit" that obviously need to be picked first. Some things should clearly be done first, and this Guide gives the reader a "ranking" for each measure that should be taken, in order to reduce the energy consumption of a lift or an escalator to an absolute minimum.

You will get more information, above all the full E4 Report, by contacting ELA, the European Lift Association, at www.ela-asisbl.org or by email, at info@ela-aisbl.org .

It is also worth consulting ANNEX B of the new ISO Norm 25745-2, dealing with energy efficiency if lifts and giving examples of applications

INTRODUCTION

This document (prELA/QSEE/TR xxxx:2011) has been prepared by ELA/QSEE/WGEE and is a proposal for a technical report to the Technical Committee CEN/TC 10 “Guidelines for New Lift Installations and Retrofitting”, the secretariat of which is held by AFNOR.

This document is an extract of the brochure ENERGY EFFICIENT ELEVATORS AND ESCALATORS from the E4 project: http://www.e4-project.eu

It summarizes the guideline to increase energy efficiency of lifts and escalators. This document is a proposal of the European Lift Association for a CEN Technical Report.

Lifts and escalators are individually engineered systems instead of off‐the‐shelf products or standardized products. Elevators in particular are very heterogeneous systems: they can be standard systems; more individualized systems based on standard components or, in special applications, individually tailored installations where individual components and equipment are used.

This document provides advice on options to increase energy efficiency of new and existing installations. However, recommending standard measures is difficult, if not impossible, due to the large heterogeneity of installations and their usage. Thus, in order to increase energy efficiency, the system as a whole has to be evaluated, taking into account both the energy performance of single components and their interaction, as well as further conditions, starting with frequency of use. There are only few features that are advisable in general.

Therefore, a list is provided, identifying features that are possibly helpful in reducing energy consumption. It has been compiled from the project findings, from discussions with experts and stakeholders (cf. [11]), and from relevant literature (e.g. Nipkow 2005 [12], Guideline VDI 4707 [6], Draft International Standard ISO/DIS 25745‐1[7], Clausnitzer et al. 2009 [13], Barney 2007 [14], Beier 2009 [15]). It is supposed to be used as a checklist for planning new installations or increasing the energy efficiency of existing installations. The checklist claims to be neither conclusive nor exhaustive, nor does it claim general energy efficiency or costeffectiveness of the measures.

In the following, several lists with features that can possibly help increase energy efficiency are provided. These lists are either relevant for lifts, escalators or both systems. Each feature is briefly discussed and commented. Then a recommendation for an energy-efficient solution is given, with an indication under which conditions this feature is especially relevant.

1.1 Common features for energy-efficient installations

1.1.1 Awareness & knowledge

Energy efficiency of installations can be best obtained if energy efficiency is considered from the very beginning of the planning process (see also [16], pp. 60–63). Awareness and knowledge are crucial prerequisites for the appropriate design, selection, operation and maintenance of energy‐efficient equipment.

Table 1 - Energy efficiency: Awareness and knowledge, provides a list of aspects that are not directly linked to the energy performance of individual installations, but that are in general an important contribution to energy efficiency.

Table 1 - Energy efficiency: Awareness and knowledge

<table>
<tr><td>1</td><td colspan="6">Educate sales and design staff</td></tr>
<tr><td></td><td colspan="3">Impact to standby</td><td colspan="3">Impact to travel</td></tr>
<tr><td></td><td>High</td><td>Medium</td><td>Low</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td></td><td>X</td><td></td><td></td><td>X</td><td></td><td></td></tr>
<tr><td></td><td colspan="6">Suitability of function or process for modernisation or refurbishment</td></tr>
<tr><td></td><td>X</td><td></td><td></td><td colspan="3"></td></tr>
<tr><td></td><td colspan="6">The role of a sales person is a very important one when offering and selling technology. During an expert consultation (cf. [9]) it was repeatedly stated that sales personnel are often not sufficiently aware of the consequences of certain technological choices or available technological possibilities.

Recommendation: especially manufacturing companies (but not limited to them) should sensitise their sales and design staff to issues of energy efficiency.</td></tr>
<tr><td></td><td colspan="6"></td></tr>
<tr><td>2</td><td colspan="6">Educate installation and maintenance staff concerning energy efficiency</td></tr>
<tr><td></td><td colspan="3">Impact to standby</td><td colspan="3">Impact to travel</td></tr>
<tr><td></td><td>High</td><td>Medium</td><td>Low</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td></td><td></td><td>X</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td></td><td colspan="6">Suitability of function or process for modernisation or refurbishment</td></tr>
<tr><td></td><td></td><td>X</td><td></td><td colspan="3"></td></tr>
<tr><td></td><td colspan="6">Next to assuring and verifying comfort and safety during maintenance, maintenance personnel should also be sensitised to energy issues. Problems of increasing energy demand can sometimes be found by simple inspection. In addition, maintenance staff is usually closest to the final customer or operator, thus often giving the impetus for taking retrofit measures to increase, among others, energy efficiency.

The role of the staff performing the installation is also very important, especially for lifts. This issue is further discussed in Table 5 - Energy efficiency: Lift installation

Recommendation: sensitise installation and maintenance staff.</td></tr>
<tr><td></td><td colspan="6"></td></tr>
</table>

3	Check benefits of including third party support					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
		X				X
	Suitability of function or process for modernisation or refurbishment					
		X				
	Often offers for new installations or retrofit measures primarily come from the service company or the company known to the customer from earlier transactions. Thus the scope of offers may be limited to the production program of this company (cf. [9]). Checking offers from other companies could be helpful by having a baseline for comparison. Engaging an independent expert lift consultant may help extend the scope of ideas and they can evaluate different available solutions. **Recommendation:** check whether to ask more than one company for an offer and whether to include a third party expert.					

1.1.2 Specification

When looking at specific installations, a first step in determining the best solution in terms of energy efficiency is to check, analyse and discuss the actual requirements and expectations.

Table 2 - Energy efficiency: Specification, provides a list of aspects that contribute to choosing energy efficiency solutions in this specification phase.

Table 2 - Energy efficiency: Specification

4	Check necessity of lift or escalator installation					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
		X				X
	Suitability of function or process for modernisation or refurbishment					
	X					
	The purpose of elevators and escalators is to provide accessibility to all. Any building with two levels or more may need elevators and/or escalators for accessibility reasons. **Recommendation:** in a building where elevators or escalators already exist, it should be discussed first whether already existing installations could be modified or extended to satisfy the transportation capacity while ensuring acceptable waiting time, before adding further installations. **Relevance:** new installations and retrofits located in buildings where more than one vertical transportation systems are found.					

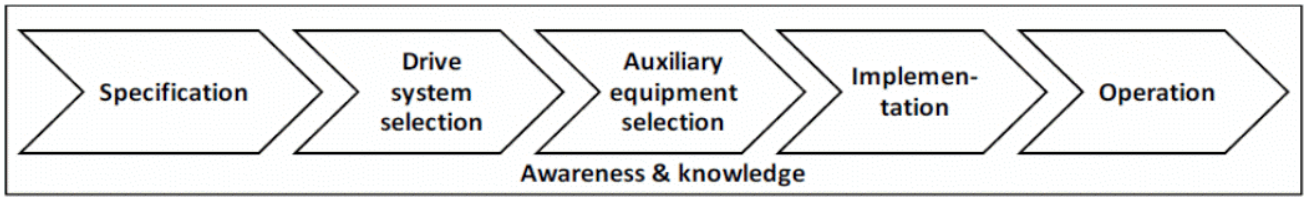
<table>
<tr><td rowspan="7">5</td><td colspan="6">Check location and number of installations</td></tr>
<tr><td colspan="3">Impact to standby</td><td colspan="3">Impact to travel</td></tr>
<tr><td>High</td><td>Medium</td><td>Low</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td></td><td>X</td><td></td><td>X</td><td></td><td></td></tr>
<tr><td colspan="6">Suitability of function or process for modernisation or refurbishment</td></tr>
<tr><td>X</td><td></td><td></td><td colspan="3"></td></tr>
<tr><td colspan="6">Selecting the appropriate location for lifts or escalators can increase comfort and ease for the users and it can help reduce the number of required installations.

Recommendation: in buildings where several lift installations are planned, different arrangements of lifts or escalators can be considered. Reducing the number of installations by one can mean reducing overall consumption, but it has to be addressed together with other aspects, such as building design, accessibility, traffic handling capacity, acceptable waiting time, safety, and so on. The location of the lift and escalator should also be analysed, together with the location of staircases. Easily accessible and attractively designed staircases may contribute to reducing energy consumption due to a lower frequency of use of the lift or escalator.

Relevance: especially relevant for new installations.</td></tr>
<tr><td colspan="6"></td></tr>
</table>

1.2 Specific features for energy-efficient lifts

The previous section dealt with aspects that are relevant both for lifts and escalators. In this section, features that are specifically relevant for lifts are discussed. The roles of specification, awareness and knowledge have already been discussed in the previous section. For lifts, the equipment selection process is further examined, both for the drive system and ancillary equipment. Then issues concerning the installation process are discussed. Finally, measures taken during operation are discussed



Aspects of energy-efficiency through the life-cycle of lifts (source: Fraunhofer ISI)

1.2.1 Design of the drive system

Aspects of drive systems are discussed in

Table 3 - Energy efficiency: Lift drive system, aspects concerning ancillary equipment are treated in Table 4 - Energy efficiency: Lift auxiliary equipment.

Table 3 - Energy efficiency: Lift drive system

<table>
<tr><td>6</td><td colspan="6">Check dimensioning</td></tr>
<tr><td></td><td colspan="3">Impact to standby</td><td colspan="3">Impact to travel</td></tr>
<tr><td></td><td>High</td><td>Medium</td><td>Low</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td></td><td></td><td></td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td></td><td colspan="6">Suitability of function or process for modernisation or refurbishment</td></tr>
<tr><td></td><td></td><td></td><td>X</td><td colspan="3" bgcolor="#d9d9d9"></td></tr>
<tr><td></td><td colspan="6">The dimension of the car, the load and the speed determine among others the requirements for the drive system.

Recommendation: to determine the number of lifts, their relevant car size and speed, the specific needs for accessibility and emergency requirements in combination with a careful analysis of traffic handling and acceptable waiting times has to be carried out. Some exemplary recommendations are given by Nipkow [12], p. 37.

Relevance: especially relevant for new installations, but also for (larger) retrofits.</td></tr>
<tr><td></td><td colspan="6"></td></tr>
<tr><td>7</td><td colspan="6">Check necessity of additional non‑lift comfort equipment</td></tr>
<tr><td></td><td colspan="3">Impact to standby</td><td colspan="3">Impact to travel</td></tr>
<tr><td></td><td>High</td><td>Medium</td><td>Low</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td></td><td></td><td>X</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td></td><td colspan="6">Suitability of function or process for modernisation or refurbishment</td></tr>
<tr><td></td><td></td><td>X</td><td></td><td colspan="3" bgcolor="#d9d9d9"></td></tr>
<tr><td></td><td colspan="6">For reasons of providing information, comfort and design, lifts are sometimes equipped with additional appliances such as permanently running TV screens, music, and other equipment.

Such equipment can have a significant impact on energy consumption, especially when it runs permanently.

Recommendation: check the necessity, consumption patterns/energy efficiency, and frequency of use of this additional equipment to reduce consumption.

Relevance: new installations and retrofits.</td></tr>
<tr><td></td><td colspan="6"></td></tr>
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<table>
<tr><td>8</td><td>
<table>
<tr><td colspan="6">Check for appropriate drive technology</td></tr>
<tr><td colspan="3">Impact to standby</td><td colspan="3">Impact to travel</td></tr>
<tr><td>High</td><td>Medium</td><td>Low</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td>X</td><td></td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Suitability of function or process for modernisation or refurbishment</td></tr>
<tr><td>X</td><td></td><td></td><td colspan="3"></td></tr>
<tr><td colspan="6">As described in Chapter 2, different principles exist to move lift cars. The consumption of drive technology can have a very large impact on energy consumption, especially for installations that are running very often.

Conventional hydraulic lifts have a higher running consumption than conventional traction lifts under comparable conditions (Sachs [2], p. 2, Nipkow [12], p. 7, Brzezina [17]. Nipkow [12], p.35 or ISO Draft International Standard ISO/DIS 25745-1 [7], p. 12). Note that modern hydraulic concepts can provide similar efficiencies to modern traction lifts.

Recommendations: it should be checked which technology is the best choice in terms of energy efficiency in a given case.

Relevance: choosing energy-efficient drive technology is more relevant in the case of new installations and retrofits with medium or high numbers of trips. In case of low frequency of usage (low number of trips), more attention should first be paid to standby consumption.</td></tr>
<tr><td colspan="6"></td></tr>
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</td></tr>
<tr><td>9</td><td>
<table>
<tr><td colspan="6">Check for adequate gearing & roping of the system</td></tr>
<tr><td colspan="3">Impact to standby</td><td colspan="3">Impact to travel</td></tr>
<tr><td>High</td><td>Medium</td><td>Low</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td>X</td><td></td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Suitability of function or process for modernisation or refurbishment</td></tr>
<tr><td></td><td></td><td>X</td><td colspan="3"></td></tr>
<tr><td colspan="6">A gear is used to transform the torque-speed ratio of a motor. In traction lifts, this gear is found between the motor and the traction wheel. A gear has moving parts, causing friction and thus causing energy losses; the overall amount of losses depends among others on the type of gearing used. Using a high efficiency gear or removing a gear can thus increase energy efficiency. Roping, that is, the configuration of how car and counterweight are connected to the motor, has a function similar to gearing, as it can help reduce the required torque of the motor. Modern traction systems are nowadays offered as gearless systems, using high torque motors to move the car.

Recommendation: using the right combination of gearing, roping and pulleys to achieve optimal energy efficiency and functionality is a complex task. Nipkow [12] p. 38 proposes using planetary gears or gearless systems to increase energy efficiency.

Discussing different solutions should help increase energy efficiency.

Relevance: especially relevant for new installations but also for (larger) retrofits.</td></tr>
</table>
</td></tr>
</table>

10	Check system architecture					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
		X				X
	Suitability of function or process for modernisation or refurbishment					
			X			
	Ropes or hydraulic cylinders can be connected to the car in different places. They are either connected in a central position (in the middle of the car) or laterally. **Recommendation:** according to Clausnitzer et al. [13], p. 44 and Nipkow [12], p. 38, using a central connecting point reduces friction and thus reduces energy consumption. **Relevance:** especially relevant for new installations but also for (larger) retrofits.					
11	Check usage of high efficiency & properly sized motor					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
		X		X		
	Suitability of function or process for modernisation or refurbishment					
		X				
	The efficiency of the motor driving a lift system is a key component for energy consumption. The motor efficiency means the ratio between electrical input power and mechanical output power of the shaft. The higher the efficiency rating, the lower the losses during operation. The efficiency rating outside the nominal operating point is variable. Overdimensioning motors can, however, provide additional thermal operating safety according to Nipkow [12], p. 25. **Recommendation:** the chosen motors should have a high efficiency both in terms of full load efficiency but also in terms of part - load efficiency. **Relevance:** especially relevant for new installations but also for (larger) retrofits.					

<table>
<tr><td>12</td><td>
<table>
<tr><td colspan="6">Check benefits of using regenerative drives</td></tr>
<tr><td colspan="3">Impact to standby</td><td colspan="3">Impact to travel</td></tr>
<tr><td>High</td><td>Medium</td><td>Low</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td></td><td></td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td colspan="6">Suitability of function or process for modernisation or refurbishment</td></tr>
<tr><td>X</td><td></td><td></td><td colspan="3"></td></tr>
<tr><td colspan="6">Regenerative drives are systems that can convert or store braking energy from a moving lift car.

In conventional traction lifts, braking energy is dissipated by a braking resistor. A regenerative system allows energy to be recovered and fed back either into the building or into the electrical grid, depending on the configuration and local regulations. Nipkow [12], p. 35, estimates that the degree of energy recovery (as the relation of recovered energy to overall energy demand for travelling up and down) for small lifts (630 kg, 1,6 m/s) is below 30% while for large installations (2.200 kg, 2,5 m/s), it can be up to 40%. Recovery is possible during a period of stable running, thus decreasing the recovery potential for lifts with shorter shafts.

In conventional hydraulic systems, braking energy from a descending car is dissipated via a throttling valve. Recent hydraulic solutions allow, for example, accumulating pressure in a storage vessel due to a descending car. This pressure can reduce the energy consumption to hoist the car during the next usage.

Recommendation: especially for often running, large installations; using a drive system with regenerative capabilities is a possibility to reduce energy consumption.

It is advised to check whether it is possible and permitted to use the recovered energy and it should be discussed whether the usage of the regeneration technology leads to higher standby consumption or not.

Relevance: especially relevant for new installations but also for (larger) retrofits.</td></tr>
<tr><td colspan="6"></td></tr>
</table>
</td></tr>
</table>

13	Check usage of a frequency converter with automatic standby function					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
		X			X	
	Suitability of function or process for modernisation or refurbishment					
	X					
	Modern lift installations are often equipped with frequency converters. These units allow for a controlled start and operation of motors, thus providing controlled movement of the car and increasing comfort. Furthermore, they reduce slip losses during motor start - up. The use of frequency converters can lead to additional standby consumption. Modern units provide an auto standby function, this means that internal components automatically switch to reduced or no consumption when not needed. **Recommendation:** using frequency converters without standby can help decrease standby energy consumption **Relevance:** especially relevant for new installations but also for (larger) retrofits.					
14	Check usage and optimisation of counter - balancing					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
	X			X		
	Suitability of function or process for modernisation or refurbishment					
			X			
	A counter - balance reduces the load the lift drive system has to move when the lift is running. This allows the use of smaller motors and less energy is required to operate the system. Often a counter - balance has the same mass as a lift car plus half of the nominal load. Therefore, it requires less energy when the lift is carrying half of the payload. In practice, lifts often travel empty to their destination floors, or they transport only a small number of passengers, thus the actual average load is below 50% Adjusting the mass of the counterweight can thus be an option to reduce the average motor load and to reduce energy requirements. **Recommendation:** consider using a counter - weight to reduce the load the drive system has to lift and optimise it in accordance with the actual usage requirements. **Relevance:** especially relevant for new installations but also for (larger) retrofits.					

15	Reducing the mass of the car					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
	X		X	X		
	Suitability of function or process for modernisation or refurbishment					
			X			
	In systems without a counter‑weight, the motor has to lift both the weight of the cabin as well as the additional payload. Therefore, the reduction in cabin weight, by using for example light weight materials, can increase energy efficiency, provided that both stability and safety remain unaffected. In addition, a reduced mass can decrease energy demand for acceleration and deceleration, also in systems with a counter‑weight. **Recommendation:** check benefits of using a car with reduced mass. **Relevance:** especially relevant for new installations and (larger) retrofits that are often used and that do not have a counter‑weight.					

1.2.2 Design of ancillary lift equipment

Table 4 - Energy efficiency: Lift auxiliary equipment

16	Use energy‑efficient lighting & appropriate surface material					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
		X				X
	Suitability of function or process for modernisation or refurbishment					
	X					
	Lighting can be one of the most important energy consumers in a lift, especially when it is burning 24 hours a day. Reducing the required lighting power is thus an important option to increase energy efficiency. Modern lighting technology like compact fluorescent lamps or LED technology can reduce energy consumption. Avoiding dark surface materials and textures in the car interior can also contribute to reducing the energy consumption required by lighting. **Recommendation:** the most energy‑efficient solution for permanently running lighting is to use LED lighting. Using energy‑efficient lighting and switching it off is a complementary solution (see also item 22). **Relevance:** very relevant for new installations and also for minor retrofits. A replacement of the lighting equipment can also be easily accomplished in existing installations. This measure is estimated					

	to be very cost effective.					
17	Avoid stalled motor door operator					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
		X				X
	Suitability of function or process for modernisation or refurbishment					
		X				
	Arbitrarily opening doors are a safety hazard in lifts. Therefore, car doors have to remain shut while the car is moving, for safety reasons. Some locking mechanisms rely on a stalled motor to keep doors closed, also when the car is not in use [13]. Therefore, these systems require energy permanently. **Recommendation:** using door‑locking mechanisms that do not permanently require energy for the locking mechanism when the lift is not in use. **Relevance:** this is both relevant for new installations and (smaller) retrofits.					
18	Use energy‑efficient transformer and power supply					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
		X				X
	Suitability of function or process for modernisation or refurbishment					
		X				
	Some lift circuits require low voltage energy that is supplied by a transformer or power supply. **Recommendation:** the efficiency of this transformer or power supply during operation should be selected as high as possible, while standby consumption should be low (cp. [12], p. 34). **Relevance:** this is both relevant for new installations and (smaller) retrofits.					
19	Use energy‑efficient components for all other components and equipment					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low

		X				X
	Suitability of function or process for modernisation or refurbishment					
		X				
	An installation includes further equipment, such as ventilation systems, operating panels, buttons, intercoms, etc. that are not discussed in detail in this document. However, it may be worthwhile to check the energy efficiency of these components as well. **Recommendation:** for ventilation, high ‑ efficiency motors should be used. Operating panels, buttons and other auxiliary equipment should also be selected to be as energy ‑ efficient as possible. **Relevance:** this is both relevant for new installations and retrofits.					

1.2.3 Installation

When energy ‑ efficient equipment is selected, the equipment has to be properly installed to make use of its full energy ‑ saving potential. Table 5 - Energy efficiency: Lift installation, discusses the role of installation quality and the lift ‑ building interface.

Table 5 - Energy efficiency: Lift installation

20	Ensure installation quality					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
			X			X
	Suitability of function or process for modernisation or refurbishment					
	X					
	A factor influencing the energy consumption of a lift is the quality of the installation. A bad installation quality often has a negative impact on energy consumption. If guiding rails are for example poorly installed, additional friction is induced, thus more energy is needed to move the car. **Recommendation:** the installation of a system should be accomplished by personnel with the appropriate qualifications. Otherwise, energy losses are likely to occur due to bad installation quality, sometimes even negating the effects of the selected energy ‑ efficient equipment. **Relevance:** all lift installations.					
21	Interface lift and building: shaft ventilation, smoke clearance, shaft insulation					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
			X			X

	Suitability of function or process for modernisation or refurbishment			
			X	
	Ventilation of the lift shaft has two purposes: first, to provide fresh air to the lift shaft and the cabin, second to remove smoke from the building in case of fire. Ventilation is in the simplest case, accomplished by a permanently opened hole in the building shell. Therefore, depending on the configuration, this opening can lead to uncontrolled thermal losses. As the shaft and its features are a part of the building, lift companies often do not feel responsible for this issue. However, as this is induced by lift installations, building planners and constructors do not feel responsible either. As this can lead to considerable losses, this aspect also needs to be taken into account. Furthermore, shaft walls are heat ‑ conducting parts of the building that are often forgotten when the building is insulated [13]. **Recommendation:** the lift system needs to be closely monitored also regarding its integration into the building as a whole. Uncontrolled ventilation and losses by heat conduction should be avoided. **Relevance:** all lift installations.			

1.2.4 Operation

Next to their energy efficiency, the running time and usage of these components are very important factors for overall energy demand. A list of different operational and organisational measures to reduce energy consumption can be found in Table 6 - Energy efficiency: Lift operation.

Table 6 - Energy efficiency: Lift operation

22	Switching off car lighting when not in use					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
		X				X
	Suitability of function or process for modernisation or refurbishment					
	X					
	Some light sources such as modern LEDs can be dimmed and switched off without reducing their life time. Provided that such light sources are installed in a lift, switching off the car lights when a lift is not in use can lead to significant energy savings (see also [11]). Sensors may be installed to verify whether a person is in the car. In the case of glass cars, sensors may also be used to check the lighting provided by external sources and to adjust lighting accordingly. **Recommendation:** switching off car lighting is a very cost ‑ effective and simple method to increase energy efficiency. **Relevance:** all lift installations.					

23	Use automatic car fan control / switch - off fan					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
		X				X
	Suitability of function or process for modernisation or refurbishment					
		X				
	Sometimes, a fan provides fresh air to the car. Independently of its efficiency, it is permanently using energy when running. **Recommendation:** using an automatic control system (e.g. time or temperature controlled) for operating the car fan, if available, can reduce energy consumption. **Relevance:** all lift installations.					

24	Switch off other lift components when not in use					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
		X				X
	Suitability of function or process for modernisation or refurbishment					
		X				
	Stand‐by consumption can be a main driver of energy consumption; various strategies to switch off components exist. For shorter periods of non‐usage, only some of the components may be switched off (“sleep mode”). Putting the lift back into standby operation will require only a short period of time (some seconds). For longer periods, for example during the night, more components can be switched off, (“deep‐sleep mode”). **Recommendation:** components not in use should be switched off while the lift is not operating, while ensuring the safe operation of the lift. **Relevance:** all installations.					
25	Switch off comfort equipment when not required					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
			X			X
	Suitability of function or process for modernisation or refurbishment					
			X			
	As pointed out above, it should also be checked whether non‐lift comfort equipment must necessarily run 24 hours a day or if it can be put into sleep mode as well. **Recommendation:** check switching off comfort equipment. **Relevance:** all installations.					

26	Switch temperature control of machine room according to requirements					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
		X				X
	Suitability of function or process for modernisation or refurbishment					
		X				
	Due to energy losses, heat is accumulated in the machine room. To avoid components from overheating or freezing, machine rooms sometimes need to be climate controlled. The settings for the temperature control should be adjusted appropriately for the equipment. Too narrow limits lead to higher energy demand than necessary. **Recommendation:** use temperature control in the machine room only when the temperature levels move outside acceptable limits. **Relevance:** all installations.					
27	Operate oil heater and cooler only when required					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
	X				X	
	Suitability of function or process for modernisation or refurbishment					
		X				
	In hydraulic systems, hydraulic fluids are best used in certain temperature intervals (due to reasons of viscosity and safety of operation). To assure an adequate oil temperature, heating and cooling devices are used to keep temperature at a steady level. **Recommendation:** oil heating and cooling should only be engaged when the oil temperature leaves the normal operating temperature. **Relevance:** relevant both for new and existing installations with oil heaters and coolers.					

28	Switch off car roof light/ shaft illumination after service					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
		X				X
	Suitability of function or process for modernisation or refurbishment					
	X					
	The shaft and sometimes also the car roof have lighting which is necessary for service and maintenance work. This lighting should be switched off if not needed. **Recommendation:** check if illumination is switched off after service or use an automatic switch - off function. **Relevance:** all installations.					
29	Check correct type and adequacy of lubrication					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
			X	X		
	Suitability of function or process for modernisation or refurbishment					
	X					
	Adequate lubrication (if required) of the guiding rails should be part of the regular maintenance programme to avoid unnecessary losses due to friction. **Recommendation:** check adequate lubrication where required. **Relevance:** all installations where lubrication is required.					
30	Optimise traffic handling and management					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
	X			X		
	Suitability of function or process for modernisation or refurbishment					
	X					
	Optimising traffic handling and management can be both relevant for single installations as well for groups of installations. For lift groups energy consumption can be reduced by putting one or more					

	installations into a sleep or deep ‑ sleep mode during periods with low traffic, for example, during night time or at weekends, thus reducing or completely avoiding standby losses. **Recommendation:** check possibilities to use or switch off lifts and to optimise traffic handling. **Relevance:** new and retrofit installations where more than one transportation system is available.					
31	Check benefits of using condition monitoring					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
		X			X	
	Suitability of function or process for modernisation or refurbishment					
	X					
	Modern technological solutions such as condition monitoring provide the possibility to check the state of operation of a lift. Irregularities in the mode of operation can also indicate problems that affect the energy efficiency of the installation. **Recommendation:** check benefits to use condition monitoring and to include information on energy consumption. **Relevance:** new installations and retrofits.					

1.3 Features specific to energy-efficient escalators

Escalators are primarily found in locations operated by owners who have dedicated experts for energy issues (for example, commercial shopping centres or public traffic infrastructure). The running time of escalators is usually much longer than that of most lifts. A number of aspects concerning both lifts and escalators have already been discussed in Table 7 - Energy efficiency: Escalator drive system and Table 8 - Energy efficiency: Other aspects of escalators presents additional aspects specific to escalators.

1.3.1 Drive system

Table 7 - Energy efficiency: Escalator drive system

1	Use high efficiency & properly sized motor					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
			X	X		
	Suitability of function or process for modernisation or refurbishment					
			X			

	As with lifts, the drive motors in escalators plus the hand rail motor should be selected from the most energy‐efficient motors. This is relevant for both the main motor for moving the stairs as well as the hand rail drive. In addition, a motor should be chosen that also provides a good efficiency ratio when running outside the nominal point of operation. **Recommendation:** motors should be chosen to have a high efficiency both in terms of full load efficiency, but also in terms of part‐load efficiency. **Relevance:** relevant for new installations and (larger) retrofits.

<table>
<tr><td>2</td><td>
<table>
<tr><td colspan="6">Check for adequate gearing</td></tr>
<tr><td colspan="3">Impact to standby</td><td colspan="3">Impact to travel</td></tr>
<tr><td>High</td><td>Medium</td><td>Low</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td></td><td></td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td colspan="6">Suitability of function or process for modernisation or refurbishment</td></tr>
<tr><td></td><td></td><td>X</td><td colspan="3"></td></tr>
<tr><td colspan="6">As in geared lifts, gears are used in escalators to transform a torque ‑ speed ratio.

Recommendation: gearing in escalators should be very efficient due to the high share of running time. Planetary, helical and hypoid helical gears can for example reach higher efficiencies than worm gears.

Relevance: relevant for new installations but also for (larger) retrofits.</td></tr>
<tr><td colspan="6"></td></tr>
</table>
</td></tr>
<tr><td>3</td><td>
<table>
<tr><td colspan="6">Check benefits of using variable speed drives / low speed mode / stop mode</td></tr>
<tr><td colspan="3">Impact to standby</td><td colspan="3">Impact to travel</td></tr>
<tr><td>High</td><td>Medium</td><td>Low</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td></td><td></td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Suitability of function or process for modernisation or refurbishment</td></tr>
<tr><td>X</td><td></td><td></td><td colspan="3"></td></tr>
<tr><td colspan="6">When using a variable speed drive, the speed of the escalator can be reduced until the next passenger arrives. However, an additional frequency converter is necessary to thus adjust speed. This additional energy consumption has to be compared to possible gains.

As an alternative or complementary option, it is also possible to set the escalator in a stop mode.

Recommendation: check the benefits of using variable speed drives and using a low ‑ speed mode and / or a stop mode.

Relevance: relevant for new installations but also for (larger) retrofits.</td></tr>
<tr><td colspan="6"></td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td>4</td><td colspan="6">Check benefits of using regenerative drives</td></tr>
<tr><td></td><td colspan="3">Impact to standby</td><td colspan="3">Impact to travel</td></tr>
<tr><td></td><td>High</td><td>Medium</td><td>Low</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td></td><td></td><td></td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td></td><td colspan="6">Suitability of function or process for modernisation or refurbishment</td></tr>
<tr><td></td><td>X</td><td></td><td></td><td colspan="3"></td></tr>
<tr><td></td><td colspan="6">Escalators transporting loads in a downward direction offer the possibility to generate energy. Induction motors have an inherent regenerative capability that can be improved by using regenerative drives. This recovered energy can be used in the building, for other escalators, or it can be fed back into the power grid.

Recommendation: check the benefits of using a regenerative solution.

Relevance: relevant for new installations and for (larger) retrofits.</td></tr>
<tr><td></td><td colspan="6"></td></tr>
<tr><td>5</td><td colspan="6">Use high - efficiency bearings</td></tr>
<tr><td></td><td colspan="3">Impact to standby</td><td colspan="3">Impact to travel</td></tr>
<tr><td></td><td>High</td><td>Medium</td><td>Low</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td></td><td></td><td></td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td></td><td colspan="6">Suitability of function or process for modernisation or refurbishment</td></tr>
<tr><td></td><td></td><td></td><td>X</td><td colspan="3"></td></tr>
<tr><td></td><td colspan="6">Bearings are a source of losses in escalators.

Recommendation: use low friction bearings for the operation of the escalator.

Relevance: all installations.</td></tr>
<tr><td></td><td colspan="6"></td></tr>
</table>

1.3.2 Other aspects

Table 8 - Energy efficiency: Other aspects of escalators

<table>
<tr><td rowspan="9">6</td><td colspan="6">Check benefits of adjusting operation mode to load and passengers</td></tr>
<tr><td colspan="3">Impact to standby</td><td colspan="3">Impact to travel</td></tr>
<tr><td>High</td><td>Medium</td><td>Low</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td></td><td></td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Suitability of function or process for modernisation or refurbishment</td></tr>
<tr><td></td><td></td><td>X</td><td colspan="3" rowspan="2"></td></tr>
<tr><td colspan="3">During periods with small loads or no load at all, speed and torque can be adjusted by various means, for example, by using a pole‑switching motor, variable speed drives, or by adjusting the voltage settings of the motor (star‑delta switching).

Recommendation: check benefits of adjusting speed and torque to current load situations.

Relevance: all installations.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="9">7</td><td colspan="6">Use energy‑efficient lighting</td></tr>
<tr><td colspan="3">Impact to standby</td><td colspan="3">Impact to travel</td></tr>
<tr><td>High</td><td>Medium</td><td>Low</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td></td><td>X</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Suitability of function or process for modernisation or refurbishment</td></tr>
<tr><td>X</td><td></td><td></td><td colspan="3" rowspan="2"></td></tr>
<tr><td colspan="3">Some escalators are equipped with additional light sources to illuminate the steps.

Recommendation: use energy‑efficient lighting systems (LEDs for example).

Relevance: all installations.</td></tr>
<tr><td colspan="3"></td></tr>
</table>

8	Use sleep‑mode on escalator equipment					
	Impact to standby			Impact to travel		
	High	Medium	Low	High	Medium	Low
	X					X
	Suitability of function or process for modernisation or refurbishment					
	X					
	For escalators that are set into a stop mode (e.g. outside of regular opening times), some components (e.g. frequency converter, lighting) could be switched off to minimize energy demand. **Recommendation:** switch off components when lifts are outside their normal operating times (e.g. during night time). **Relevance:** new installations and retrofits with suitable equipment.					

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