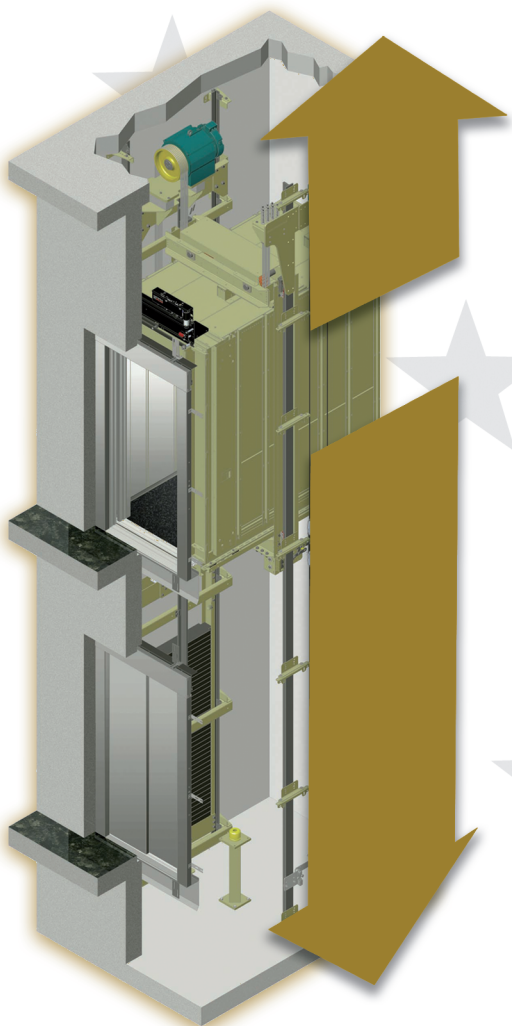




OPTIONS TO IMPROVE LIFT ENERGY EFFICIENCY



E4 – ENERGY-EFFICIENT ELEVATORS & ESCALATORS

OPTIONS TO IMPROVE LIFT ENERGY EFFICIENCY

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Why this brochure

Lifts (Elevators) and escalators are the crucial element that makes living and working several floors above the ground practical.

Even in smaller multi-story buildings, lifts are fundamental to allow elderly and disabled people to easily access offices and apartments.

The aging of the European population further increases the need for higher vertical mobility.

In the EU-27 there are more than 4.8 million lifts currently installed.

Lifts account for a significant amount (3 to 8%) of electricity consumption in buildings.

In the E4 Project, the total yearly electricity consumption due to the lifts installed in the EU-27 plus Switzerland and Norway was estimated.

The most important finding concerned the high stand-by consumption, which accounted for 5-90 percent of total consumption. The average value in residential buildings resulted around 70%.

Assuming that the Best Available Technologies (BAT) are used, the estimated overall savings were favourably high (about 60%) when all 4.8 million existing lifts in Europe would have been modernized or replaced.

Savings in stand-by energy consumption are particularly noteworthy. A decrease in stand-by power of over 80% is considered feasible with off-the-shelf technologies.

This brochure is intended to help building designers, building owners and managers, installers and maintenance companies to make better choices for a higher lift energy efficiency. It emphasizes what improvements are possible and where these improvements are most relevant.



Types of lifts

Hydraulic lifts

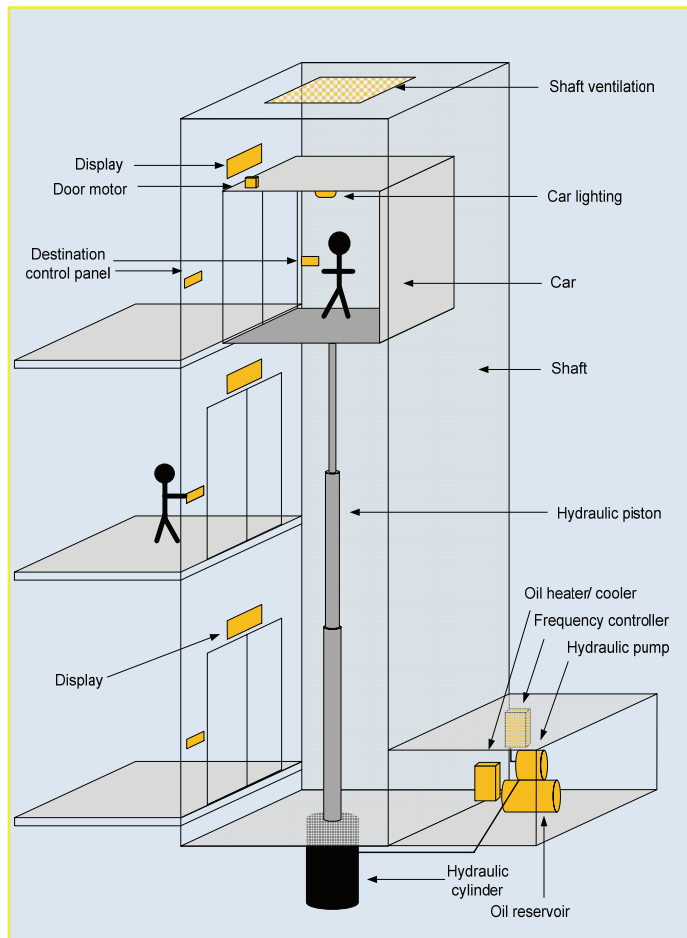
This type of lift uses a hydraulic cylinder to move the car.

An electric motor drives a pump which forces a fluid into the cylinder.

Valves control the fluid flow for a gentle descent allowing the hydraulic fluid (usually oil) to flow back to the tank.

In European countries hydraulic lifts are usually telescopic cylinder or roped types.

- Low speed: $< 1 \text{ m/s}$
- Maximum travel distance: 20 m



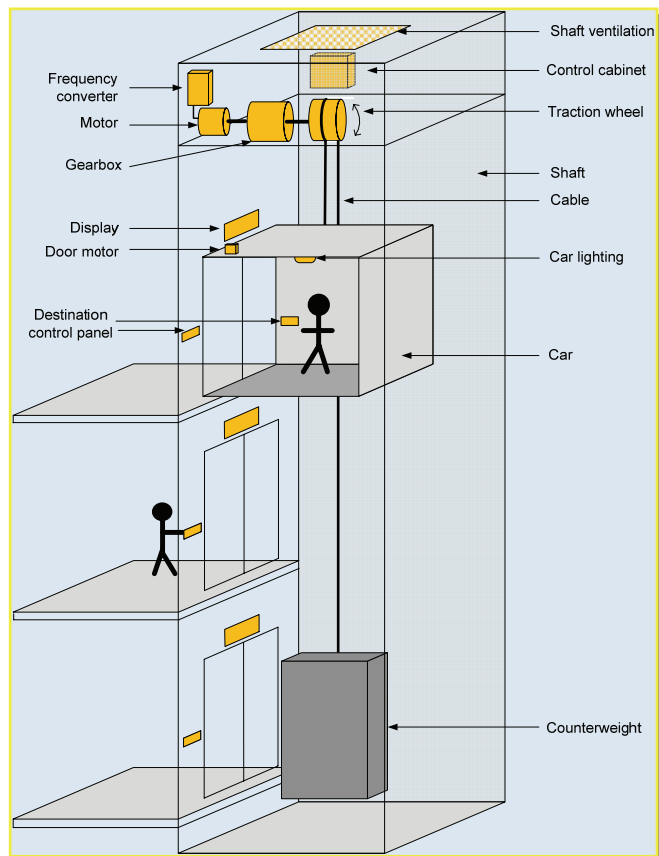
Hydraulic lift
(Source: Fraunhofer ISI, 2010: Features for new elevator installations and retrofitting)

Traction lifts

In traction lifts the car is suspended by wire ropes (or belts) wrapped around a sheave driven by an electric motor. The weight of the car is usually balanced by a counterweight that equals the mass of the car plus 45% to 50% of the rated load. The purpose of the counterweight is to make sure a sufficient tension is maintained in the suspension system so as to ensure adequate traction is developed between ropes/belts and drive sheave. In addition it maintains a

near constant potential energy level in the system as a whole, significantly reducing energy consumption.

Traditionally, electric traction lifts were equipped with DC motors because of their easy controllability, but the development of variable frequency drives led to the introduction of the now prevalent AC induction motors or permanent-magnet synchronous AC motors. These drives provide excellent ride conditions, with smooth acceleration and deceleration, and high levelling accuracy.



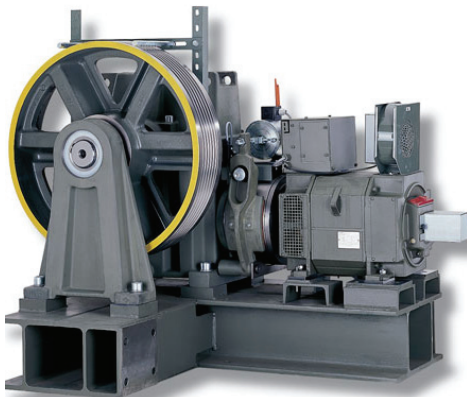
Traction lift
(Source: Fraunhofer ISI,
2010: Features for new
elevator installations and
retrofitting)

Traction lifts can be further subdivided into:

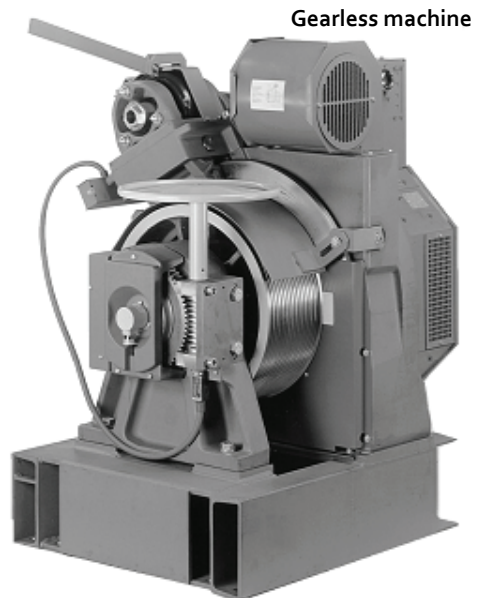
Gearless lifts, using a reduction gear to reduce the speed of the car. Gearless lifts are typically used in mid-rise applications (7 to 20 floors) where high speed is not a major concern (typical speeds range from 0.1 m/s to 2.5 m/s). The reduction gear ratio allows for the use of smaller, more efficient motors

that run at higher speeds producing the desired torque.

Gearless lifts, where the sheave is driven directly by the motor, thus eliminating losses in the gear train. Gearless lifts are used in a wide range of applications with nominal speeds from 0.63 m/s to 10 m/s and more. It is the leading technology used today.



Gearless machine

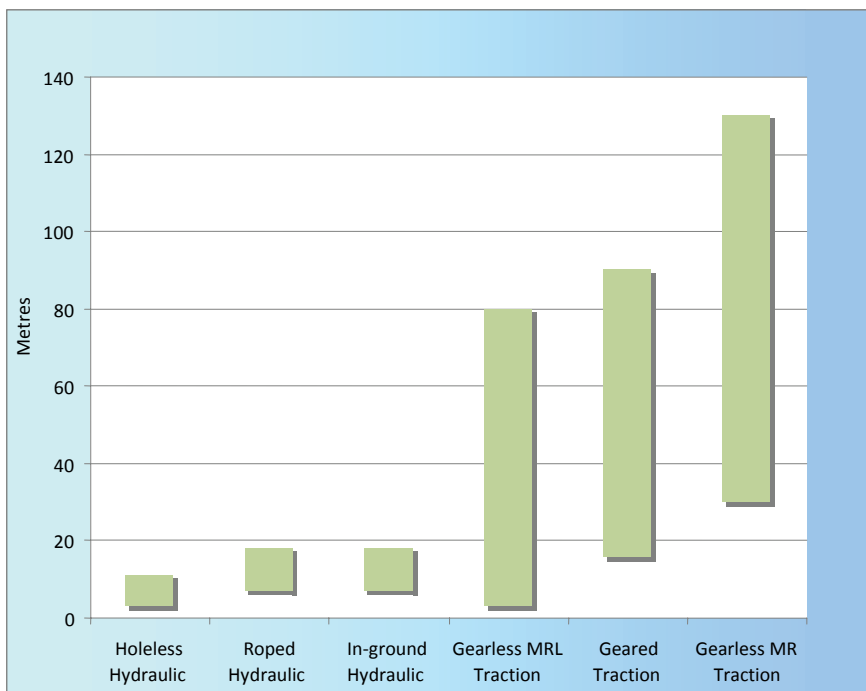


Machine roomless lifts. Saving highly-valued construction space has always been a concern for lift designers and has generated some highly innovative technological solutions.

Conventionally, all lifts, either traction or hydraulic, required a machine room where the motor – and pump in the case of hydraulic lifts – and a control cabinet were stored. This machine room was typically located above the lift shaft as to

traction lifts (or below it in the case of hydraulic lifts).

Evolution in permanent-magnet motor technology and motor drives allowed for a significant reduction in size and shape of these components which, in turn, made it possible to fit all the equipment directly inside the lift shaft (these lifts are usually equipped with high-efficiency gearless permanent-magnet motors).

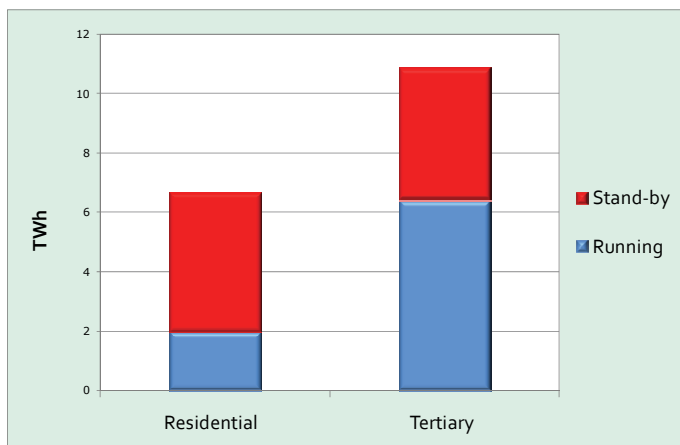


Typical rises for commonly used lift technologies
(Source: de Almeida et al. 2009: Technology assessment)

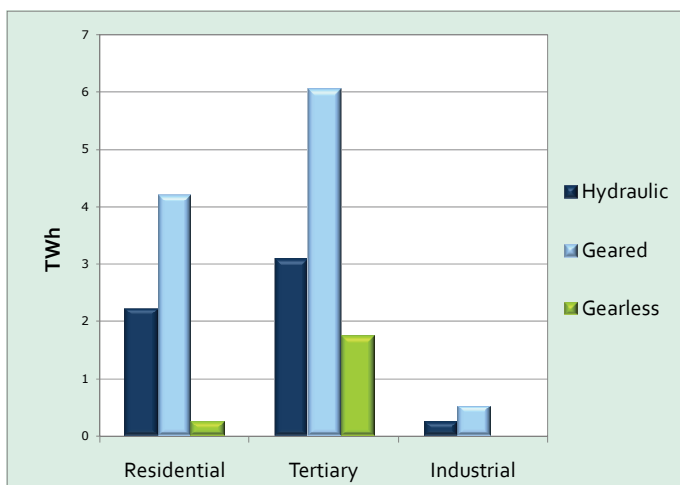
Lift energy consumption in Europe

The total yearly electricity consumption of the lifts installed in the EU-27 plus Switzerland and Norway is estimated at 18.4 TWh, 6.7 TWh of which refer to the residential sector, 10.9 TWh to the tertiary sector and only 810 GWh to industry. It is the equivalent to the

energy production of two large coal or nuclear power plants. Although there are fewer lifts installed in the tertiary sector their energy consumption is far greater than in the residential sector, due to their more intensive use.



Total yearly energy consumption by sector, EU-27 (Source: de Almeida et al. 2009: Technology assessment)



Total yearly energy consumption by technology, EU-27 (Source: de Almeida et al. 2009: Technology assessment)

Options to improve lift energy efficiency

So far the main drivers of lift design have been focused on safety, travel speed, acoustic noise, ride comfort and occupied space.

However, in the last few years, the demand for energy efficient products and greener buildings has increased, fostered also by the improved cost-effectiveness as a consequence of rising electricity prices. The lift industry has rapidly responded to the increased demand by applying and developing new

energy efficient technologies for new and existing equipment.

Replacing and using best available technology for all existing lifts and escalators is estimated to result in energy savings of about 60% (Table 1).

The savings from realizing this potential would not only decrease electricity consumption directly and contributes to the environmental influence of lifts and escalators but they may also lead to lower energy bills.

Table 1 – Estimated energy demand of lifts and escalators in the EU-27 (Source: de Almeida et al. 2009: Estimation of saving potentials)

		Running (TWh)	Stand by (TWh)	Total (TWh)	Savings (%)
Technology in existing equipment	Lifts	8.7	9.7	18.4	
	Escalators	0.82	0.08	0.90	
	Both	9.52	9.78	19.30	
Best available technology	Lifts	4.2	2.6	6.8	63
	Escalators	0.4	0.24	0.64	28
	Both	4.6	2.84	7.44	60

Lifts consume energy even when they are not raising or lowering loads. This energy consumption can represent more than 90% of the total electricity consumption in elevators with a low number of daily trips and is attributable to equipment constantly working such as control systems, lighting, ventilation, floor displays and operating consoles in each floor and inside the elevator cabin.

Energy efficient technologies applied to lifts

Lighting

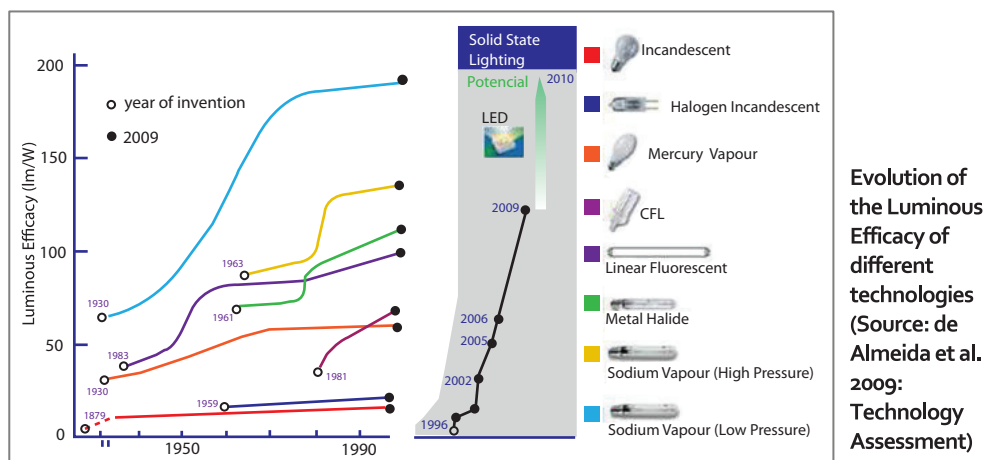
Lighting is one of the loads that most contributes to the stand-by electricity consumption of lifts and therefore provides an opportunity that should not be overlooked, especially since very good off-the-shelf solutions are nowadays available. Lift car lighting is usually provided either by incandescent or fluorescent lamps. A comparison of the major lamp characteristics is showed in Table 2.

LED lighting is a technology that has been subject to great improvements in the last few years. Although LEDs are still expensive when compared to other types of lamps, their price is likely to decrease thanks to the economy of scale and is already offset by a very long lifetime that can reach 50.000 hours. Additionally, their lifetime is not reduced by frequent on/off cycles.

LEDs are also a very efficient solution for displays which can be dimmed for even lower consumption, and can be cycled on-off without impacting their lifetime.

Table 2 - Comparison of the major lamp characteristics (Source: de Almeida et al. 2009: Technology assessment)

Type of Lamp	Lifetime (hours)	Luminous efficacy (lm/W)
Incandescent	750-2,000	10-18
Halogen incandescent	3,000-4,000	15-20
Compact fluorescent (CFL)	8,000-10,000	35-60
Linear fluorescent	20,000-30,000	50-100
High Power White LED	35,000-50,000	30-150



Switching-off energy consuming equipment

Besides using efficient components, energy can be saved by switching-off equipment, or putting it in a low energy mode when the lift is not being used.

During low demand periods, even completely shutting down one or more lifts within a group can be a good energy saving option, without compromising quality of service.

One alternative is to have two distinct stand-by modes working in a sequence.

The first mode provides that only components that can be instantly turned on would be completely or partially disabled. Some examples would be: lighting, ventilation, car displays (directional arrows, floor indicator, etc.), dimmable landing displays. This option does not involve an increase in passenger waiting time.

The second stand-by mode shuts down further components, but the system may take a longer time to reboot due to the nature of the switched-off equipment such as drive unit, door operators, car electronics, light curtains / door detectors. Due to the extension of waiting time, the rebooting sequence can take up to 30 seconds. This second stand-by mode would only be suitable for long periods of low passenger demand.



Directional arrows, floor indicator

Premium efficiency induction motors

These motors are characterized by lower losses and improved efficiency owing to the use of superior magnetic materials and the adoption of optimized design and construction techniques.

The initial cost is higher but, over time, the efficiency improvement will translate into energy and financial savings. Due to lower losses the operating temperature can be lower, leading to improved reliability.

Thus, it is wise to consider Premium efficiency motors in all new motor procurements.

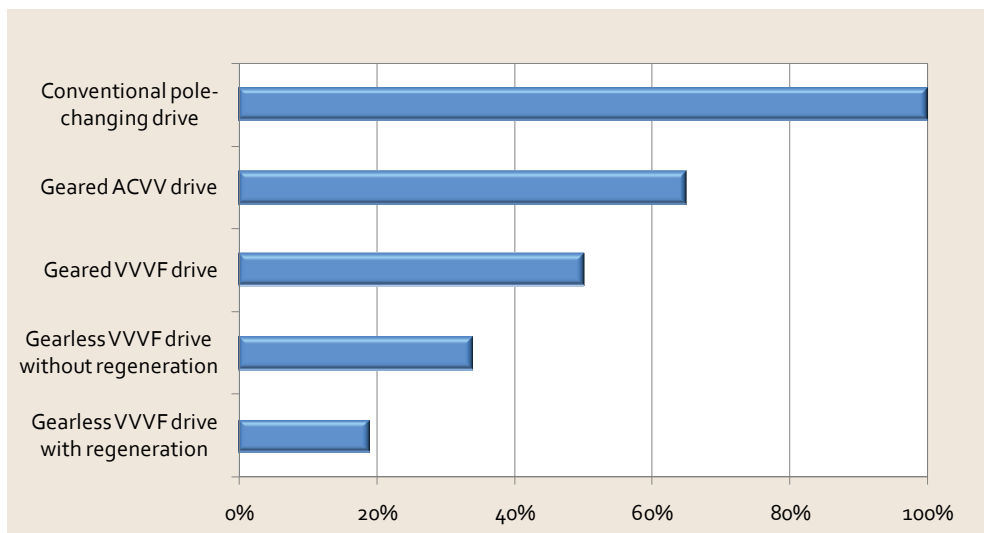
Advanced drives

Motor-driven systems are often designed to handle peak loads that have a safety factor. This often leads to energy inefficiency in systems operating for extended periods at reduced load. The capability to adjust motor speed enables closer matching of motor output to load and often results in energy savings. Variable speed drives are used:

- to improve the efficiency of motor-driven equipment by matching speed to changing load requirements;
- to allow accurate and continuous process control over a wide range of speeds.

Today, the most widely used drive system is the Variable Voltage Variable Frequency (VVVF) drive. VVVF drives improve the energy efficiency, ride comfort, levelling accuracy and reduce the dimensioning of the main power supply due to lower peak load.

Gearless VVVF drives with regeneration can reduce energy consumption by up to 80%, when compared to a conventional pole changing drive system (two-speed induction motor) as can be seen in the following figure.



Energy balance of lifts, Average energy consumption, percentage
(Source: Flender-ATB-Loher, Systemtechnik)

Traffic Handling/Management

Lift controllers ensure that lifts are properly dispatched, doors open and close at the right time, etc.

Where a number of lifts are installed together, their controls are interconnected to optimise their operation.

Modern traffic controllers can use

artificial intelligence techniques (artificial neural networks, fuzzy logics and/or genetic algorithms) to enhance the service effectiveness and energy efficiency.

By efficiently delivering passengers with the least amount of trips, starts and stops, as well as the number of lifts used, the energy consumed is significantly reduced.



Efficient escalators and moving walks

As in lifts, escalator component efficiency is of the utmost importance. High efficiency motors, drives, transmissions, bearings, etc. can yield significant savings and are, in most cases, cost-effective.

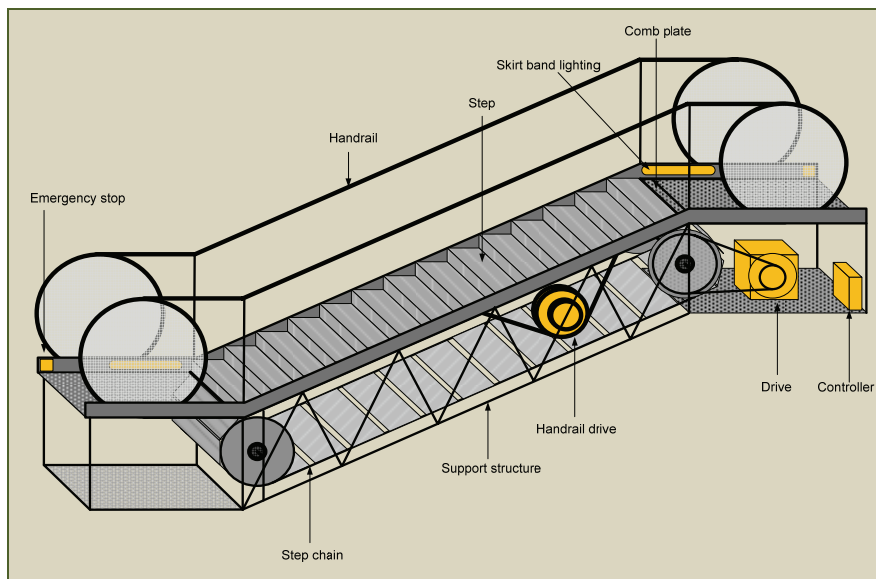
As an example, planetary, helical and hypoid helical gears can reach efficiencies of 96 % and are now available from many manufacturers as a substitute for lower efficiency worm gears.

Proper maintenance and lubrication of components also helps to keep the



equipment efficiency at its maximum.

Escalators should not run when there are no passengers to move. An other option is to reduce the speed to match the passenger demand, thus reducing energy consumption by the use of VVVF drives; VVVF drives provide very smooth, almost imperceptible speed transitions.



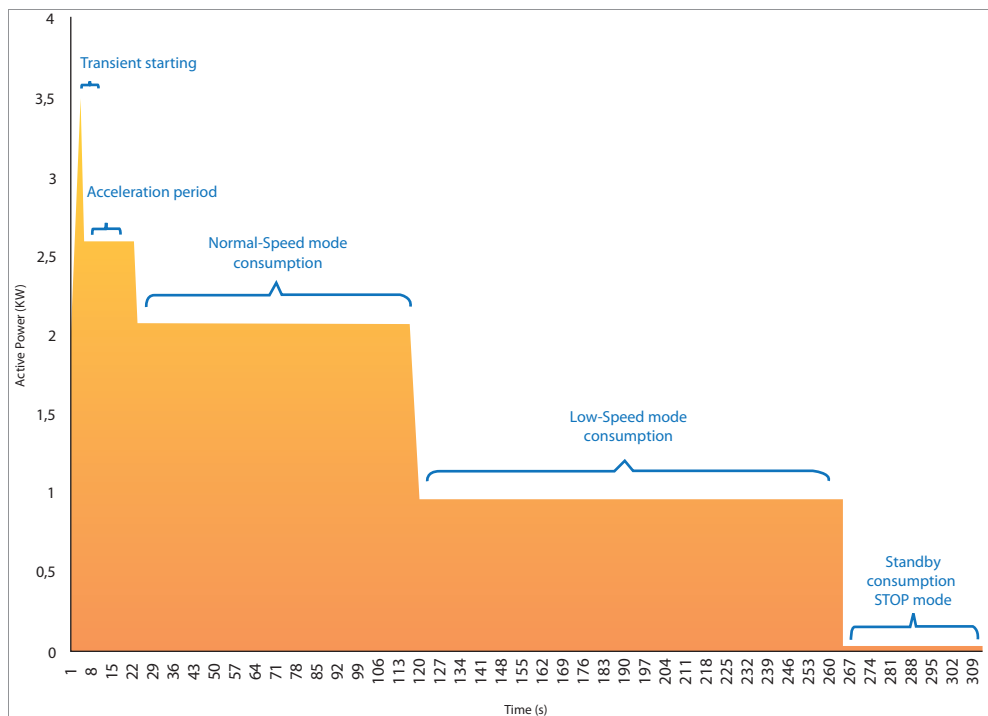
Escalator (Source: Fraunhofer ISI, 2010: Features for new elevator installations and retrofitting)

Typically, three operation modes are provided by variable speed escalators. After a predefined period of inactivity, escalators reduce their speed and reach the so called “reduced-speed” mode.

The consumption in this “reduced-speed” mode is more or less half the consumption in the normal operation mode. After reaching this mode of operation, and after another predefined interval of time, the escalator is put into a STOP mode. In this STOP mode only the control system and the passenger

detection system (pressure mats, photocells or infra-red beams) are kept running. When a passenger is detected the escalator slowly begins to move again, gently accelerating until it reaches nominal speed.

Depending on the intensity of use of the escalator these options can save up to 40% of escalator energy consumption. Next figure illustrate one escalator’s power consumption at different operating modes.



Active power of an escalator in different operation modes (source: ISR-UC)

The E₄ Project

The E₄ project (E₄-Energy Efficient Elevators and Escalators, www.e4project.eu) is targeted at the improvement of the energy performance of lifts and escalators, in tertiary sector buildings (hotels, hospitals, schools, shopping centres, offices, etc.) and in multifamily residential buildings. The countries directly involved in the project are Germany, Italy, Poland and Portugal, covering different regions of the EU. The European Lift Association (ELA) with agencies in most EU countries also participating in the project.

The main objectives of this project are:

- to characterize people conveyors (lifts and escalators) electricity consumption in the tertiary sector and in residential buildings in the EU;
- to promote the efficient use of electricity in lifts and escalators through the dissemination of information on cost-effective energy efficient technologies available in the market.



ISR – University of Coimbra



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EUROPEAN LIFT ASSOCIATION



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