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ASSOCIATION OF GERMAN ENGINEERS	Lifts Energy efficiency	VDI 4707 *Draft*

Lifts – Energy efficiency

Objections by 2008-05-31

- *preferably in tabulated form as a file via e-mail to tga@vdi.de*
  The template for this table can be accessed under http://www.vdi-richtlinien.de/einsprueche
- *in paper form to*
  VDI-Gesellschaft Technische Gebäudeausrüstung
  Postfach 10 11 39
  40002 Düsseldorf

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VDI- company specialised in technical equipment for buildings

Preliminary remark

The content of this guideline has come about with respect to the terms of reference and recommendations of guideline VDI 1000.

This VDI guideline was drafted with the participation of the following:

Wolfgang Adldinger, Wiedenzhausen
(acting chairman)
Dipl.-Ing. *Werner A. Boehm* VDI
Harald Giehl, Eltville
Theodor Helmle, Harthausen
Hans M. Jappsen, Oberwesel
Urs Lindegger, Ebikon (CH)
Michael Machovec, Hannover
Friedhelm Meermann VDI, Herbolzheim
(chairman)
Dr.-Ing. *Gerhard Schiffner*, Ostfildern
Dipl.-Ing. *Günter Volz* VDI, Ehningen
Uli Vetter, Künzelsau
Horst Wittur, ZFA Roßwein
Dipl.-Phys. *Thomas Wollstein* VDI, Düsseldorf
Peter Zeitler, Gräfelfing

Our thanks go to all who cooperated voluntarily on the drafting of this VDI guideline.

Introduction

Guideline VDI 4707 deals with the energy efficiency of lifts.

Its aim is to establish and provide a transparent representation of the assessment and classification of the power requirement and consumption of lifts according to standard criteria. This is based on a calculation of the requirement and consumption.

The guideline is aimed at builders, architects, planning consultants, assembly/maintenance companies and operators as well as testing organisations.

The guideline applies to all types of buildings. Because of the particular technical features of lifts within Building Services it has been separated from the complete documentation of the VDI 2067 series of guidelines.

Since the publication of EU directive 2002/91/EC of 16.12.2002 resource efficient operation has been the focal point of building technology and its management. Converting this directive into national law was completed with the adoption of the Energy Saving Ordinance (EnEV) by a cabinet decision on 26.05.2007. Now the German legislator and his national and local administration are turning their attention to all types of building. They are demanding reports of the energy efficiency of heating, cooling, ventilation and air conditioning and lighting technology for both new and existing buildings. This does not explicitly include hoisting and conveying engineering in the building. The lift industry, however, has voluntarily adopted the position of driving forward the energy efficiency of lifts in the sense of the Kyoto protocol. Future, more extensive regulations are to be expected; they may indeed also be forced to include hoisting and conveying engineering.

The development of technology and standards was also the driving force behind establishing nationally applicable principles for the German Federal Republic, which would allow the energy consumption for the operation of lifts to be measured, evaluated, rated and reported in a transparent fashion. This would take into account existing technical regulations as well as the recommendation and consultation on SIA 380/4[1)] and the report compiled by S.A.F.E.[2)] commissioned by the Swiss Federal Office of Energy.

The results may support resource efficient operation and form a quality feature of lifts and their operation as well as lead to sustainable management. At the same time energy efficient lift design can make a long lasting and effective contribution to a safer environment in the future through its lower environmental impact.

It is recognized that, to achieve the universal objective of the rational use of electrical energy in buildings, we must take into account not only energy efficiency but also the ecological balance. This applies also to lifts, where, in addition to the period of operation, the manufacture of the lifts, provision of raw materials and their disposal - the so-called lifecycle assessment (LCA) - must also be included. This further technical evaluation, however, is not the subject of this guideline.

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1) Swiss Association of Architects and Engineers

2) Swiss Agency for Energy Efficiency

1 Scope of application

This guideline applies to the assessment and rating of the energy efficiency of new lifts for people and goods. It may also be referred to, in order to establish retrospectively the energy efficiency of existing lifts as well as to check manufacturers' energy demand figures and to determine prospective power consumption.

The purpose of this guideline is to allow a universally comprehensible and transparent assessment of the energy efficiency of lifts based on methods for evaluating and testing their energy demand. This provides builders, architects, planning consultants, assembly and maintenance companies and operators as well as supervisory bodies with the opportunity, to include also the energy demand of lifts in their assessment of the energy efficiency of buildings and select beneficial products.

This guideline provides the basis for an energy rating of lifts within the framework of the overall energy efficiency of buildings. The result may be illustrated by attaching an energy certificate for lifts and forwarding to the operator as a supplement to the operating documentation.

2 Terms

The terms listed below are used in the present guideline:

Lift
Lift is used in this VDI guideline to mean lifts and lift assemblies.

Travel demand[3)]
The *travel demand* is the total energy consumption of the lift during trips at specified trip cycles with a defined load, see section 3.2.

Usage category
Division of lifts into classes according to frequency or intensity of use, average daily travel and standby time and type of building for the purpose of assigning to an energy efficiency class in accordance with this VDI guideline.

Standby demand
The total energy consumption of the lift in standby mode, see section 3.1.

[3] Building Services distinguishes between values for consumption and demand, whereby the former are the actual consumption figures, whilst the latter are the expected values based on certain precepts.

3 Characteristic values

The energy demand of lifts can be expressed as a specific demand value, in which by means of

- standby demand and
- travel demand

a specific value for the **required energy per kg nominal load and distance travelled in metres**, E_{eff} is determined in mWh/(kg·m). This specific value of energy demand allows the energy efficiency of lifts of different types of design and construction to be compared.

3.1 Standby demand

The standby demand is the total energy demand of the lift in standby mode. This means that only the parts of the electrical equipment and the components that contribute to operating the lift or maintaining it in standby need to be taken into account. (machine room and shaft lighting, for example, are not considered.)

Note: Standby demand and travel demand are quoted separately, see also section 4.5.

3.2 Travel demand

The travel demand is the total energy demand of the lift

- during trips at specified trip cycles and
- with a defined load.

The resultant specific demand value in mWh/(m·kg) is related to the distance travelled in metres and the nominal load in kilogrammes.

Note: Standby demand and travel demand are quoted separately, see also section 4.5.

3.3 Energy efficiency classes

Lifts are assigned to energy efficiency classes according to their own specific energy demand.

Seven energy efficiency classes are defined, labelled with the letters A to G, whereby energy efficiency class A corresponds to the best energy efficiency.

3.4 Usage category

Besides its type of construction the total energy demand of a lift depends essentially on its usage. Depending on the type of building, the use of the lift and the number of users, this guideline specifies four usage categories, which are distinguished in particular by the average travel time per day. Depending on the proportions of time of standby demand and travel demand, various specific energy demand values are given for the four usage categories and in part therefore also different energy efficiency classes.

Table 1 lists the average durations of usage for the four usage categories and typical examples of lifts in these usage categories.

4 Determination of figures and characteristic values

4.1 Standby demand

The standby demand may be determined by measurement or adding up the individual demand values, as far as they are sufficiently known. The standby demand is determined ten minutes after the last trip has ended.

4.2 Travel demand

The travel demand is determined for a reference trip. A reference trip consists of travel over the whole vertical rise with an empty car upwards and downwards and includes the movement of the doors.

The travel demand may be determined by measurement or adding up the individual, known demand values.

The energy consumption measured during the reference trip or the energy demand determined in Watt hours (Wh) is related to the distance travelled (double the vertical rise) and the nominal load of the car. To ensure the accuracy of the measurements, the reference trip may be carried out several times in succession.

Since the energy consumption of drives for rope driven and hydraulic lifts may de dependant on their temperature due to, for example, the viscosity of oils, measurements should be carried out at average operating temperatures.

The reference trip with an empty car applies to common lifts that use traction drive and a counter-weight compensation of 40% to 50% or hydraulic or drum drive with a small or no compensation weight.

Table 1. Usage categories for lifts according to VDI 4707

Usage category	**1**	**2**	**3**	**4**
Usage intensity/ frequency	low seldom	medium occasionally	high frequently	very high very frequently
Average travel time in hours per day*)	0.5 (≤ 1)	1.5 (> 1-2)	3 (> 2-4.5)	6 (> 4.5)
Average standby time in hours per day	23.5	22.5	21	18
Typical types of building and use	• Residential block with up to 20 dwellings • small office and administrative building with 2 to 5 floors • small hotels • goods lift with little operation	• Residential block with up to 50 dwellings • medium-sized office and administrative building with up to 10 floors • medium-sized hotels • goods lift with medium operation	• Residential block with more than 50 dwellings • tall office and administrative building with more than 10 floors • large hotel • small to medium-sized hospital • goods lift in a production process with a single shift	• Office and administrative building over 100 m in height • large hospital • goods lift in a production process with several shifts

*) May be determined from the average number of trips and average trip duration.

For lifts with a different compensation weight the energy demand must be determined for travel with a collective load. This includes:

- 40% trips with an empty car
- 30% trips with 1/3 loading
- 30% trips with 2/3 loading

An individual load collective can be specified for special types of use. This must be documented.

4.3 Measurement of energy consumption values

The measurements are taken after the main switch for the power circuit and after the switch for the lighting circuits of the lift installation (see diagram 1).

Shaft and machine room lighting are not taken into account when determining energy consumption

Circuits for controlling groups of lifts may also be present. For these circuits a measurement is also undertaken in standby and the consumption value added proportionately to the standby consumption of the individual lifts.

Apart from the circuits and connected consumers mentioned, there may be other devices (e. g. for heating or cooling), which are required to operate the lift, connected in separate circuits. The energy consumption values for these consumers must also be determined and reported separately.

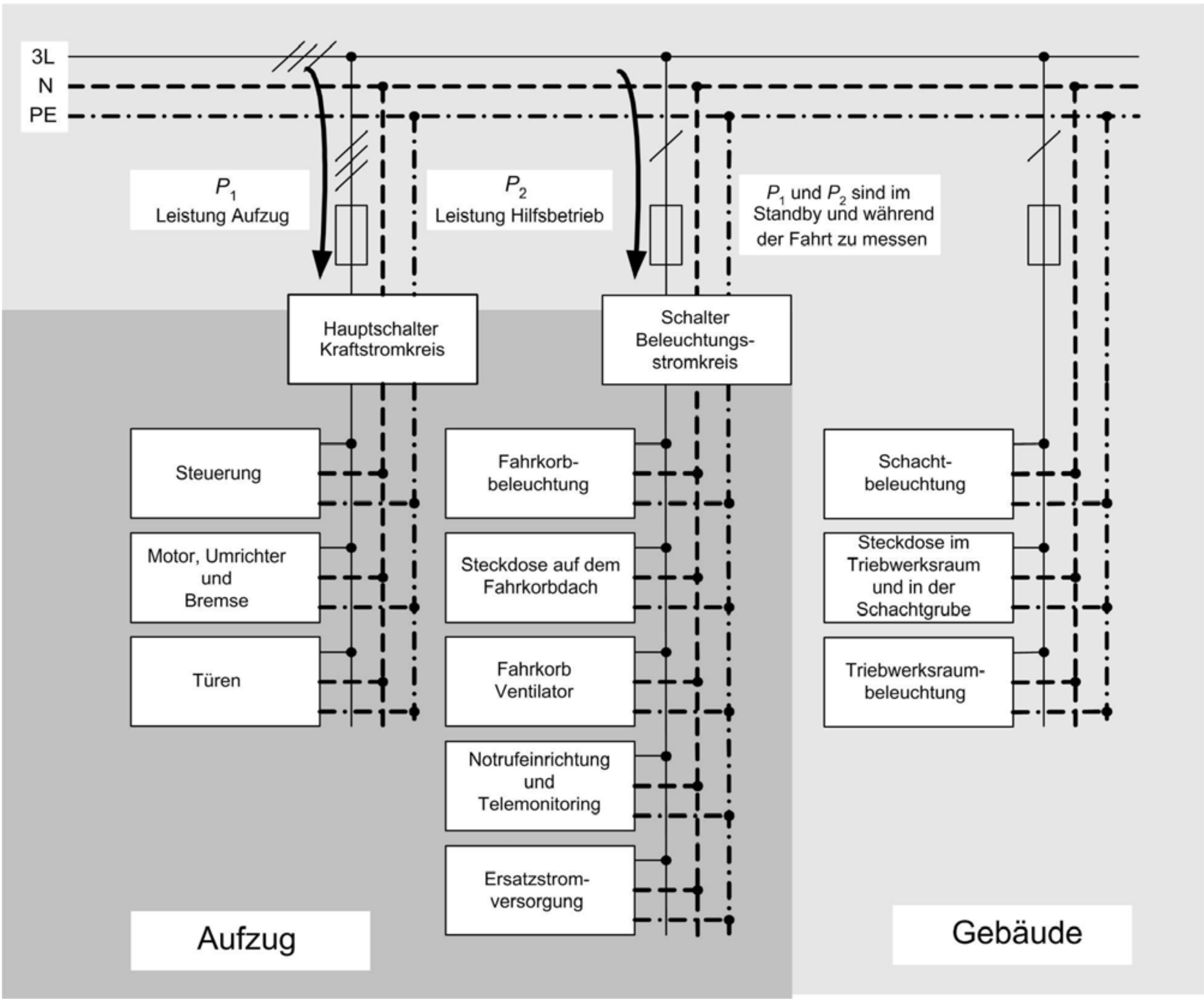

Diagram 1. Determination of the energy consumption of lifts, schematic diagram

4.4 Demands on measurement and the measuring devices for measuring the power circuit

Small standby outputs and high acceleration outputs with totally non-ideal harmonic currents place great demands on the measuring equipment.

4.4.1 Demands on the measuring devices for measuring the power circuit

- Creation of the 3 phase effective power with a minimum of three values per second
- Consideration of harmonics produced by voltage to frequency converters
- sufficient measurement range for acceleration and standby
- The output is determined by the measuring device from the effective values of the voltage and the current.
- The effective values must be created between two unbroken readings.
- Recording of the output values during the reference trip (graph: output as a function of time).

4.4.2 Demands on the measuring devices for measuring the lighting circuit

- Creation of the single phase effective power with a minimum of three values per second
- Consideration of harmonics
- The output is determined by the measuring device from the effective values of the voltage and the current.
- The effective values must be created between two unbroken readings.
- Output values can be read off statically.

The measurement must be carried out by competent technical staff familiar with the measuring devices. There must also be the appropriate lift operating personnel present to ensure safety.

Advice on carrying out the measurements is given in ISO 25745-1.

4.5 Energy consumption classes and energy efficiency classes

The lift is assigned to energy demand classes in accordance with table 2 and table 3 according to the demand values for standby and travel determined in line with section 5.1 and section 5.2.

The energy efficiency classes for a lift are determined from the energy demand values for standby and travel, by grossing up the output in standby and the energy demand for travel with the average standby times and travel times according to table 1 to a daily consumption and then dividing by the number of metres travelled and the nominal load. This gives the specific total energy demand value of the lift, to which energy efficiency classes are assigned according to table 4.

4.6 Lift energy certificate according to VDI 4707

The characteristic values determined may be quoted by a manufacturer to the builder or operator as part of an offer for a lift. The characteristic values may be reported in a subsequent energy certificate. This energy certificate may form the basis of an evaluation of the energy efficiency of lifts within the scope of the EnEV (building energy pass).

4.7 Sample calculation

A lift manufacturer is to submit to a customer an offer for a lift, of which the basic parameters for the intended use and the expected amount of traffic have been first selected as follows (see also table D1):

Type of building:	Residential block/ doctor’s practice
Nominal load:	320 kg
Speed:	0.63 m/s
Stops:	5
Vertical rise:	11.2 m
Trips per day:	approx. 100

The estimated number of trips per day and an average distance travelled of under 6 m gives a daily travel time of approx. 0.5 h. **This means the lift falls into usage category 1** (light usage).

Table 2. Energy demand classes for standby

Output in W	≤ 50	≤ 100	≤ 200	≤ 400	≤ 800	≤ 1600	> 1600
Class	A	B	C	D	E	F	G

Table 3. Energy demand classes for travel

Spec. Energy consumption in mWh/m kg	≤ 0.8	≤ 1.2	≤ 1.8	≤ 2.7	≤ 4.0	≤ 6.0	> 6.0
Class	A	B	C	D	E	F	G

Table 4. Energy efficiency classes

Energy efficiency class	**Specific energy demand** in mWh/(kg·m)			
	Usage category			
	1	**2**	**3**	**4**
A	≤ 1.45	≤ 1.01	≤ 0.90	≤ 0.84
B	≤ 2.51	≤ 1.62	≤ 1.39	≤ 1.28
C	≤ 4.41	≤ 2.63	≤ 2.19	≤ 1.97
D	≤ 7.92	≤ 4.37	≤ 3.48	≤ 3.04
E	≤ 14.41	≤ 7.33	≤ 5.56	≤ 4.67
F	≤ 26.88	≤ 12.67	≤ 9.11	≤ 7.33
G	> 26.88	> 12.67	> 9.11	> 7.33

Note: The tabulated values have been derived for a lift with a nominal load of 1000 kg and a nominal speed of 1 m/s from combining the consumption values in table 2 and table 3 with the same class in each case (e. g. travel class A + standby class A = total efficiency class A, travel class D + standby class D = total efficiency class D).

Lift manufacturer:

Location:

Lift model:

Lift type:	Hydraulic lift
Nominal load:	320 kg
Nominal speed:	0.63 m/s

Standby demand:	**Travel demand:**
≤ 200 W	> 6 mWh/(m·kg)
(class C)	(class G)

Note: Additional consumers (other devices, which are required to operate the lift), if present: see attachment(s)

Usage category 1 according to VDI 4707

Comparisons of energy efficiency classes can only be made for the same usage category.

Energy efficiency class

A	B	C	D	E	**[F]**	G

Diagram 2. Example of a fictitious lift energy certificate according to VDI 4707 for offer and acceptance (see also section 5.6)

The lift manufacturer determines a standby consumption of 110 W for the equipment desired by the customer (lighting, displays etc.) and for the electrical components envisaged for the lift. This corresponds to **energy demand class C for standby consumption**.

The specific consumption for one trip up and down amounts to 8.93 mWh/(kg·m). This means the lift falls into **energy demand class G for the travel demand**.

In usage category 1 we assume an average travel time of 0.5 hours per day. Ignoring the acceleration and deceleration periods, the lift would travel a distance of 1,134 m per day at 0.63 m/s. This gives an energy demand of

$$E_{\text{travel}} = 8.93 \text{ mWh/(m·kg)} \times 1{,}134 \text{ m} \times 320 \text{ kg}$$
$$= 3.24 \text{ kWh}$$

For 23 hours of standby per day, this gives a standby demand of

$$E_{\text{standby}} = 110 \text{ W} \times 23 \text{ h} = 2.59 \text{ kWh}$$

The total energy demand per day, therefore, amounts to

$$E_{\text{tot}} = 3.24 \text{ kWh} + 2.59 \text{ kWh} = 5.82 \text{ kWh}$$

If this value is again divided by the distance travelled per day and the nominal load, the specific energy demand value of the lift comes to

$$E_{\text{spec}} = 5.82 \text{ kWh/(1,134 m} \times 320 \text{ kg)}$$
$$= 16.05 \text{ mWh/(m·kg)}$$

This means the lift belongs overall in energy efficiency class F.

A different usage of the same lift would result in different classes. For examples, see appendix D.

5 Testing the characteristic values on the lift as well as determining the consumption values of existing lifts

In order to check the energy consumption values quoted by the lift manufacturer and/or to test whether changes in the lift equipment as a result of age, maintenance or building alterations have changed the energy demand values, the operator can test the characteristic values on an existing lift. To do this, the same procedure and measuring technique as described in section 4 must be followed.

Note that, when making a comparison with the original figures quoted by the manufacturer, there may be deviations of the order of up to ±20% as a result of scatter and slight differences in settings.

The same procedure may be used to determine retrospectively the energy demand values of an existing lift.

6 Calculation of the annual energy demand

The approximate expected demand for electrical energy to operate a lift in a building may be extrapolated from the energy demand characteristic values, by multiplying the specific value of the installed lift with the expected number of trips, the average distance per trip and an average loading factor (loading and balancing) and the nominal load. For lifts, whose daily usage times vary significantly from the assumed travel times according to table 1, the annual energy demand may also be extrapolated from the energy demand characteristic values for travel and standby using the estimated times for travel and standby. The time for travel is given by the expected number of trips and the average distance travelled per trip.

The calculation of the expected annual energy demand is given by extrapolating from the total energy demand per day determined as follows:

- nominal load Q in kg
- standby demand P_{stand} in W
- specific travel demand E_{spec} in mWh/(m·kg)
- usage time t_{use} in hours per day
- distance travelled s_{nom} during the usage time per day in m
- $s_{\text{nom}} = v_{\text{N}} \cdot t_{\text{use}}$ or $s_{\text{nom}} = n_{\text{trip}} \cdot h_{\text{F}}$

  where,

  v_{n} nominal velocity in m/s

  n_{trip} number of trips per day[4)]

  h_{F} average distance travelled
- loading factor k (k = 0.8 for rope operated lifts, k = 1.2 for hydraulic lifts)

This gives the energy demand per day:

$$E_{\text{stand}} = P_{\text{stand}} \cdot (24 \text{ h} - t_{\text{use}})$$
$$E_{\text{travel}} = k \cdot E_{\text{spec}} \cdot s_{\text{nom}} \cdot Q$$
$$E_{\text{day}} = E_{\text{stand}} + E_{\text{travel}}$$

The energy demand per year comes to:

$$E_{\text{year}} = E_{\text{day}} \cdot N$$

where N is the number of operating days per year.

[4)] For lifts with two stops, h_{F} is the vertical rise, for more than two stops, half of the vertical rise is used for h_{F}.

7 Selection of lift parameters at the design stage

Design must follow the recognised rules of engineering. The design must be carried out by a competent person. Necessary competence can be demonstrated e. g. by successful completion of training according to guideline VDI 2168. The designer must check the completeness and correctness of the documents provided by the client.

The following specifications must be agreed between the client and the designer.

Details, which are required for calculation of the capacity, are e. g.:

- Type of building
- Usage(category)
- Population of individual floors
- Number of stops
- Vertical rise
- Choice of drive design

When determining the necessary selection, the number and size of the lifts, the designer must also determine the effect on energy efficiency of the various solutions. Together with the client, he establishes the usage category according to table 1.

Further parameters must be taken into account during the design in accordance with the technical layout:

- operating times
- constant consumers
- switchable consumers
- add-on units

Systems, which lead to a reduction in the standby demand, must be taken into account at the design stage (see also appendix A for possibilities of optimisation).

The designer must work together with the client to develop and evaluate alternative ideas for a solution. The design result as well as the selection made by the client must be documented.

Appendix A Influence of assembly, servicing and maintenance

In addition to the selection of components, assembly, servicing and maintenance have a significant impact on the actual energy consumption of the lift in operation.

Particular points to be aware of are

- Alignment of the guide rails
- Car and counter-weight counterbalanced in the guides
- Lubrication
- Inching
- Switching off machine room and shaft lighting after completing the work

Appendix B Influencing factors for lift components, recommendations for manufacturers

Table B1 gives a list of the possibilities of reducing the energy consumption.

Table B1. Lift components

Component	**Travel**	**Standby**	**Possibilities of optimisation**
Machine • Motor with ventilation • Gear or pump • Brakes or valves • Oil cooler • Oil heating • Pressure contact	X		high level of efficiency or low power consumption
Mechanical components • Lift system (centre/eccentric suspension) • Car guide rail (shoe/roller guide) • Rope drive (number of ropes, number and diameter of the pulleys, inclined lift) • Pressure line (tube/hose) • Jack	X		Smooth running of the installation, low friction design of car and counter-weight guide rails; use fewest possible diverting pulleys with low inertia
Drive control/generator including line filter/line choke/ tacho/encoder/brake resistance	X	X	• low consumption in standby or sleep mode • line choke with low volt drop • replace Ward Leonard generators with an electronic control
Energy recuperation	X	X	• low standby demand • recuperation only meaningful for high power consumptions and high level of efficiency of the installation and drive
Control			Basic rule to observe: low consumption in standby or sleep mode
Shaft selector	(X)	X	Absolute encoder, switchable
Shaft limit switch	(X)	X	
Switches on all safety components	(X)	X	
Alarm system	(X)	X	
Intercom	(X)	X	
Load measuring system	(X)	X	
Car door operator	(X)	X	only active when door moving
Door control	(X)	X	Sleep mode
Light barrier	(X)	X	only active when door open
Car lighting	(X)	X	Turn off, when the lift is not in use, use energy efficient lighting **Note:** In many cases the highest power consumer in standby. High savings potential!
Travel control device in the car	(X)	X	energy saving lighting
Information displays in the car	(X)	X	• Avoid displays with a high energy consumption • switch off, when the lift is not in use
Fans for the car	(X)	X	switch off, when the lift is not in use
Threshold heating	(X)	X	temperature controlled
Travel control devices on the floors	(X)	X	energy saving lighting
Information displays on the floors	(X)	X	switch off, when the lift is not in use
Landing entrance lighting			use energy saving lighting
Shaft ventilation			• temperature controlled • ensure that heat/cold does not dissipate unnecessarily from the building

Component	Travel	Standby	Possibilities of optimisation
Fans for machine room	(X)	X	temperature controlled
Air conditioning unit to cool the machine room	(X)	X	temperature controlled
Shaft lighting (if in constant operation)	(X)	X	use energy saving lighting
Machine room lighting (if in constant operation)	(X)	X	use energy saving lighting

(X) - low impact

Appendix C Examples

Example 1: Lift in a residential building

Lift A is to be used in a residential building having the following characteristic values:

- 5 floors
- 20 dwellings
- 12 m vertical rise
- approx. 200 trips per day

The estimated number of trips per day and an average trip distance of 6 m give a daily travel time of 0.33 h. This means the lift falls into usage category 1 (low usage).

For this purpose the lift manufacturer offers a standard hydraulic lift with a nominal velocity of 0.63 m/s and a nominal load of 630 kg.

For the equipment desired by the customer (lighting, displays etc.) and the electrical components envisaged for the lift, the lift manufacturer determines a standby demand of 31 W. This corresponds to energy efficiency class A for standby demand.

From measurements on other comparable installations, we know that the lift system with an indirect hydraulic drive and rucksack suspension has a specific travel demand of 6.83 mWh/(m·kg) and therefore falls into energy efficiency class G for travel demand.

We assume an average travel time of 0.5 h per day in usage category 1. Ignoring acceleration and deceleration periods, the lift would cover a distance of 1,134 m per day at a nominal velocity of 0.63 m/s. This gives an energy demand of

$$E_{FT} = 6.83\ \text{mWh/(m·kg)} \times 1{,}134\ \text{m} \times 630\ \text{kg}$$
$$= 4.88\ \text{kWh/d}$$

23.5 hours of standby per day gives a standby demand of

$$E_{ST} = 31\ \text{W} \times 23.5\ \text{h} = 0.73\ \text{kWh/d}$$

The total energy demand per day, therefore, amounts to

$$E_{Ttot} = 4.88\ \text{kWh} + 0.73\ \text{kWh} = 5.61\ \text{kWh/d}$$

If this value is again divided by the distance travelled per day and the nominal load, this gives a specific energy demand value for the lift of

$$E_{Aspec} = 5.61\ \text{kWh/(1,134 m} \times 630\ \text{kg)}$$
$$= 7.85\ \text{mWh/(m kg)}$$

This means the lift is overall in energy efficiency class D.

For a different usage of the same lift, the demand values and classes would be given according to table C1.

Table C1. Different energy efficiency classes of the same lift for various usage categories

	Usage category			
	1	**2**	**3**	**4**
Travel time per day in h	0.5	1.5	3	6
Energy demand for travel per day in kWh	4.88	14.64	29.28	58.55
Standby time per day in h	23.5	22.5	21	18
Energy demand in standby in kWh	0.73	0.70	0.65	0.56
Total energy demand per day in kWh	5.61	15.34	29.93	59.11
Specific energy demand in mWh/(m•kg)	7.85	7.16	6.98	6.90
Energy efficiency class	**D**	**E**	**F**	**F**

Example 2: Lift in an office building

Lift B is to be used in an office building having the following characteristic values:

- 15 floors
- 500 employees as well as a large number of visitors
- 49 m vertical rise

During the design stage, lifts in a group of 3 with a nominal load of 1,000 kg and nominal velocity of 2.5 m/s are specified. Calculating the amount of traffic gives 1,200 trips per day with an average distance travelled of 20 m for each lift. This gives an average travel time of 2.67 h per day, which means the lift falls into usage category 3 (heavy usage).

For the equipment desired by the customer (lighting, displays etc.) and the electrical components envisaged for the lift, the lift manufacturer determines a standby demand of 750 W. This corresponds to energy efficiency class E for standby demand.

From measurements on other comparable installations, we know that the lift system with a gearless drive and recuperation has a specific travel demand of 0.95 mWh/(m·kg) and therefore falls into energy efficiency class B for travel demand.

We assume an average travel time of 3 h per day in usage category 3. Ignoring acceleration and deceleration periods, the lift would cover a distance of 27,000 m per day at a nominal velocity of 2.5 m/s. This gives an energy consumption of

$$E_{FT} = 0.95 \text{ mWh/d(m·kg)} \times 27{,}000 \text{ m} \times 1{,}000 \text{ kg}$$

$$= 25.65 \text{ kWh/d}$$

21 h standby per day gives a standby demand of

$$E_{ST} = 750 \text{ W} \times 21 \text{ h} = 15.75 \text{ kWh/d}$$

This means the total energy demand per day amounts to

$$E_{Ttot} = 25.65 \text{ kWh} + 15.75 \text{ kWh} = 41.4 \text{ kWh/d}$$

If this value is again divided by the distance travelled per day and the nominal load, this gives a specific energy demand value for the lift of

$$E_{Aspec} = 41.4 \text{ kWh/(27,000 m} \times 1{,}000 \text{ kg)}$$

$$= 1.53 \text{ mWh/(m kg)}$$

This means the lift is overall in energy efficiency class C.

For a different usage of the same lift, the demand values and classes would be given according to table C2.

If the standby consumption of this lift were to be reduced from 750 W to 400 W, it would give a specific energy consumption value for usage category 3 of 1.26, which means the lift would then fall into energy efficiency class B.

Table C2. Different energy efficiency classes of the same lift for various usage categories

	Usage category			
	1	**2**	**3**	**4**
Travel time per day in h	0.5	1.5	3	6
Energy demand for travel per day in kWh	4.28	12.83	25.65	51.3
Standby time per day in h	23.5	22.5	21	18
Energy demand in standby in kWh	17.63	16.88	15.75	13.5
Total energy demand per day in kWh	19.56	29.71	41.4	64.8
Specific energy demand in mWh/(m•kg)	5.29	2.2	1.53	1.2
Energy efficiency class	**D**	**C**	**C**	**B**

Appendix D Sample data

Table D1 lists data, which come from the final report of the research project of the Swiss Federal Office of Energy (DIS-Project No. 101106) from 2005, see also http://www.electricity-research.ch.

33 lifts measured in Switzerland are evaluated according to VDI 4707.

Table D1. Lifts, evaluated according to VDI 4707

Referenznummer	**Nennlast** in kg	**Geschwindigkeit** in m/s	**Förderhöhe** in m	**Anzahl Haltestellen**	**Gebäudeart**	**Jahrgang**	**Aufzugsart/Technik**	**Fahrtenzahl pro Jahr**	**Motorleistung lt. Typenschild** in kW	**Motorleistung gemessen** in kW	**Leistungsaufnahme Standby** in W	**Bedarfsklasse Stillstand**
1	320	0,63	11,2	5	Wohnhaus/ Arztpraxis	2002	Hydraulik indirekt	26198	9	9,5	110	**C**
2	320	1	14,0	6	Wohnhaus	1977	Schneckengetriebe, Relaissteuerung, 2 Geschwindigkeit	62351	4,9	3,9	0	**A**
3	500	0,6	13,4	6	Wohnhaus	1994	Hydraulik Indirekt	11181	11	12,6	31	**A**
4	500	1	12,4	5	Personen-aufzug	2004	Hydraulik indirekt, Druckspeicher, Zugzylinder	Test-anlage	7,5	4,7	39	**A**
5	500	1,6	10,2	6	Wohnhaus	2004	Getriebelos 2:1	zu neu	5,5	7,5	112	**C**
6	630	1	17,4	7	Wohnhaus	2002	Getriebelos 2:1	39843	3,7	5,2	38	**A**
7	630	1	14,6	6	Wohnhaus	2005	Getriebelos 2:1	zu neu	3,7	4,8	40	**A**
8	630	1	6,9	3	Büro	2005	Getriebelos 2:1	zu neu	3,9	4	128	**C**
9	630	1	27,5	8	Büro	2000	Getriebelos 2:1	107257	5	4,2	150	**C**
10	630	1	14,4	6	Parking	2004	Getriebelos 2:1	55070	6,4	3,7	84	**B**
11	630	1	29,0	12	Wohnhaus	2001	Getriebelos mit Ausgleichsorganen	76947	6,5	5,3	130	**C**
12	630	1	11,6	5	Wohnhaus	2000	Schneckengetriebe	16361	6,7	6	45	**A**
13	630	1	14,0	6	Wohnhaus	2002	Schneckengetriebe Umrichter	33171	6,7	3,4	59	**B**
14	630	1	11,8	4	Büro	1992	Spannungsgesteuert	278926	8	6,3	94	**B**
15	630	1,6	14,6	4	Büro	2004	Getriebelos 2:1 mit Rückspeisung	zu neu	7,5	15,8	248	**D**
16	750	1,6	26,1	10	Wohnhaus	2000	Planetengetriebe	164577	9	7,2	100	**B**
17	800	1	15,6	5	Büro	1992	Spannungsgesteuert	115583	9,6	6,7	131	**C**
18	800	1	16,5	6	Wohnhaus	2004	Getriebelos 2:1	zu neu	9,7	4,9	60	**B**
19	900	1,48	13,3	6	Parking	1972	Getriebelos 2:1	352973	17,7	15	228	**D**
20	900	2	7,8	4	Parking	1999	Schneckengetriebe	329967	18	16	460	**E**
21	1000	1	23,7	10	Wohnhaus	2001	Planetengetriebe	42440	7	8,5	78	**B**
22	1200	2,5	37,8	11	Kranken-haus	1994	Getriebelos 1:1 Rückspeisung	670567	18,8	26	270	**D**
23	1500	2,5	68,1	22	Büro	1972	Wardleonard Rückspeisung	339846	25	27,1	1700	**G**
24	1500	2,5	73,7	21	Büro	2001	Planetengetriebe	195577	27,4	19,3	308	**D**
25	1600	1	3,0	2	Shopping	2004	Getriebelos 2:1	211484	10,5	12,7	105	**C**
26	1600	1,4	12,4	5	Industrie	1994	Hydraulik	Testa.	47	40	---	**G**
27	1800	1,6	38,4	10	Kranken-haus	2001	Getreibelos 1:1 Rückspeisung	688036	28	20	400	**D**
28	2000	1,6	34,0	10	Kranken-haus	1993	Schneckengetriebe	312960	26,5	21,6	306	**D**
29	2000	1,6	51,9	14	Büro	2002	Schneckengetriebe	118706	27	18	550	**E**
30	2200	2,5	34,0	11	Parking	2001	Getriebelos 1:1 Rückspeisung	512726	34,4	19	980	**F**
31	2500	0,6	11,2	4	Autolift	1995	Hydraulik Zugzylinder 1:x	37140	28	15,8	342	**D**
32	3000	2	42,9	12	Büro	2003	Planetengetriebe	157141	49	40	810	**F**
33	3200	0,5	8,9	3	Industrie	2000	Hydraulik, Druckspeicher, Zugzylinder	48940	24	3,16	88	**B**

Table D1. Lifts, evaluated according to VDI 4707 (continued)

Bedarf auf/ab in Wh	**Spezifischer Bedarf für eine Auf-und-Ab-Fahrt** in mWh/kgm	**Fahr-Energieklasse**	**Spezifischer Energiebedarf bei Fahrt** in Ws/kgm	**Standby-Energiebedarf pro Tag** in kWh/d	**Fahrdistanz pro Tag** in m/d	**Fahrenergie pro Tag** in kWh/d	**Energiebedarf pro Tag** in kWh/d	**Davon Standby** in %	**Berechnete Fahrten pro Jahr**	**Fahrtenabweichung** in %	**Spezifischer Energiebedarf pro Tag und Nutzungskategorie** in mWh/mkgd	**Energieklasse in der Nutzungskategorie**	**Nutzungskategorie**
63,87	8,93	**G**	47,123	2,59	1134	3,24	5,82	44	74045	183	16,05	**F**	1
34,16	3,81	**E**	12,188	0,00	1800	2,20	2,20	0	93857	51	3,81	**C**	1
91,39	6,83	**G**	42	0,73	1080	3,69	4,41	17	58880	427	8,17	**E**	1
27,65	2,24	**D**	9,4	0,92	1800	2,01	2,93	31	106397		3,26	**C**	1
16,59	1,63	**C**	9,375	2,63	2880	2,35	4,98	53	206523		3,46	**C**	1
29,72	1,36	**C**	8,254	0,89	1800	1,54	2,43	37	75648	90	2,15	**B**	1
27,82	1,52	**C**	7,619	0,94	1800	1,72	2,66	35	90247		2,35	**B**	1
11,07	1,27	**C**	6,3492	2,88	5400	4,32	7,20	40	569653		2,12	**C**	2
34,68	1,00	**B**	6,6667	3,53	1800	1,13	4,66	76	47782	-55	4,11	**C**	1
16,95	0,93	**B**	5,873	1,97	1800	1,06	3,03	65	91250	66	2,67	**C**	1
50,29	1,38	**C**	8,4127	3,06	1800	1,56	4,62	66	45310	-41	4,07	**C**	1
27,24	1,86	**D**	9,5238	1,06	1800	2,11	3,17	33	112984	591	2,79	**C**	1
19,68	1,12	**B**	5,3968	1,39	1800	1,27	2,65	52	93857	183	2,34	**B**	1
38,81	2,61	**D**	10	2,21	1800	2,96	5,16	43	111168	-60	4,55	**D**	1
15,11	0,82	**B**	15,675	5,58	8640	4,49	10,07	55	433485		1,85	**C**	2
43,3	1,11	**B**	6	2,35	2880	2,39	4,74	50	80552	-51	2,19	**B**	1
52,78	2,12	**D**	8,375	3,08	1800	3,05	6,13	50	84285	-27	4,25	**C**	1
28,67	1,09	**B**	6,125	1,35	5400	4,69	6,04	22	238909		1,40	**B**	2
79,85	3,34	**E**	11,261	5,36	2664	8,00	13,36	40	146220	-59	5,57	**D**	1
26,79	1,91	**D**	8,8889	10,81	3600	6,18	16,99	64	336923	2	5,24	**D**	1
58,48	1,23	**C**	8,5	1,83	1800	2,22	4,05	45	55443	31	2,25	**B**	1
115,27	1,27	**C**	8,6667	5,67	27000	41,17	46,84	12	521429	-22	1,45	**C**	3
221,1	1,08	**B**	7,2267	35,70	27000	43,83	79,53	45	289427	-15	1,96	**C**	3
170,63	0,77	**A**	5,1467	6,93	13500	15,64	22,57	31	133809	-32	1,11	**B**	2
16,31	1,70	**C**	7,9375	2,47	1800	4,89	7,36	34	438000	107	2,56	**C**	1
112,16	2,84	**E**	17,857	---	15120	68,66	68,66	0	893733		2,84	**D**	3
55,64	0,40	**A**	6,9444	7,20	34560	25,01	32,21	22	656316	-5	0,52	**A**	4
186,38	1,37	**C**	6,75	6,89	8640	23,68	30,57	23	185506	-41	1,77	**C**	2
191,96	0,92	**B**	5,625	12,93	2880	5,32	18,25	71	40477	-66	3,17	**C**	1
71	0,47	**A**	3,4545	22,05	13500	14,10	36,15	61	289853	-43	1,22	**B**	2
111,22	1,99	**D**	10,533	8,04	1080	5,38	13,41	60	70582	90	4,97	**D**	1
257,82	1,00	**B**	6,6667	19,04	3600	10,82	29,85	64	61259	-61	2,76	**C**	1
34,72	0,61	**A**	1,975	2,07	900	1,76	3,82	54	73820	51	1,33	**A**	1

Literature

Laws, ordinances, administrative regulations

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Diagram 2. Determination of the energy consumption of lifts, schematic diagram

Lift power
Auxiliary plant power
P_1 and P_2 must be measured in standby and during travel
Main switch power circuit
Switch lighting circuit
Control
Car lighting
Shaft lighting
Motor, converter and brake
Socket on the car roof
Socket in the machine room and the pit
Doors
Car ventilator
Machine room lighting
Alarm system and telemonitoring
Standby supply
Lift
Building

Table D2. Lifts, evaluated according to VDI 4707

Reference number	Nominal load in kg	Velocity in m/s	Vertical rise in m	Number of stops	Type of building	Year	Type of lift/technology	Number of trips per year	Motor power according to rating plate in kW	Motor power measured in kW	Standby power consumption in W	Standby demand class
1					Residential building/doctor’s practice		Indirect hydraulic					
2							Worm gears, relay control, 2 speed					
3							Indirect hydraulic					
4					Lift for people		Indirect hydraulic, pressure accumulator, pull cylinder	Test installation				
5					Residential building		Gearless 2:1					
6					Residential building		Gearless 2:1					
7					Residential building		Gearless 2:1					
8					Office		Gearless 2:1					
9					Office		Gearless 2:1					
10					Car park		Gearless 2:1					
11					Residential building		Gearless with compensating ropes					
12					Residential building		Worm gears					
13					Residential building		Worm gears converter					
14					Office		Voltage controlled					

15					Office		Gearless 2:1 with recuperation	Too new				
16					Residential building		Epicyclic gears					
17					Office		Voltage controlled					
18					Residential building		Gearless 2:1					
19					Car park		Gearless 2:1					
20					Car park		Worm gears					
21					Residential building		Epicyclic gears					
22					Hospital		Gearless 1:1 recuperation					
23					Office		Ward Leonard recuperation					
24					Office		Epicyclic gears					
25					Shopping centre		Gearless 2:1					
26					Industrial		Hydraulic	Test installation				
27					Hospital		Gearless 1:1 recuperation					
28					Hospital		Worm gears					
29					Office		Worm gears					
30					Car park		Gearless 1:1 recuperation					
31					Car lift		Hydraulic pull cylinder 1:x					
32					Office		Epicyclic gears					
33					Industrial		Hydraulic, pressure accumulator, pull cylinder					

Table D1. Lifts, evaluated according to VDI 4707 (continued)

Demand up/down in Wh	Specific demand for an up and down trip in mWh/kgm	Travel energy class	Specific energy demand for travel in Ws/kgm	Standby energy demand per day in kWh/d	Travel distance per day in m/d	Travel energy per day in kWh/d	Energy demand per day in kWh/d	Of which standby in %	Calculated trips per year	Trip deviation in %	Specific energy demand per day and usage category in mWh/mkgd	Energy class in the usage category	Usage category