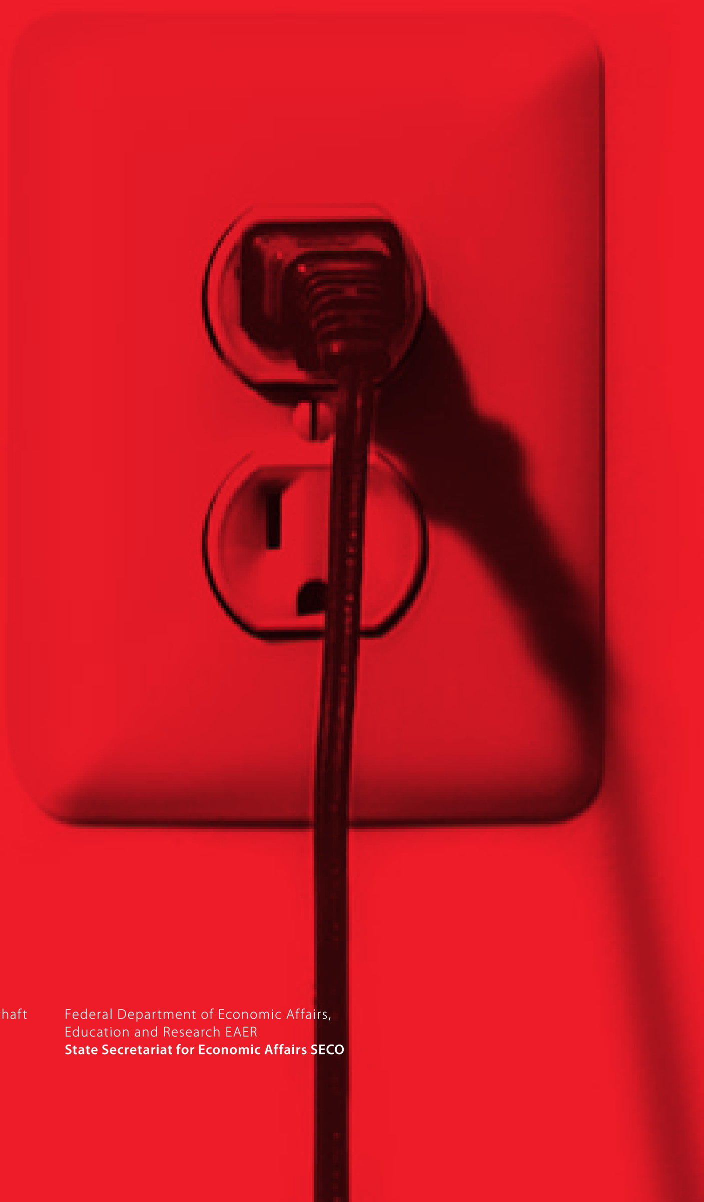
JAKARTA GREEN BUILDING USER GUIDE

VOL. 4

ELECTRICITY SYSTEM & VERTICAL TRANSPORTATION



The Government of the Province of
Jakarta Capital Special Territory

In cooperation with:

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Federal Department of Economic Affairs,
Education and Research EAER
State Secretariat for Economic Affairs SECO

CODE REQUIREMENTS

Electricity (EL)
EL01 BMS for Centrally Cooled Buildings
EL02 Energy Sub-metering

Transportation System (VT)
VT01 VVVF Motors for Elevators
VT02 Automatic Control for Escalators

The calculation should be done using the calculator available on this website
http://greenbuilding.web.id

Checklist for all code requirements lists the required documents is also available on this website
http://greenbuilding.web.id

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ELECTRICITY SYSTEM & VERTICAL TRANSPORTATION

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Electricity System & Vertical Transportation: **An Introduction**

Electrical power system transports the electricity generated at the source (typically power plants) and supplies it to buildings and its individual systems, such as lighting, cooling, appliances and ventilation.

Energy losses take place in all segments of the electric system including generation, transport, distribution and consumption. While the first three segments are outside the scope of this code, consumption losses represent a major drain on resources and operational cost.

A majority of the consumption losses are due to use of energy saving equipment or systems when they are not needed. For example, it is quite common to see lights and airconditioning being left on in unoccupied rooms. Automating the controls to partially or fully shutdown systems that are not needed can be a significant energy saving measure.

A big hurdle to energy conservation in a large building is the lack of information of the energy being consumed by various systems, such as lighting, cooling and elevators, in a building. This information can inform a building manager about the consumption patterns and behaviours, and help identify energy and water wastage quickly.

Till a few decades ago, all energy used for transportation in buildings was human generated. However, with increased building heights and comfort expectations, mechanically powered transportation systems are now common in most medium to high rise buildings. As the urban density increases in Indonesian cities, the average height of buildings is expected to go up, leading to an increase in the use of elevators and escalators. Elevators and escalators can be a fairly energy intensive, based on how they are designed, installed and operated. According to an estimate, they can use 3% to 8% of all energy consumption in an average sized commercial building. In some buildings this can go up to 15%.[1]

Buildings up to about five to seven stories typically use hydraulic elevators because of their lower initial cost. Mid-rise buildings commonly use traction elevators with geared motors, while high-rise buildings typically use gearless systems where the motor directly drives the sheave. The energy using components include the motors and controls as well as the lighting and ventilation systems for the cabs.[2]

FIGURE. 01

Hydraulic

This type of elevator uses a hydraulic cylinder to move the car. An electric motor drives a pump which forces a fluid into the cylinder moving the car up. When descending, an electric valve opens and the fluid is allowed to drain (slowly) from the cylinder into the tank; Hydraulic elevators are available for lifts up to a rated speed of 1m/s. The maximum travel distance for this type of elevators is around 18m, so they are typically used for low-rise buildings. They are less efficient than the traction elevators used in higher buildings.

Traction Elevators: Geared and Gearless (Direct Drive)

Geared elevators use a reduction gear between the motor and the sheave to reduce the speed of the cab, while gearless elevators the sheave is directly coupled to the motor.

[1] ISR-University of Coimbra (Portugal) with ELA (Europe); ENEA (Italy); FhG-ISI (Germany); KAPE (Poland). 2010. Energy Efficient Elevators and Escalators. (*http://www.e4project.eu/documenti/wp6/E4-WP6-Brochure.pdf*)
Bailey, Sasha. 2010. Elevating Elevator's Energy Efficiency and Performance. (*http://www.thyssenkruppelevator.com/downloads/EW_Energy_Efficiency_Byline.pdf*)

[2] Commercial Energy Service Network. 2010. Commercial Buildings Energy Modeling Guidelines and Procedures. (*http://www.comnet.org/sites/default/files/images/100813_COMNET_Final_PDF_Only.pdf*)

TABLE. 01

Comparison of Different Types of Elevator

TYPE OF ELEVATOR	TYPICAL APPLICATIONS	ADVANTAGES	DISADVANTAGES
Hydraulic	Low Rise 2-6 Floors	Low Cost	Slow High Energy Use Maintenance Issues
Traction Geared	Mid Rise 3-25 Floors	Low Cost for Application	Speed Energy Consumption
Traction Machine Roomless	Low-Mid Rise 2-10 Floors	Easy Installation Energy Savings	Higher Cost than Hydraullic Option
Traction Gearless (Direct Drive)	High Rise > 25 Floors	Energy Savings High Speed	Higher Cost

The measured consumption in standby mode in elevators represents from 4.2% to 90.3% (257 to 6001kWh/year) of the overall consumption. In escalators this percentage goes from 1.3% to 54.25% (112 to 3017kWh/year).[3]

[3] Patrao, Carlos; Fong Joao; Rivet, Luc; Almeida, Anibal de. Energy Efficient Elevators and Escalators. (*http://www.eceee.org/conference_proceedings/eceee/2009/Panel_4/4.037/presentation*)

01 *code requirement*

REFERRING TO ARTICLE 13

1 **Code Requirement 1**
All centrally cooled buildings, except educational buildings should be installed with a Building Management System (BMS) to control VSDs, VAV system, Chillers and associated pumps.

2 **Code Requirement 2**
For any energy group in the building having a load higher than 100 KVA, energy sub-meters should be provided. Energy data for the sub-metered groups should be recorded automatically.

3 **Code Requirement 3**
All passenger elevators with velocity above 60 meters/ minute must be equipped with alternating current (AC) induction motors with a Variable Voltage Variable Frequency (VVVF) controller as described in section 6.1.1 of SNI 03-6573 2001.

4 **Code Requirement 4**
All escalators must be fitted with controls to reduce speed or to stop when no traffic is detected. This control must be done through occupancy sensors suitably placed at the top and bottom landing.

02 *code requirement details*

CODE REQUIREMENT 1

All centrally cooled buildings, except educational buildings should be installed with a Building Management System (BMS) to control VSDs, VAV system, Chillers and associated pumps.

A Building Management System is also known by the terms, "Building Automation and Control System" and "Energy Management System" is a system to control energy consuming equipment in the building efficienctly in order to conserve energy. These systems typically have a central computer, distributed programmable controllers and a digital communication system.

BMS is commonly installed only in large buildings (typically above 10,000 m^2) and can monitor, control and optimize the following equipment:

- HVAC equipment: Chillers, Air Handling Units (AHUs), Roof-top Units (RTUs), Variable Air Volume boxes (VAVs) etc.
- Electrical equipment: lighting, audio visual, security/ card access, entertainment, fire alarm, etc.

The biggest way to save energy using this system is to switch off systems when not needed through a schedule or sensors. For controlling HVAC equipment, typically temperature and occupancy sensors are used. Photosensors are often used to control lighting.

Average energy savings of 5 to 15% with paybacks between 8 to 10 years have been shown in a study done by the US Department of Energy.[4]

[4] Brambley, M.R; Haves, P; McDonald, S.C; Torcellini, P; Hansen, D; Holmberg, Roth, K.W. 2005. Advanced Sensors and Controls for Building Applications: Market Assessment and Potential R&D Pathways. (*http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/pnnl-15149_market_assessment.pdf*)

CODE REQUIREMENT 2

For any energy group in the building having a load higher than 100 KVA, energy sub-meters should be provided.

Typically, the electricity power groups meeting this criterion are chillers, air handling units and lifts.

Meters are physical measurement devices that measure and record resource use, such as energy or water consumption. Often a single utility meter is provided for the whole building. Sub-meters are designed to measure energy consumption for specific end-uses, such as lighting or plug loads, or even for specific parts of a building.

Sub-metering can provide very beneficial insight into operation and maintenance issues, occupant behaviors, performance of installed equipment, and verification of installed efficiency technologies. However, sub-metering by itself does not save energy consumption. New building management practices or technologies are typically needed to realize the savings. An integration of the sub-meters with the building automation system can streamline the energy management efforts.

A detailed report on energy and water sub-metering is available at:

Submetering of Building Energy and Water Usage

Analysis and Recommendations of the Subcommittee on Buildings Technology Research and Development. 2011, By National Science and Technology Council Committee on Technology ; Subcommittee on Buildings Technology Research and Development.

http://www.bfrl.nist.gov/buildingtechnology/documents/SubmeteringEnergyWaterUsageOct2011.pdf

Efficiently designed buildings can still use a lot of energy and water resources if the occupants do not use it efficiently. Motivating occupants to proactively participate in the energy and water conservation efforts requires a lot of careful planning and encouragement.

Some ideas on influencing occupant behavior are found here:

The High Performance Potfolio: Motivating and Rewarding Success

by Betterbricks, Bottom Line Thinking on Energy.

http://www.betterbricks.com/graphics/assets/documents/Motivating-Success_Final.pdf

CODE REQUIREMENT 3

All passenger elevators with velocity above 60 meters/minute must be equipped with alternating current (AC) induction motors with a Variable Speed Variable Frequency (VVVF) controller as described in section 3.1.1 of SNI 03-6573 2001.

VVVF control regulates input voltage and frequency to the motor throughout the journey. Variation of electrical current drawn by different lift motor drives during the whole journey of a lift car controls the speed of the lift especially at the beginning and ending. VVVF drive draw much less current during acceleration and deceleration than a typical drive.

*If hydraulic motors are used, see the **Other Good Practices** section of this document for ways to reduce energy consumption.*

Variable speed drives can reduce peak motor starting currents by as much as 80% compared with conventional motor drives. Further, wear and tear of the equipment can also be reduced during start/stop of the motor by using VVVF motor drive.[5]

Since hydraulic elevators are available up to a rated velocity of 60 meters/minute (1m/s) this requirement would not typically apply to them.

CODE REQUIREMENT 4

All escalators must be fitted with controls to reduce speed or to stop when no traffic is detected. This control must be done through occupancy sensors suitably placed at the top and bottom landing.

In escalator applications, VVVF control can be incorporated with automatic start/stop control or automatic two-speed control to vary the escalator speed according to the passenger flow. The operation of these kinds of escalator is determined by the presence or absence of passengers; hence energy can be saved when the escalator is idle. Since the operation of the escalator is determined by the presence or absence of passengers, it is known as “service-on-demand” (SOD) escalator.

There are basically two types of SOD escalator.

a. Automatic start/stop control

When an approaching passenger is detected, the escalator will start running and complete the traveling cycle. The escalator will stop after a period of time when no further passenger is detected.

[5] HKEE Net. Variable Voltage Variable Frequency (VVVF) Controller. (*http://ee.emsd.gov.hk/english/lift/lift_tech/lift_tech.html*)

b. Automatic two-speed control (crawl mode)

Similar to the arrangement of auto on-off controlled escalator, the auto two-speed control SOD escalator will be actuated by the presence of passenger to run at rated speed. The auto two-speed controlled SOD escalator will run at a lower speed (crawling speed) when it detects no passenger for a set period of time. The crawling speed is usually set at about 0.2 m/s, while the rated operating speed is 0.5m/s to 0.75 m/s.

Various kinds of detection methodologies can be employed for sensing the presence of passenger, such as optical detectors, step sensors, light barriers etc. The detectors for monitoring the approaching passengers can be integrated into a pair of sensing post installed at the entry of the escalator, or they can be incorporated into the handrail entry of the escalator.

The amount of saving depends on the type of buildings and passenger flow pattern. Based on a measurement carried out by the Electrical and Mechanical Services Department, the energy saving of service-on-demand escalators can be up to 52% and 14% for automatic start/stop and two-speed escalator respectively in an office building.[6]

[6] HKEE Net. Variable Voltage Variable Frequency. (*http://ee.emsd.gov.hk/english/lift/lift_tech/lift_tech.html*)

03 *other good practices*

1. TRANSFORMERS

Electricity from the power plants is transported to the building sites in high tension voltage lines in order to reduce losses and transmission cost. A step down transformer then reduces the voltage to more usable levels. Most large buildings have their own transformers.

Even in the most efficient transformers, 1-4% energy is lost due to dissipation in the windings and core. While the loss is proportional to the load current, even an idle transformer can lose electricity. Losses can be reduced by proper design of the transformer. When selecting the transformer, losses at both 50% and full load should be reviewed.

2. MOTORS

Motors convert electricity into usable mechanical energy and can be found in ventilation fans, pumps, elevators and other equipments. Unfortunately, some energy is lost in this conversion. Depending on the building type, a fairly significant part of the total energy in a building goes into running motors. Motors on critical systems like ventilation fans, chilled water pumps can operate over 5000 hours per year.

The simplest way to save motor energy is to use it only when needed. Powering off motors, when not needed can result in significant energy savings. Installling variable speed motors can be another major strategy in reducing energy use.

High/premium efficiency motors are available now with increased efficiencies due to improvement in technology and design. These motors can have efficiencies in the 87%-94% range vs. the 82-84% for standard motor efficiencies.

Some guidance on selecting energy efficient motors is provided in:

- Evaluation and Application of Energy Efficient Motors, by GE Industrial System *(http://apps.geindustrial.com/publibrary/checkout/e-GEA-M1019?TNR=White%20Papers|e-GEA-M1019|generic)*

3. POWER FACTOR

Power factor measures the efficacy of electrical current's conversion into useful work output. Usually, a power factor over 0.9 is desirable. Power factor can be lowered by induction loads such as transformers, electric motors and fluorescent lamps. **Working with low power factor is costly and inefficient**, as they may cause:

- Increased electricity consumption
- increased power losses
- overheating
- equipment failure

According to a USAID report[7] the average power system load factor in Indonesia in 2006 was about 64%, varying from 34% in North Sumatra to about 91% in Jambi (eastern part of Sumatera). This low load factor has made it difficult for PLN to expand its base load generation capacity.

Power factor can be improved by:

- shutting down motors when they are not needed
- using high efficiency motors
- operating motors near their rated capacity
- adding capacitors to the circuit.

4. HARMONICS

Harmonic distortion refers to the distortion factor of a voltage or current waveform with respect to a pure sine wave. In buildings with a large number of sophisticated pieces of equip¬ment, increased harmonic distortion in the electrical distribution system could result in energy use increase.

It is extremely difficult to asses the energy loss due to harmonics content in the load current, but total harmonics distortion of around 10% in inductive circuits results in a loss of around 30% of the energy drawn from the system where the harmonics exists.[8]

[7] USAID Report. Indonesia Energy Assessment. (*http://indonesia.usaid.gov/documents/document/Document/400/USAID_Indonesia_Energy_Assessment.pdf*)

[8] Magnetic & Transformer Technologies Corporation. Lighting Voltage Controller "Wattmanager". (*http://www.wattmanager.us/wm_ed_hdis.html*)

5. GENERATORS

To avoid downtime during power outages, diesel generators are commonly used in many buildings in Jakarta as a backup power source. They can also serve the purpose of peak shaving, i.e reducing the peak demand therefore its associating charges. Although diesel generators do not use electricity from the grid, they are costly to operate and maintain. Sizing the generator according to expected demand is critical, since they operate at much lower efficiencies at part load as compared to full load.

Some good practices on diesel generators can be found at:
Guide to Best Energy for Remote facilities
Arctic Energy Alliance. 2011.

Arctic Energy Alliance. 2011 - http://aea.nt.ca/files/download/99

Other useful resources on these subjects are:

- Energy Efficient Electrical Systems Development of Building Regulations and Guidelines to Achieve Energy Efficiency in Bangalor City by Renewable Energy and Energy Efficiency Partnership & Teri *(http://www.teriin.org/ResUpdate/reep/ch_6.pdf)*
- Basic Manual Energy Efficiency *(http://www.cnpml.org.sv/UCATEE/UCATEE/docs/Manual%20EE_English_final.pdf)*
- M.R. Brambley, et al., "Advanced Sensors and Controls for Building Applications: Market Assessment and Potential R&D Pathways," prepared for the U.S. Department of Energy by Pacific Northwest National Laboratory (April 2005), p. 2.15.
- Energy Efficiency Manual by Donald Wulfinghoff
- Achieving Energy Saving with Building Automation Systems by Kristin Kamm (Sr. Associate Research) *(http://www.automatedbuildings.com/news/apr07/articles/esource/070322105430kamm.htm)*

6. ELEVATORS

An elevator uses both operational and standby energy. Operational energy is the energy used to take passengers swiftly and smoothly to the floor they want to go to. Standby energy is the energy used while the elevator is standing still but which keeps it ready to operate at any moment. The elevator industry has developed highly innovative products which consume significantly less energy for the transportation of passengers. However, a Swiss research study on the energy consumption of lifts[9] has estimated that approximately half of the energy consumed by elevators is used when it is on standby, simply in order to keep it ready for the next trip. Standby mode accounts for a high percentage of the elevator's energy consumption, especially if the number of trips per year is low. Besides

[9] Electricity Technologies and Applications Research Programme. (*http://www.electricity-research.ch*)

the operational energy use, this also creates extra heat in the space, thus increasing the building's air conditioning load.

Most elevator systems comprise of cars (also called a "cage" or "cab"), doors, lights, ventilation, a motor and a control device. The car travels within an enclosed space called the shaft or hoistway. The two main classes of lifts are hydraulic and traction lifts. Hydraulic lifts are usually limited to 7 stories or less.

Traction lifts are generally more energy efficient than hydraulic lift system. In hydraulic lifts, a considerable amount of energy is wasted in heating up the hydraulic fluid when building up the hydraulic pressure. Some installations may even need separate coolers to cool down the fluid to avoid overheating. Furthermore, hydraulic lifts are usually not provided with a counterweight. Thus the lift motor has to be large enough to raise the rated load plus the dead weight of the car cage. In traction lift, the maximum weight to be raised under normal operation is only about half of its rated load.

Traction lifts can be further subdivided into two categories: geared and gearless.

1. Geared machines use worm gears to control mechanical movement of elevator cars by "rolling" steel hoist ropes over a drive sheave which is attached to a gearbox driven by a high speed motor. These machines are generally the best option for basement or overhead traction use for speeds up to 2.5 m/s (500 ft/min).

2. Gearless traction machines are low speed, high torque electric motors where the drive sheave is directly attached to the end of the motor. Gearless traction elevators can reach speeds of up to 10 m/s (2,000 ft/min), or even higher.[10]

Inefficiencies in vertical transportation can be caused by direct and indirect losses.

1. The most common direct losses are:
   - Friction losses
   - Transmission losses
   - Motor losses
   - Brake losses
   - Lighting losses
   - Controller losses

2. Indirect causes are related to the operation of the equipment and are associated with user behaviour or traffic management options.

[10] Escon. 2011. Traction Elevators, Machine Room Less Elevator (MRL). (*http://www.esconelevators.com/tractionelevator.aspx*)

In general the principles for achieving energy efficiency for lift/escalator installations are as follows:

- Specify energy efficiency equipment for the system.
- Do not over design the system.
- Suitable zoning arrangement.
- Suitable control and energy management of lift equipment
- Use light weight materials for lift car decoration.
- Good house keeping.

Some good practices for energy conservation include using more efficient motors and drives, regeneration converters, better control software, optimization of counterweights, direct drives versus rope traction elevators, efficient cabin lighting.

Maintenance of the vertical transportation system (including frequent preventive inspections) is critical in keeping it running efficiently. While energy consumption for lighting inside elevators is small as compared to the total, there are some simple options available. Using efficient lamps, such as LEDs or CFLs along with sensors to switch off lights (along with fans) when the elevator is not moving, can significantly reduce lighting energy use.

Elevators operation involves a lot of braking to stop or slow down the elevators. This braking energy is usually lost, but can be harvested using the "regenerative system" available now. According to ThyssenKrupp's promotional materials, conventional elevator machinery can lose more than 30 percent of its energy in the form of waste heat. Equipped with a regenerative system, this loss can be reduced to about five percent. The rest gets shunted back into the building's electrical system to reduce its demand on the grid.

More information on regenerative breaking is available at:
Donald Vollrath, Magnetek, Inc.
Regenerative Elevator Drives: What, How, and Why

http://www.elevatorbooks.com/Content/Site108/ProductContent/June2010CEU_00000004566.pdf

Other options for conserving energy and reducing environmental impact of elevators and escalators are; efficient electric motors and drives, better controllers (hardware & software), optimisation of counterweights, use of direct drives versus rope traction elevators, and replacing traditional hydraulic oil with biodegradable oil.

In addition to the mandatory requirements for escalators mentioned above, a soft start technology could be employed, that leaves the speed of the escalator unchanged, but reduces the power it consumes when fewer people are on it.

ENERGY OPTIMIZER FOR LIFTS AND ESCALATORS

The energy optimizer (also known as performance controller, energy saver or power factor controller) is a solid-state controller that reduces losses in AC induction motors in the form of energy efficiency and soft starting capability. During the low load condition, induction motors usually operating at full supply voltage have very low power factor and are less efficient. The energy optimizer could provide the required motor operating voltage to suit various loading conditions, resulting in power factor improvement and reduction of motor losses. The energy optimizer could be used for any AC motor application with constant speed and variable load.

The amount of energy saving due to the energy optimizer in lift and escalator applications depends on the actual load of the lift or escalator. Based on the measurement of a retrofit project in a government office in Singapore, the average energy saving can be up to 10% by using the energy optimizer.

STANDBY MODE OF LIFT EQUIPMENT

Some lift equipment can be shut down when the lift is being idled during off peak hours, while keeping the demand during off peak to be handled by the remaining equipment (e.g. shut down one of the lift in a lift bank).

The control of early lifts was achieved by electro-mechanical relays. Modern systems use software to provide flexible control. Some more expensive systems can "learn" where to position cabs at specific times, such as having all lifts return to the lobby in the early morning. Some will automatically save energy by matching the number of active elevators to the load in that interval.

Other useful resources for elevator and escalator design are at:

- Guidelines on Energy Efficiency of Lift and Escalator Installations 2000 Edition, By Electrical and Mechanical Services Department, The Government of the Hong Kong Special Administrative Region
- Guidelines on Energy Efficiency of Lift and Escalator Installation. 2000 Edition by Electrical and Mechanical Services Department, The Government of the Hong Kong Special Administrative Region *(http://www.emsd.gov.hk/emsd/e_download/pee/guidelines_on_ee_of_lift&escalator_installations.pdf)*
- Opportunities for Elevator Energy Efficiency Improvements. 2005. Sachs, Harvey M; One of the Series of White Papers by the American Council for an Energy-Efficient Economy (ACEEE) *(http://rste040vlmp01.blackmesh.com/files/pdf/white-paper/elevators2005.pdf)*
- Energy Efficient Elevators and escalator. 2010, By ISR –University of Coimbra (Portugal) partner with ELA (Europe), ENEA (Italy), FhG-ISI (Germany), KAPE (Poland) *(http://www.e4project.eu/documenti/wp6/E4-WP6-Brochure.pdf)*
- Energy Efficiency of Lifts, Improvements of Standby Demand in 80% of All Cases are Most Efficient, by Conradin Jost (Member of Directive Committee, VDI 4707/2 Energy Efficiency of Lift Components *(http://www.bucherhydraulics.com/bausteine.net/f/10295/Article_VDI4707_Energyefficiencyoflifts_EN.pdf?fd=3)*

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