Elevators and Escalators Energy Performance Analysis

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ABSTRACT

Elevators and escalators are the crucial element that makes it practical to live and work several floors above ground. In the EU-25 there are more than 4,8 million elevators and 75 thousand escalators and moving walks.

Elevators use about 4% of the electricity in tertiary sector buildings. This paper presents a technical analysis to the final results of the audits performed in the scope of IEE project E4, whose overall objective is the improvement of the energy performance of elevators and escalators, in the tertiary sector and in the multifamily residential buildings. A total of 82 equipments have been measured, and a collection of load curves, including the characterization of standby consumption, is also presented. There is a high energy savings potential with respect to energy-efficient technologies, investment decisions and behavioral approaches, in these sectors. The E4 project characterized people conveyors electricity consumption in the tertiary sector and in residential buildings in the EU-27, according to a common developed methodology. Standby consumption of an elevator can represent up to 80% of the total energy consumed per year, and can be drastically reduced (more than 65% is possible), by reducing the standby consumption and using more energy efficient technologies.

Introduction

Today, about 4,8 million lifts, as well as about 75.000 escalators and moving walks installed in the EU-27. Taking into account demographic trends as well as a growing need for convenience, it is expected that the number of lifts and escalators will be rising worldwide, as well as in Europe. Further urbanization in developing countries and a growing awareness for accessibility issues due to an aging population in Europe will foster the need for more of this equipment.

Their energy consumption is now estimated at 3 to 5 % of the overall consumption of a building (Sachs 2005)(E4 project 2009, D3.2). About one third of the final energy consumption in the Community is used in the tertiary and residential sector, mostly in buildings. Due to the increased comfort requirements, energy consumption in buildings recently experienced a significant increase, being one of the leading reasons for a growing amount of CO2 emissions. High untapped saving potentials exist with respect to energy-efficient equipment, investment decisions and behavioural approaches, in these sectors.

The E4-project is targeted at the improvement of the energy performance of lifts and escalators, in the tertiary sector buildings and in the multi-family residential buildings. This paper is aimed at presenting the main results of the project, with a particular focus on tertiary sector buildings.

European Elevator and Escalator Market

A survey was conducted with the cooperation of national lift and escalator member associations of the European Lift Association (ELA) in 19 European countries – Germany, Austria, Belgium, Czech Republic, Denmark, Finland, France, Greece, Hungary, Italy, Luxembourg, Netherlands, Poland, Portugal, Spain, Sweden, UK, Norway and Switzerland. The purpose of this survey was to assist in the characterization of the installed base, according to the building type and basic characteristics of the installed units.

According to the surveys there are around 4,5 million lifts installed in the 19 countries surveyed. Figure 1 shows the distribution of the lifts installed in each of the surveyed countries, by sector.

Figure 1 Lift Distribution by Sector

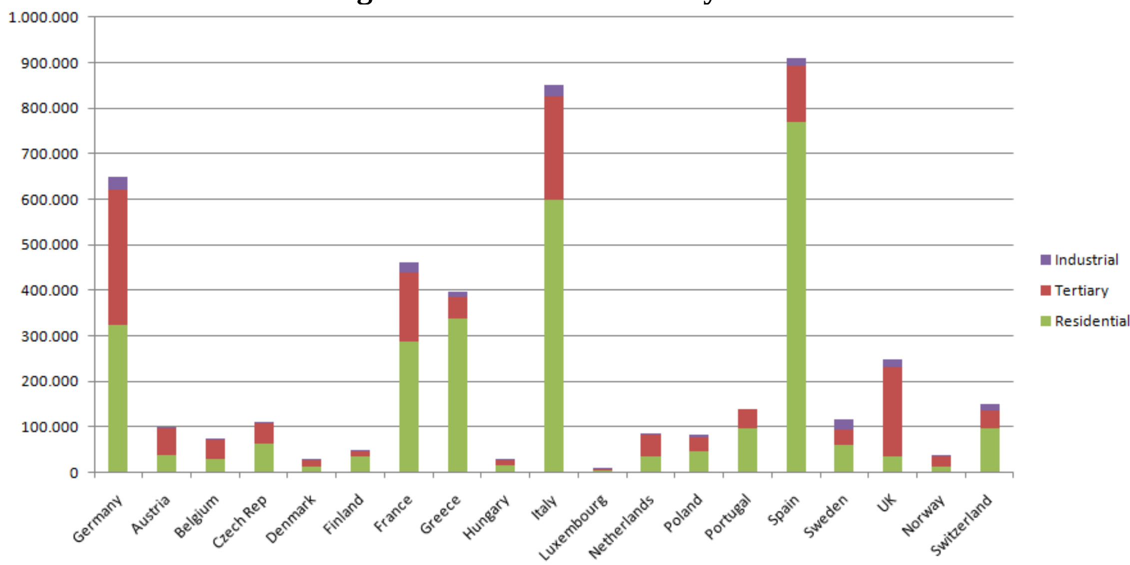
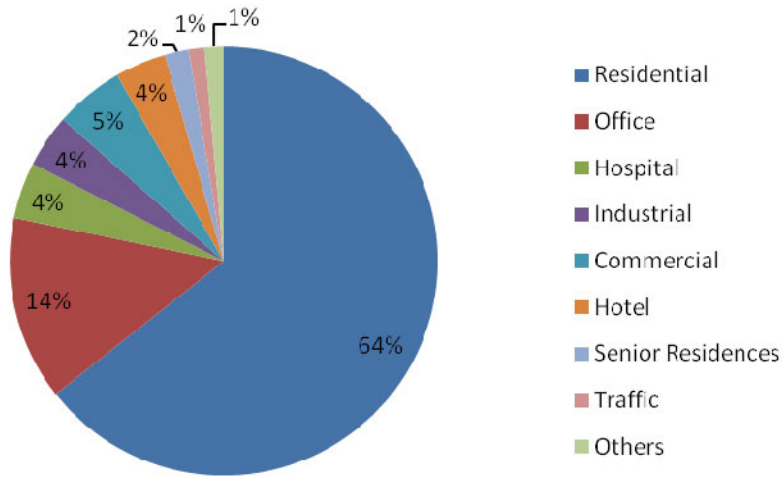


Figure 2 shows the distribution of the installed lifts according to building type. Residential lifts represent the by far the largest group with just under 2,9 million lifts in use. The Tertiary sector comes next with around 1,4 million lifts installed and the industrial sector has only 180.000 lifts.

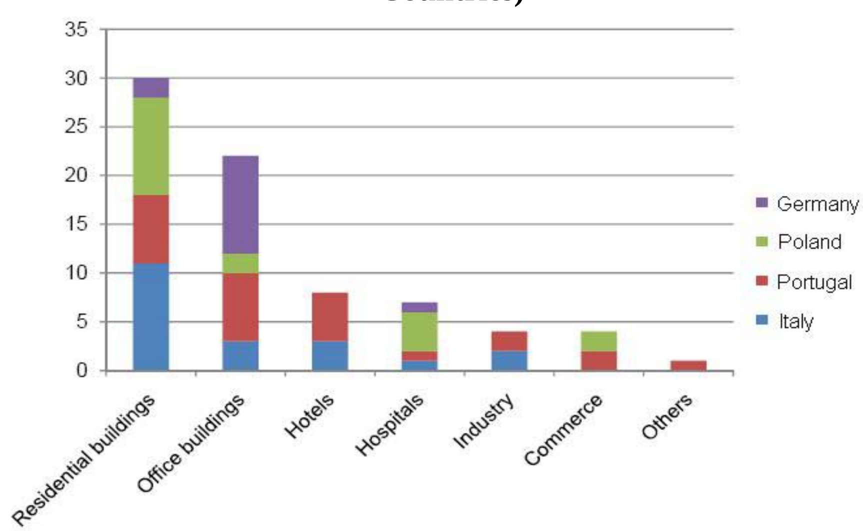
Figure 2 Lift Distribution According to Building Type



Energy Consumption of Elevators and Escalators in the Tertiary Sector

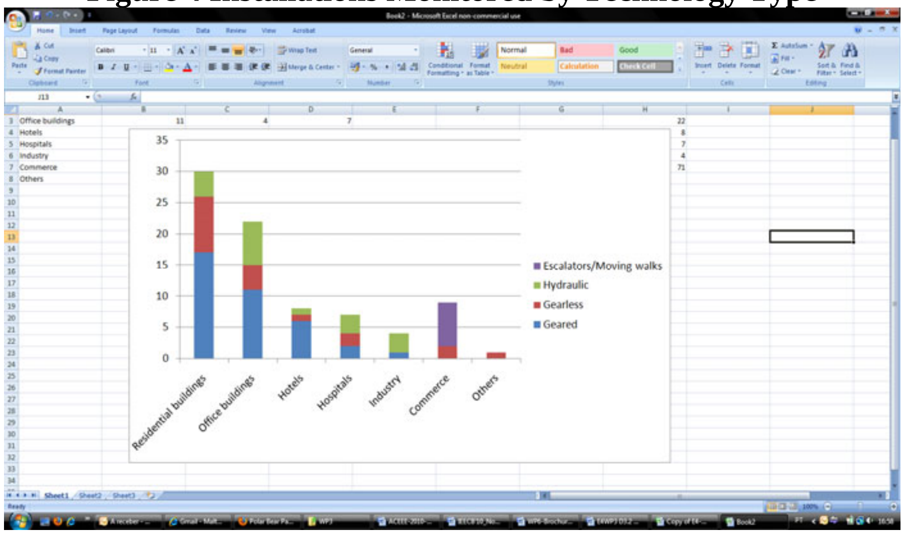
Monitoring campaigns were carried out as a contribution to improve the understanding of energy consumption and energy efficiency of lifts and escalators in Europe. The aim of this campaign is to broaden the empirical base on the energy consumption of lifts and escalators, to provide publicly available monitoring data and to find hints on high efficiency system configurations. Originally, 50 installations were planned to be monitored within the project. In the end, 74 lifts and 7 escalators, i.e. a total of 81 installations, were analyzed in the four countries under study: Germany, Italy, Poland and Portugal. Figure 3 shows the monitored installations by building category and country for all countries doing measurements in the project.

Figure 3 Monitored Lifts by Building Category (All Monitored Installations in the Four Countries)



An effort was made to select lifts for this study from different years and using different technologies in order to be able to compare the performance of a wide range of lifts with different characteristics. Figure 4 shows the segmentation of the units monitored by technology type.

Figure 4 Installations Monitored by Technology Type



A common methodology was used by all partners to ensure the repeatability of the measurements (Krzysztof 2008). The methodology considers energy measurement relating to the normal operation of the elevator, escalator and moving walk including:

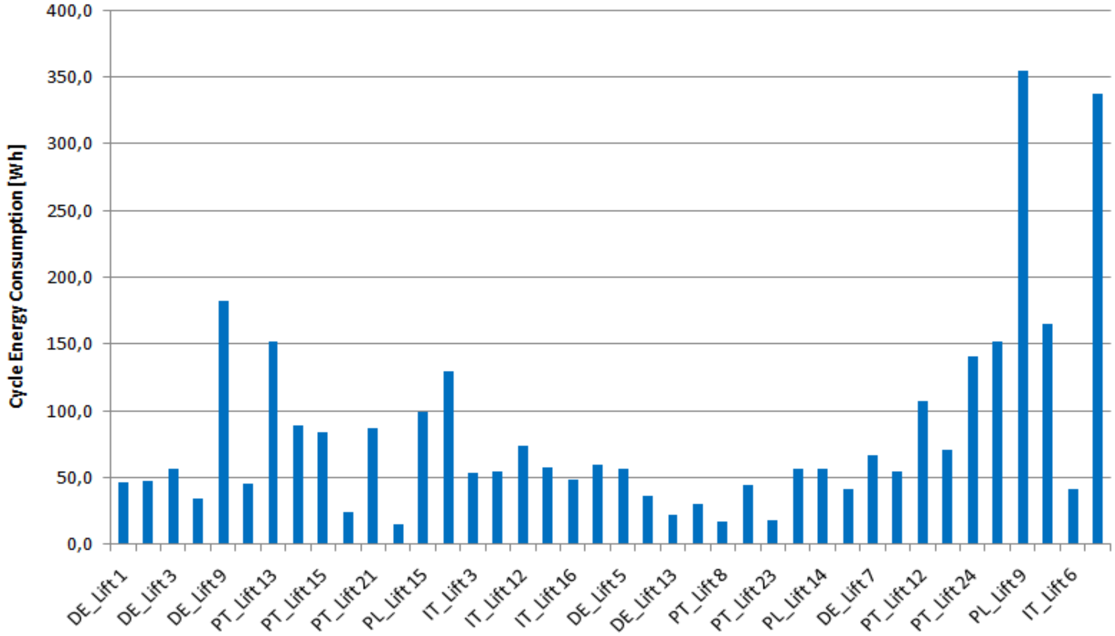
- Main energy - elevating/escalating/moving walk equipment such as: motor, frequency converter, controls, break and door.
- Ancillary energy - car auxiliary equipment such as: light, fan, alarm system, etc.

The reference measurement cycle for elevators, starting at the bottom landing, consists of:

1. Opening the Door
2. Closing the Door
3. Driving the car from the bottom landing to the top landing
4. Opening the Door
5. Closing the Door
6. Driving the car from top landing to the bottom landing

Figure 5 shows the travel cycle consumption of the lifts audited in the tertiary sector.

Figure 5 Travel Cycle Consumption of the Lifts Audited in the Tertiary Sector



It is clear that there are large differences between the energy consumption of the different elevators analyzed. Even if this consumption is compared with elevators of the same rise height, same velocity or same nominal load, the conclusions are not clear about what technology is more efficient as there are a lot more factors to be included in the analyses, such as lighting or type of control.

The measured standby power also varies widely (Figure 6). This standby consumption is due to the control systems, lighting, floor displays and operating consoles in each floor and inside the elevator cabin. In the analyzed elevators the standby power ranges from 60W to 490W in the elevators audited in the tertiary sector.

Figure 6 Measured Standby Power in the Lifts Audited in the Tertiary Sector

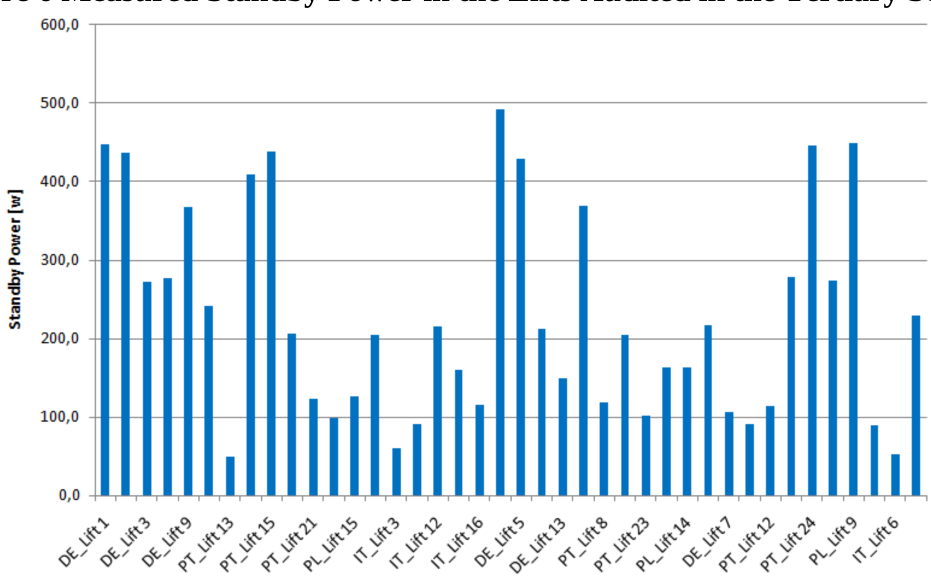
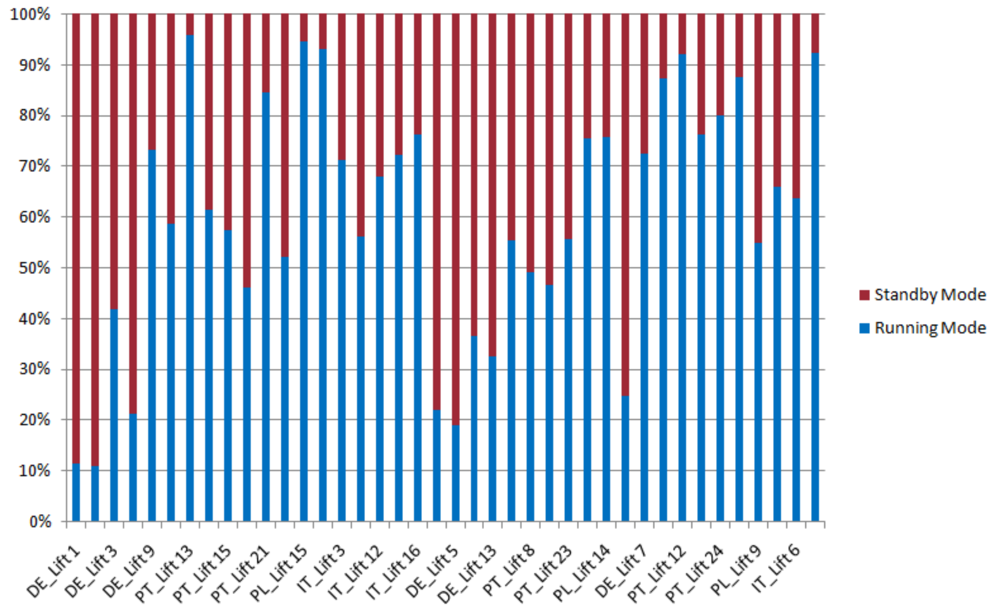


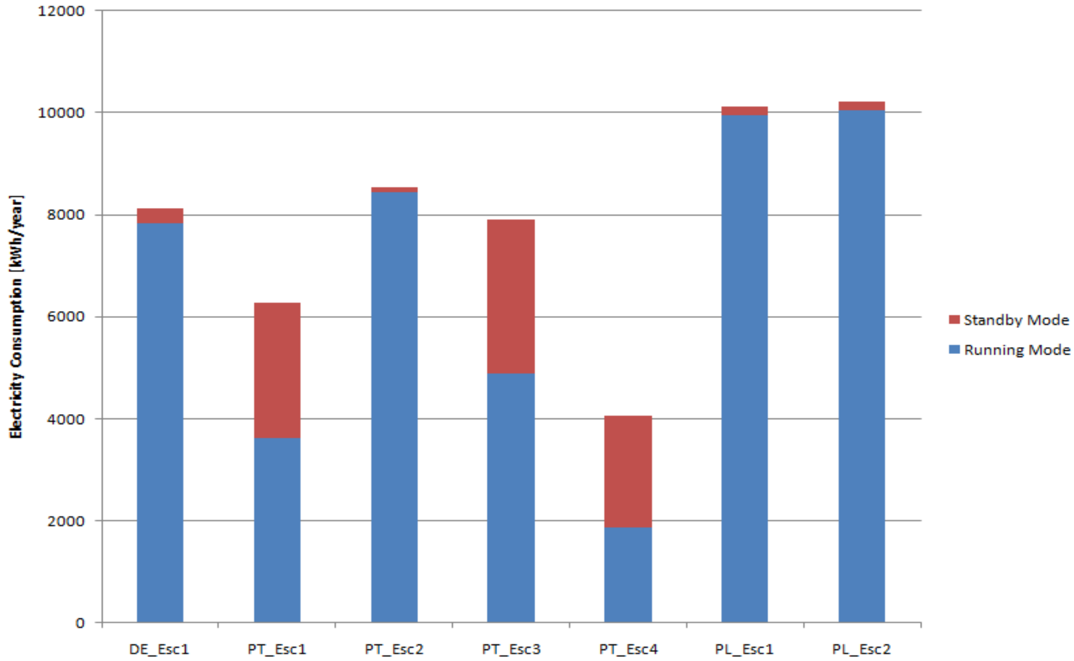
Figure 7 shows the standby consumption and the running mode consumption, in proportion to the overall consumption of the elevators audited in the tertiary sector. Standby consumption varies from 11% to 95%. These differences originate especially from different usage patterns (the higher the number of trips, the higher in tendency the running consumption) on the one hand, and from the different consumption values during running and standby on the other.

Figure 7 Share of Elevator Running and Standby Annual Electricity Consumption.



For escalators, the power consumption was determined in different states of operation. These modes of operation include measurements over a period of 5 minutes when running at nominal speed, in a stop mode and finally, if available, in a low speed mode. Measurements were made for empty escalators only. To take passenger load into account as found in real systems, annual consumption values were calculated by multiplying running-consumption with a typical load factor. The estimated annual electricity consumption of the escalators audited is shown in Figure 8.

Figure 8 Annual Electricity Consumption of the Monitored Escalators



The higher standby mode consumption of escalator PT_Esc 1, PT_Esc 3 and PT_Esc 4, which are equipped with a Variable Speed Drive and, therefore, have a reduced speed mode. The consumption in this "reduced-speed" mode is more or less half the consumption in the normal operation mode. According to the developed methodology, the standby consumption is considered to be the summation of the low-speed mode consumption and the stop mode consumption.

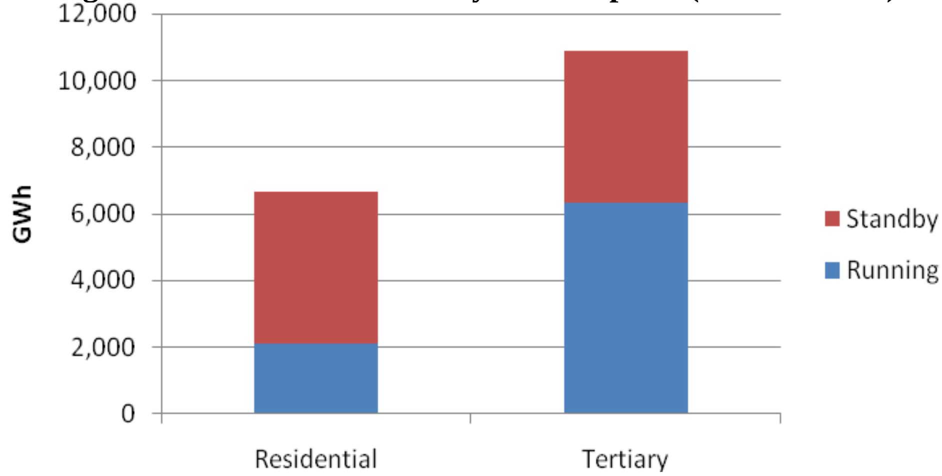
The numbers obtained with the market survey, related to 19 countries, were adjusted for EU-27, plus Switzerland and Norway (Table 1). Using the methodology previously described the total electricity consumed by lifts is estimated at 18,4 TWh, of which 6,7 TWh are in the residential sector, 10,9 TWh in the tertiary sector and only 810 GWh in the industrial sector.

Table 1 Number of Lifts instalLed (EU-27) (Almeida 2009)

	Hydraulic	Geared Traction	Gearless Traction	Total
Residential	743.979	2.254.112	100.330	3.098.421
Tertiary	333.248	946.208	270.344	1.549.801
Industrial	49.312	126.397	227	175.936
Total	**1.126.539**	**3.326.718**	**370.901**	**4.824.157**

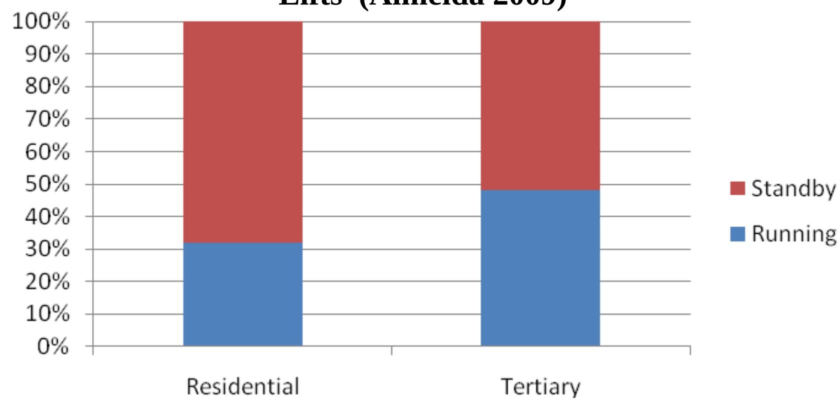
Figure 9 shows the running and standby estimated annual energy consumption of European lifts in the residential and tertiary sector. Although there is a smaller number of lifts installed in the tertiary sector their energy consumption is far greater than in the residential sector due to their more intensive use.

Figure 9 Lift Annual Electricity Consumption (Almeida 2009)



As it can be seen, the standby electricity consumption represents an important share of the overall electricity consumption, especially in lifts installed in the residential sector where the time spent in standby mode is larger. Figure 10 presents the standby consumption and the running mode consumption, in proportion to the overall consumption in the residential and the tertiary sectors.

Figure 10 Proportion of Standby and Running Mode to Overall Energy Consumption of Lifts (Almeida 2009)



According to ELA statistics there are 75.000 escalators and moving walks installed in the EU-27. Based on the surveys conducted in WP2, two assumptions are made:

- 75% of the escalators are installed in commercial buildings, the remaining 25% being in public transportation facilities.
- 30% are equipped with a Variable Speed Drive (VSD)

Escalators and moving walks are estimate to consume around 900 GWh of electricity each year.

Estimation of Potential Savings

The estimation of the potential savings in lifts is made according to the previously described methodology by assuming two scenarios: 1. that the *"Best Available Technologies"* (BAT) are used, 2. That the *"Best Not yet Available Technologies"* (BNAT) are used. *"Best Available Technologies"* are the best existing components currently being commercialised and *"Best Not Available Technologies"* are state-of-the-art technologies that are currently being developed but that are not yet commercially available.

With respect to the achieved values of potential savings, it is important to note that:

- The initial cost of the technologies used, while being an important issue regarding their application, has been not considered; therefore, no indications are provided about cost-effectiveness of using those technologies;
- Maintenance costs such as labor and spare-parts, have not been included in the calculations, even if some of the electronic components in inverters (e.g. cooling fans, capacitors, internal relays) ought to be periodically serviced in order to avoid degradation in inverter's performance;
- Some technologies may increase stand-by consumption while reducing consumption during the running phase. Therefore, their application should be carefully evaluated on a specific-case basis.

For the running mode consumption the following assumptions were made:

- Motor efficiency: 15% lower losses than IE3 in IEC60034-30 (Super Premium or Permanent Magnet Synchronous Motors) (IEC 60034-30)
- Efficiency of helical gear – 96%
- Friction losses (5%)
- Efficiency of VSD (95%) (Almeida 2005)

For the standby mode consumption two scenarios were considered:

1. **BAT** - Consider the best available technologies for each of the components which contribute to the stand-by energy consumption:
    - Led Lighting (varies from 12W for lift with load 320 kg to 18W for 1000 kg load lift)
    - Electronic Controllers (25 W)
    - Inverter (20 W)
    - Door operators (5W)

2. **BNAT** - Same as BAT scenario but:
    - Consider turning off of all non-essential components which contribute to the stand-by energy consumption when the elevator is not in use.
    - Consider putting the controller and inverter into sleep-mode (1 W each).

The next figures show the estimated electricity consumption in the tertiary sector and the total (all sectors) elevator electricity consumption, according to the different scenarios proposed.

Figure 11 Estimation of the Electricity Consumption of Lifts According to Different Scenarios in the Tertiary Sector

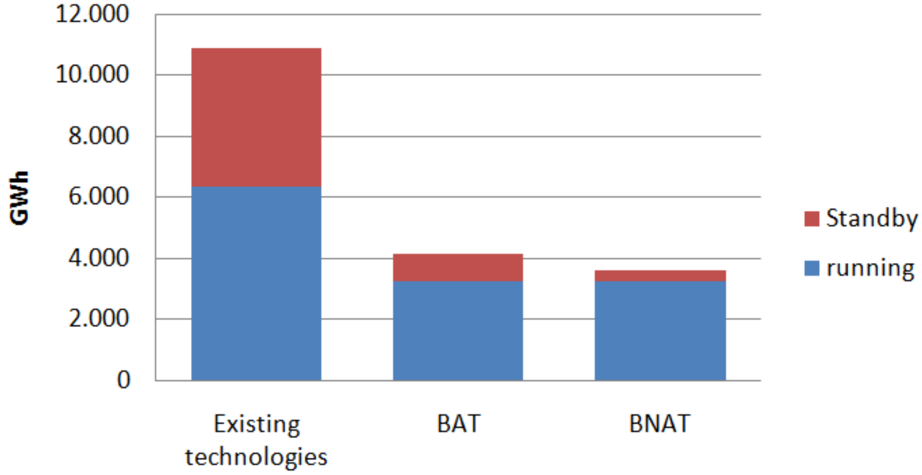
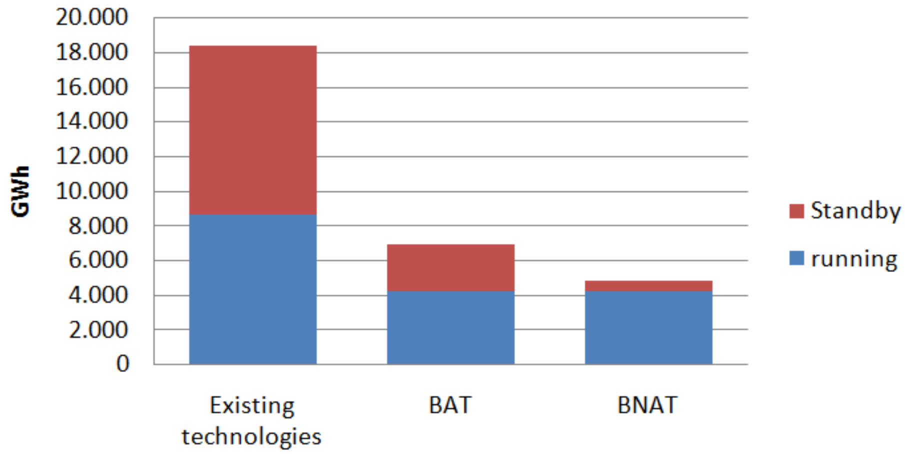


Figure 12 Estimation of the Total Electricity Consumption of Lifts According to Different Scenarios



The results show that overall savings of more than 65% are possible. A reduction of 10 TWh is achieved using the Best Technologies Available and of 12 TWh when technologies that are currently being developed are used which translate into a reduction of around 4,4 Mtons of CO2eq and 5,2 Mtons of CO2eq , respectively, with the current electricity production methods.

Savings in the standby energy consumption are particularly noticeable even in the BAT scenario where although low power equipment is used it is always kept on even when not in use, as is presently the common practice. A reduction in stand-by power of over 80 % is considered feasible with off-the-shelf technologies. In particular, the use of LED lighting can play a major role in this reduction.

For the estimation of energy savings it is considered that all of the escalators installed would be equipped with VSD. Furthermore, it is considered that when stopped the controller and inverter only consume one Watt each. A potential reduction in the electricity consumption of around 255 GWh (28 %) would be possible translating into a reduction in CO2eq emissions of 100.000 ton per year.

Conclusion

To sum up, this paper leads to the following conclusions: Notably, the potential reduction of standby energy consumption is an opportunity for energy efficiency that must not be disregarded: The energy need for standby could be reduced by 80 % if the best available technology was used. However, the share of standby mode in elevators represents 5 % to 95 % of the overall consumption which is a broad range. This broad range is on the one hand due to usage patterns - a higher number of trips usually increases the energy necessary for running. On the other hand, the energy consumption during running and standby is determined by the technology used and its energy efficiency.

Based on the calculations for the estimation of savings for EU-27, the results show that overall savings of more than 65% are possible. A reduction of 10 TWh is achieved in the BAT Scenario and of 12 TWh in the BNAT Scenario which translate into a reduction of around 4,4 Mtons of CO_{2eq} and 5,2 Mtons of CO_{2eq}, respectively, estimated based on the current electricity production of EU-27.

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