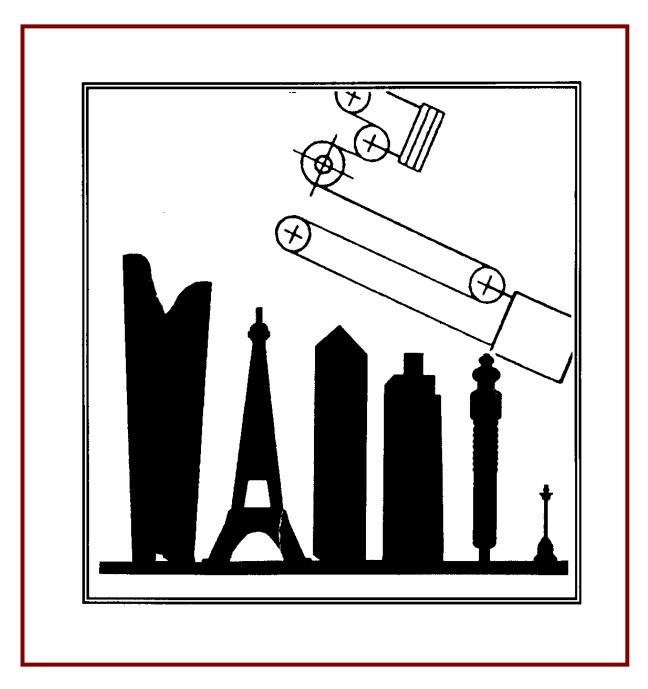
Gina Barney Associates



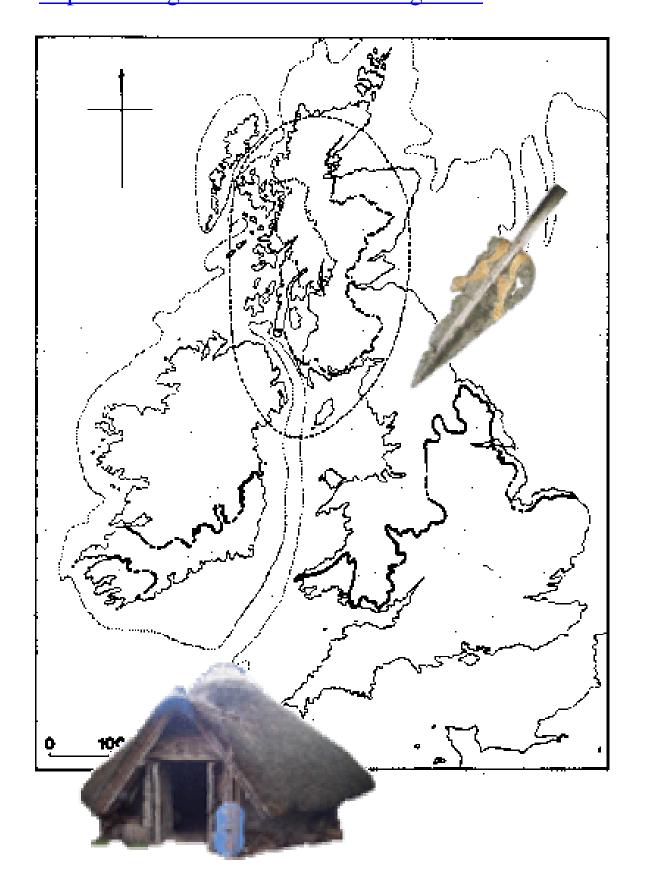
Independent vertical transportation consultants PO Box 7, SEDBERGH, LA10 5GE © Gina Barney 2007 www.liftconsulting.org

ENERGY EFFICIENCY OF LIFTS – MEASUREMENT, CONFORMANCE, MODELLING, PREDICTION AND SIMULATION

PRESENTATION CONTENT

Climate change History Ice Age **EFFICIENCY WHAT CAN BE DONE ?** REGENERATION **50things you can do to make** lifts energy efficient **CALCULATION METHODS ISO Proposed calculation method ISO ENERGY MEASUREMENT COMPUTER MODELS ISO ENERGY MODEL**

Ice Age British Isles The Last Ice sheet http://www.gallica.co.uk/celts/iceage.htm





LIFT ENERGY CONSUMPTION

Lifts do not use much energy

UK estimate about 5% in an office.

Lifts are already very efficient !!!

Let us look at the history



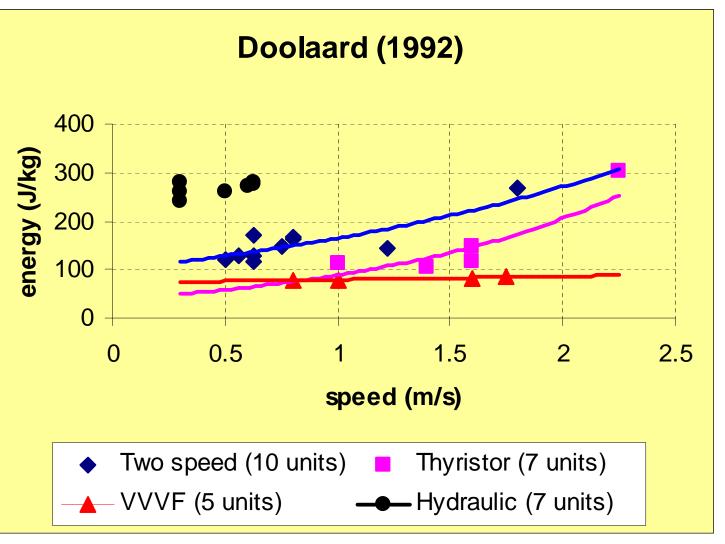








NETHERLANDS (1992) IAEE:1992 Elevator Technology 4 **DOOLAARD'S LIFT ENERGY COMPARISON**



Shows hydraulic lifts half as efficient as traction.

Shows VVVF most efficient.

Only 29 units, speed up to 2.25 m/s.



SOUTH KOREA (1999)



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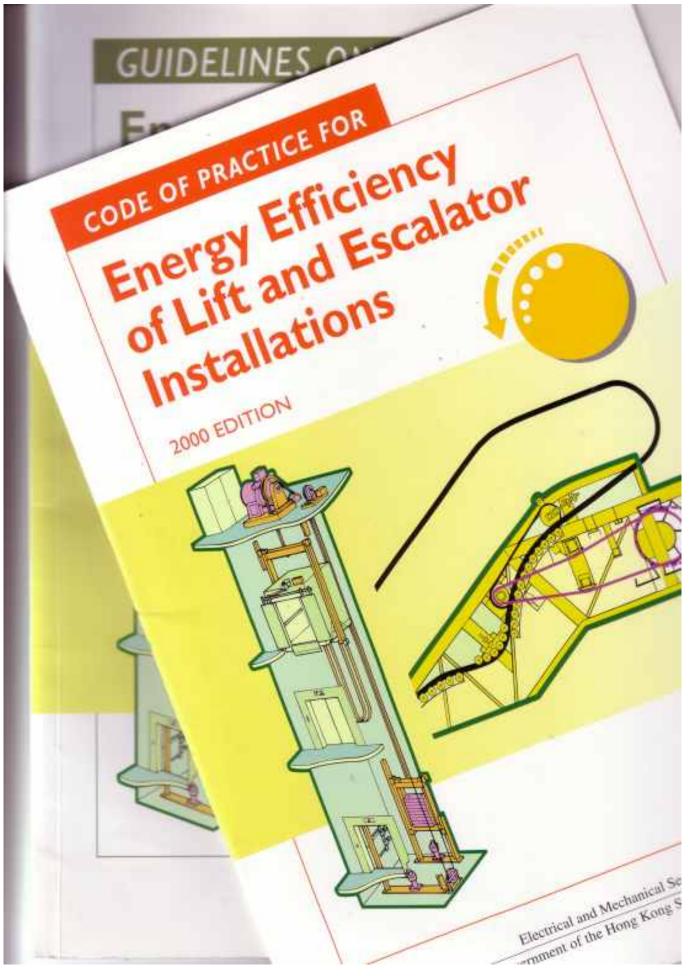
Jin, Jung-Yung et al: "An Investigation of demand side management perspectives of elevators - Electrical power consumption modelling and analysis", 1999.

Very extensive 361 page report. **Considers different types of drives. Proposes an energy formula for a lift. Tables of correction factors provided.** The number of units unknown. **Reports the diversity of demand and usage in the** given buildings.

Building type	Operating	Intensity index			
	hours	Weekdays	Saturday	Sunday	
Residential	16	1.0	1.0	1.1	
Commercial	12	1.0	0.5	0.1	
Service utility	10	1.0	0.9	1.3	
Retail	10	1.0	1.4	1.5	
Hotel	10	1.0	1.1	1.3	
Medical	12	1.0	1.0	1.0	
School, educational	10	1.0	0.5	0.1	

It is dependent on passenger usage and most specific to South Korea and hence it is unlikely that the correction factors, etc. given would be applicable worldwide.

HONG KONG



PROPOSED A LIMIT ON MOTOR SIZE.

Rated	Maximum Allowable Electrical Power						
Load	(kW) of Tract	ion Lift S	ystems for	r various		
(kg)]	Ranges of	Rated sp	eed (V _c) in	n m/s		
	V≤1	1 <v≤1.5< td=""><td>1.5<v≤2< td=""><td>2<v≤2.5< td=""><td>2.5<v≤3< td=""></v≤3<></td></v≤2.5<></td></v≤2<></td></v≤1.5<>	1.5 <v≤2< td=""><td>2<v≤2.5< td=""><td>2.5<v≤3< td=""></v≤3<></td></v≤2.5<></td></v≤2<>	2 <v≤2.5< td=""><td>2.5<v≤3< td=""></v≤3<></td></v≤2.5<>	2.5 <v≤3< td=""></v≤3<>		
L≤750	7	10	12	16	18		
750 <l≤1000< td=""><td>10</td><td>12</td><td>17</td><td>21</td><td>24</td></l≤1000<>	10	12	17	21	24		
1000 <l≤1350< td=""><td>12</td><td>17</td><td>22</td><td>27</td><td>32</td></l≤1350<>	12	17	22	27	32		
1350 <l≤1600< td=""><td>15</td><td>20</td><td>27</td><td>32</td><td>38</td></l≤1600<>	15	20	27	32	38		
$1600 < L \le 2000$	17	25	32	39	46		
2000 <l≤3000< td=""><td>25</td><td>37</td><td>47</td><td>59</td><td>70</td></l≤3000<>	25	37	47	59	70		
3000 <l≤4000< td=""><td>33</td><td>48</td><td>63</td><td>78</td><td>92</td></l≤4000<>	33	48	63	78	92		
4000 <l≤5000< td=""><td>42</td><td>60</td><td>78</td><td>97</td><td>115</td></l≤5000<>	42	60	78	97	115		

Example	Rated speed	2.50
	Rated load	200
We get fo	our possible sel	ectio
2000 kg,	2.50 m/s =39	kW,
2001 kg,	2.50 m/s =59	kW,

Motor size calculation for 80% efficiency

$$R = 0.981 \frac{1000 \times 2.5}{80} = 31 \text{ I}$$

0 (+0.01–0) m/s 00 (+0.01–0) kg ons:

> 2.51 m/s 46 =kW 2.51 m/s 70 =kW

kW

HONG KONG Hollywood Road Park



Dante C.M.Lam, Albert T.P.So, T.K.Ng: Energy conservation solutions for lifts and escalators of Hong Kong Housing Authority" IAEE:2006 Elevator Technology 16

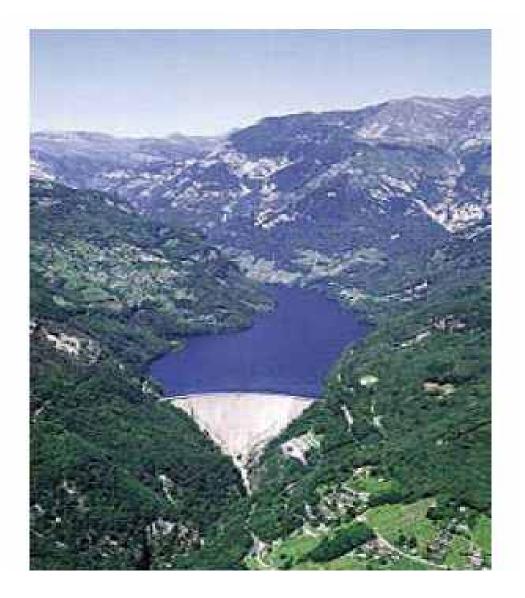
The 5,000 residential lifts in the Hong Kong Housing Authority use 100 million kWh per year. The average monetary cost is £2,000 per lift per year (at £0.1 per kWh) seems high. However residential buildings in HK are 60 or so storeys and only two/three lifts are installed.

Study 1 on two (2) lifts (1,000 kg, 2.5 m/s) It uses an energy criterion of J/kg/m to evaluate the study. Measurements are made in passenger operation no profile of the users is given. It is suggested that a 35% balance factor might be advantageous.

Study 2 looks at regeneration on an unspecified number of installations and concludes 16% to 52% regeneration was possible.

Study 3 introduces modifications to the traffic control algorithm, using genetic based group control on the two lifts in Study 1. Better energy efficiency is observed, but the resulting reduction in passenger service is not recorded.

Energy impact in Switzerland



• Lifts can account for a relevant proportion of the consumption of electricity by building systems.

- There are approximately 150,000 lifts in Switzerland.
- Lifts consume around 300 GWh p.a. equivalent to 0.5% of Switzerland's electricity demand.
- Standby energy of lifts is around 160 GWh.



Lifts are considerable electricity consumers in buildings + especially commercial.

is a Delet restants project (2005) energy consumption (kitch) and division into drive and stand-by energy have been investigated. 25 Bit of different types and manufactures were measured and studyeed A projection of everys consumption by a standard usage was calastated. Final report () your statistical -research on

Energy consumption figures

Total electricity consumption of the approx. 105,000 life it. belowing was pojected as 300 960h p.a. or 0.0% of the nearly consequences to be an includes. But may account for as in 10% of the standard y communities.

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10,010	-
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10,000

Composition of stand-by consumption Posterior shares of the offerent controperty to marking izatesimilariy - economic tella tellatenti of cable italiida



OCCUPATION AND A all the dealers Of Consulty Consults of April 1995 and private private to the case. State designing Beling Advisional

Energy saving measures.

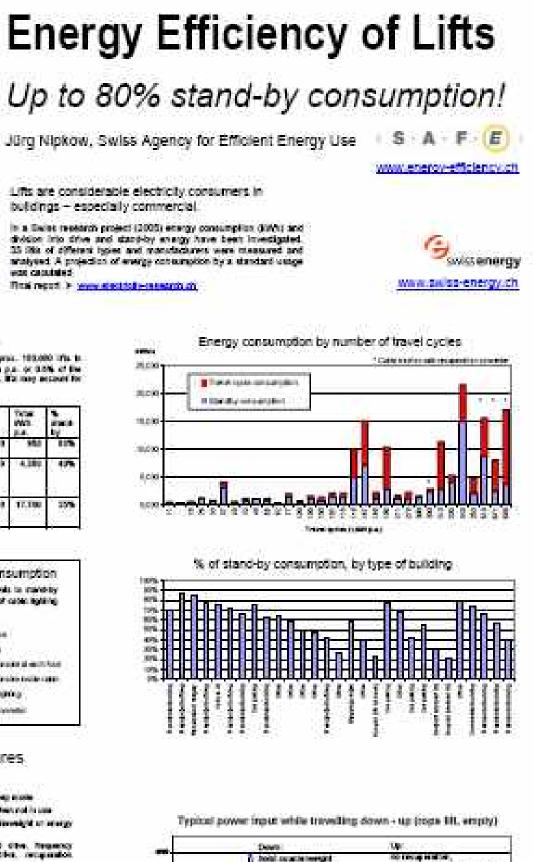
Technology

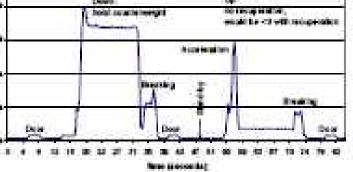
- Relace data by power, density using more
- by bights minimized access only a power relation and its same
- Into the back shall be been will a subliviation of principal and a set of principal set of any principal set of any principal set of a set of principal set of principal set of a set of principal set of princip **AND STREET** different.
- si ağırlabi işeni dile. Reşeniş Unatir, şemeti dile, retşenişti CONTRACTOR OF 100.000
- Opinication of southerenight 30% instead of 40...00% of relevant load, poperting to average load. EPideol (phase PL & CPE (extend of takeper height

Planning and dimensioning

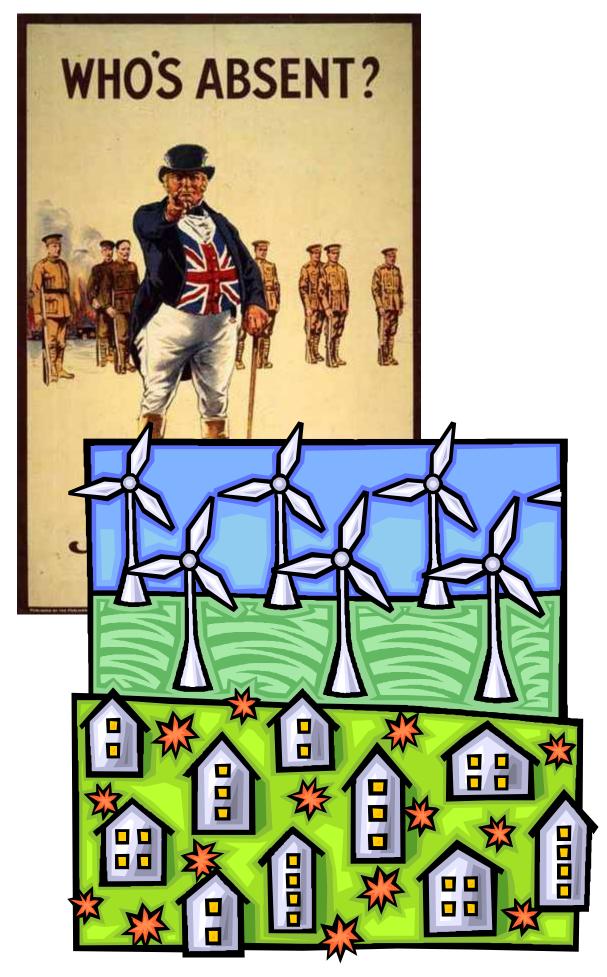
- A process insertion of the true building reduces and required space and powerintergy needs
- Convertified against twenty loss power, 0.82 metros per second is sufficient for up to 6 and more adortys. 178 control, redecible regions of that prevention serve

LR system antidelines: suspension have and made Statistics (Manufactory Victory) Internation





United Kingdom



CIBSE Guide F "Energy efficiency in buildings" ... suggests that lifts consume from 5% to 15% of a buildings energy. This statement is not justified.

CIBSE Guide D "Transportation systems in buildings" ... reviews factors affecting lift energy consumption

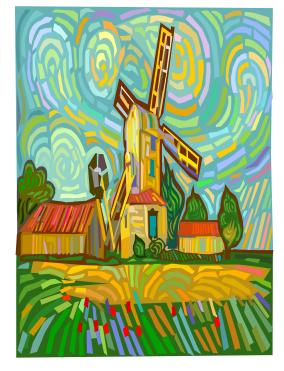
Barney surveyed 10 offices in Manchester. Only controller standby power was measured. Ranged from 28 W to 2,850 W.

The UK Government approach was to amend Part L of the Building Regulations.

Part L states "vertical transportation systems are not currently subject to the requirements of Part L".

As other energy users (HVAC, lighting, IT, etc.) reduce their demand the percentage used by lifts will rise and attract attention.

SUMMARY



Applicable to S Korea only ?

Useful pointer (29 units)

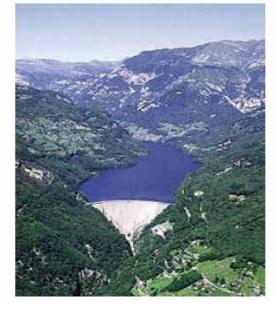


Does NOT achieve purpose



Hong Kong.

It points to a possible evaluation criterion of energy efficiency, as Joules per load carried per distance travelled (J/kg/m). It suggest this is limited to 50 J/kg/m



This is insufficient data to be authoritative, but does show the wide range of controller standby energy consumed.

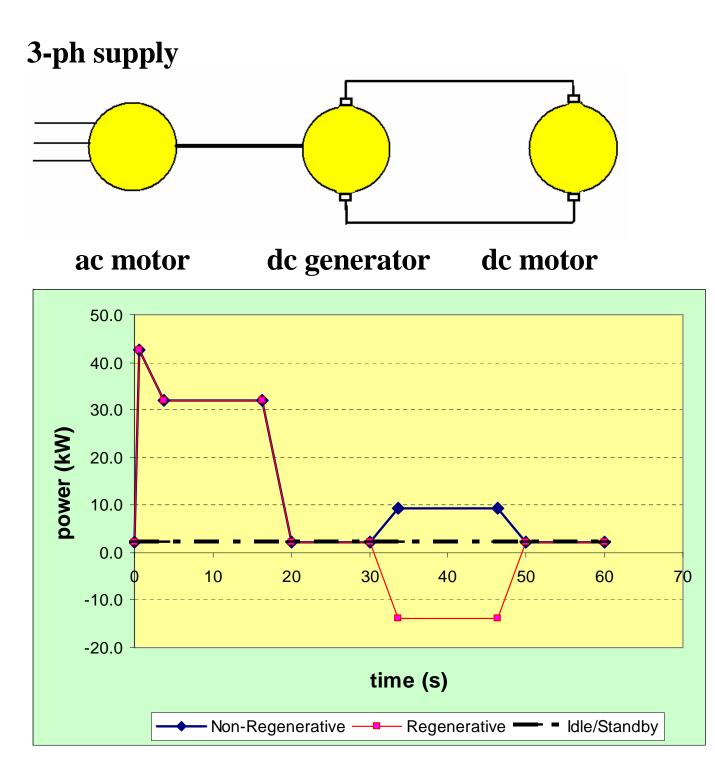
Congratulations for Part L.

The studies considered only two (2) **KONE** lifts in a residential building in a unique regional location, ie:

33 Installations measured. 65% housing. Says 80% standby Mainly Schindler lifts.



EFFICIENCY WHAT CAN BE DONE ? REGENERATION



Generating mode (energy back to mains):

... lift empty, moving up or lift full, moving down

REGENERATION CAPABILITY OF VARIOUS DRIVES.

Drive type	Description
Ward-Leonard	Regeneration
Regeneration:	naturally, h
Yes	DC generat
	becomes a 1
	motor beco
AC-single speed	Regeneration
AC-two speed	naturally, v
Regeneration:	connection
Yes	
ACVV	Energy usu
(DC injection braking)	in the low s
Regeneration:	rotor.
No	
DC thyristor	Regeneration
Regeneration:	4-quadrant
Yes	
VVVF	Regeneratio
Regeneration:	unit fitted.
Yes	
VVVF	Heat diss
Regeneration:	resistor/tra
No	

ion takes place hoist motor becomes a tor, the DC generator motor, and the AC omes an AC generator. ion takes place via the direct to the main supply.

ion is possible in t drives.

ion is possible if special

sipated in chopper ansistor combination.

50 things you can do to make lifts energy efficient

	Handling capacity				
1	Select the lowest possible rated speed				
2	Select speed appropriate to task.				
3	Select smallest possible rated load.				
4	Select the smallest possible number of lifts.				
5	Locate lifts together.				
6	Install lifts in appropriate locations.				
7	Locate symbiotic activities together.				
8	Select the lowest possible values for				
0	acceleration/deceleration/jerk.				
	Equipment design				
9	Traction lifts almost always more efficient.				
10	Select counterbalancing/accumulation				
10	systems for hydraulic units.				
11	Select energy efficient drive (eg: VVVF).				
12	Use soft start technologies.				
13	Select gearless over geared drives.				
14	Select top drive position.				
15	Select 1:1 roping.				
16	Do not select stalled motor door operator.				
17	Use roller guide shoes on both car & cwt.				
18	Ensure guide rails are stiff and do not flex.				
10	Ensure guide rails are plumb and fixed at				
17	shortest spacing.				
20	Optimize cwt balance ratio.				
21	Ensure the car is balanced.				
22	Ensure cars present low air resistance.				
23	Select largest diameter rope.				
24	Select the lowest possible sheave and pulley				
_ ·	diameters.				
25	Ensure brake not energised when lift is				
23	stationary.				
	Automatic oil tank temperature control.				
27	Automatic lift well heater control.				
28	Install hydraulic oil cooler.				
29	Install hydraulic oil coolers outside machine				
29	room.				

Operation3031Omit parking feature.3231Omit parking feature.3233Turn off car lights when on standby34Turn off car fan/HVAC when on standby35Provide automatic car fan control.36Provide automatic machine room temperature control37Recover waste heat from lift motor room.38Provide machine room thermal insulation.39Automate opening of well vent (if provided).Maintenance40Ensure regular preventative maintenance.41Adjust all critical operating parameters during maintenance.42Set acceleration/deceleration to lowest acceptable values.43Set levelling/creep distance to be small.44Ensure machine room heating operates only below 6°C.46Ensure machine room cooling/ventilation operates only above operating conditions.47Ensure guide rails are adequately lubricated.48Turn off car top light when mechanic leaves49Turn off lift well lights when mechanic leaves50Ensure compensation/tie down systems are properly adjusted.	
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50 Ensure compensation/tie down systems are properly adjusted.	leaves
properly adjusted.	Ensure compensation/tie down systems are 50^{10}
	properly adjusted.

Presented by: Gina Barney Associates Independent Vertical Transportation Consultants PO Box 7, SEDBERGH, LA10 5GE. t: 015396 20790 f: 015396 20578 www.liftconsulting.org

CALCULATION METHODS



LIFT ENERGY CONSUMPTION: CALCULATION METHOD BY SCHROEDER (1990)

The daily energy consumed (E_d) is:

 $E_d = \frac{R \times ST \times TP}{3600}$

where:

R is motor rating ST is daily number of starts *TP* is trip time factor

Schroeder defined the trip time factor according to the type of lift drive.

Hydraulic Geared ac 2-speed Geared acvv (high mass) Geared acvv (low mass) **Gearless (MG)**

Note the calculation depends on the accuracy of the trip time factor.

- **6.0** 10.5 8.5 6.5
- 5.0

ISO Proposed calculation method

Energy used (E) by a lift per year (kWh)

$$E = \frac{Tp \times D \times W \times tf(0.5 \times N) \times R}{3600} + St$$

Tp = trips/applicable day
D = number of applicable days
W = number of applicable weeks
tf(0.5N) = the time, in seconds, for the lift to travel
half the possible travel distance measured from
doors closed to doors opening
D = meature (LW)

R = motor rating (kW)

St = standby energy (kWh)

Assumptions

- **1** Average car occupancy is low (empty?).
- 2 The lift runs at rated speed over whole trip.
- **3** The average power load is the motor rating.
- 4 Distance of average trip is $0.5 \times N$.
- where: N is the total travel distance (m) of the lift
- **5** No allowance for regeneration

(reduce first term by 20% for regenerative systems).

6 No allowance made for traffic controller actions.

Guidance values

Lift Duty	Rating (starts/ hour)	Trips/ day	Exam
Low	60	<100	reside librar centre (inter
Med -ium	120	300	office car pa unive rise h centre
High	180	750	office rise h
Inten -sive	240	1000	HQ of

WARNING:

The assumptions and are guidance values are empirical and very simplistic. They must be used with care as in some circumstances some may not be valid.

nples (days/week)

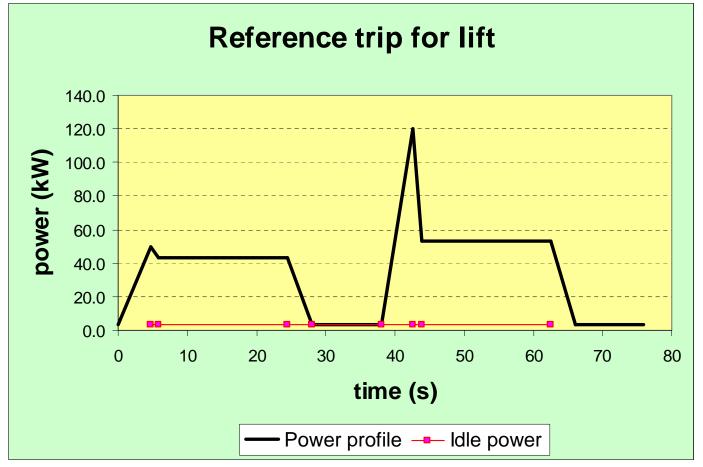
ential care (7), goods (5), ry (6), entertainment res (7), stadia

rmittent)

e car parks (5), general arks (7), residential (7), ersity (5), hotels (7), low ospitals (7), shopping res (7)

e (5), airports (7), high ospitals (7) office (5)

SOME EXAMPLES



* = geared unit # = gearless unit

The table uses a simple energy model. *

It applies to typical office buildings open for * 250 working days per year.

***** It shows the energy used to service the number of cycles per day, where one cycle is one up start, plus one down start.

The cost of the auxiliary power (car lights/fan, * alarm unit, trickle chargers, displays, indicators, controller idle power, etc.) becomes less significant as the lifts become faster and larger.

***** The dynamic energy take can be reduced by the use of regenerative drives.

Rated load (kg)	Rated speed (m/s)	Possible travel (m)	Cycles per day	per	Cost per cycle @10p/kWh	cycles	Auxiliary power (W)	Cost auxiliary power per year
630*	0.63	18	100	136	0.4 p	£100	200	£160
1000*	1.0	30	100	318	0.9p	£225	300	£240
1600*	1.6	48	200	738	2.1p	£1,050	500	£400
1600#	1.6	48	200	425	1.2p	£600	500	£400
2500#	2.5	75	400	976	2.7p	£2,700	900	£720
2500#	4.0	120	400	1451	4.0 p	£4,000	900	£720

by turning off the auxiliary power a "sleep" mode.

BBC report that for Media Village (White **City/Television Centre**) with 29 passenger lifts they can save £145 per day if staff walk **!!!** {Note: licence fee = £131.50) Go to excel sheet

- ***** The static energy take can be reduced consuming devices, or at least reducing their power requirements, by introducing

LIFT ENERGY CONSUMPTION: SUMMARY

A lift cannot be 100% efficient as:

• It has friction in both motoring and generating phases.

• Even in regeneration the machines have internal losses (copper and iron).

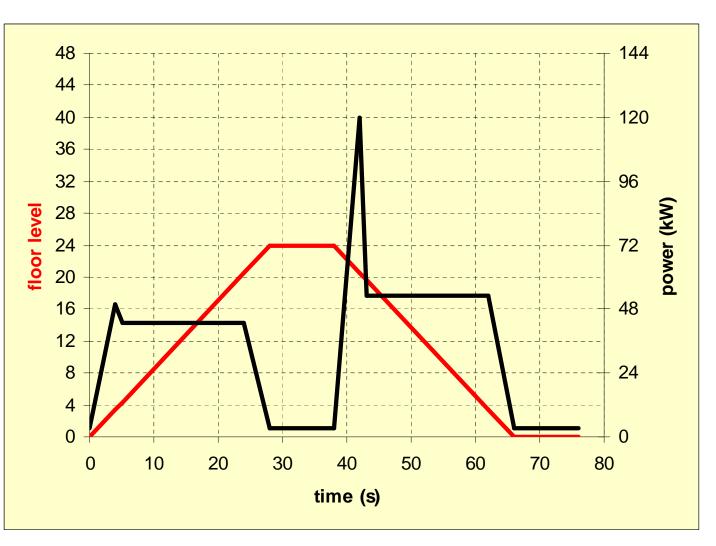
• Gear boxes especially of worm type operating in the reverse direction are less efficient.

Regeneration ...

- Helps efficiency by returning energy to the mains, provided there is a sink to use it.
- The number of starts are important and some countries propose limits.

ISO ENERGY MEASUREMENT

Propose measurement of a reference trip cycle of activity of empty car up pause for door operations and down.



Measurement to be made of energy. **Conformance by measuring current.**



ISO ENERGY MEASUREMENT

Measurements required:

Туре	Measurements
Energy	Main energy - running
measurement	Main energy - standby
verification	Auxiliary energy - standby
	Auxiliary energy - running
Energy	Main current - running
conformance	Main current - stand-by
check	Ancillary current - running
	Ancillary current – standby

Terms:

Running Idle Standby

Estimation and prediction:

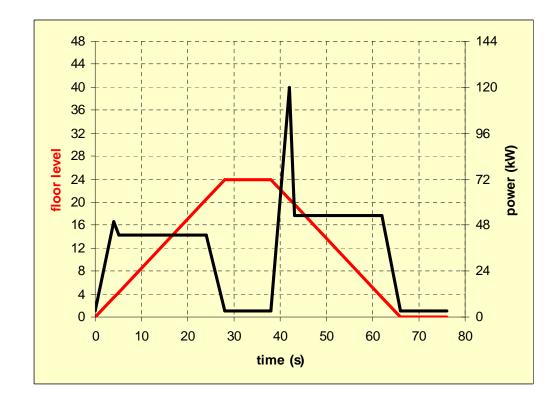
By formula By model

COMPUTER MODELS

Traffic simulators are used to study the behaviour of a particular design.

A lift traffic simulator "knows" the passenger load in the car, the direction of travel, the number of passengers entering/leaving, the travel distance, door timings, etc.

If the power used for each individual car load and each individual direction of travel were known then the simulator could estimate energy consumption.

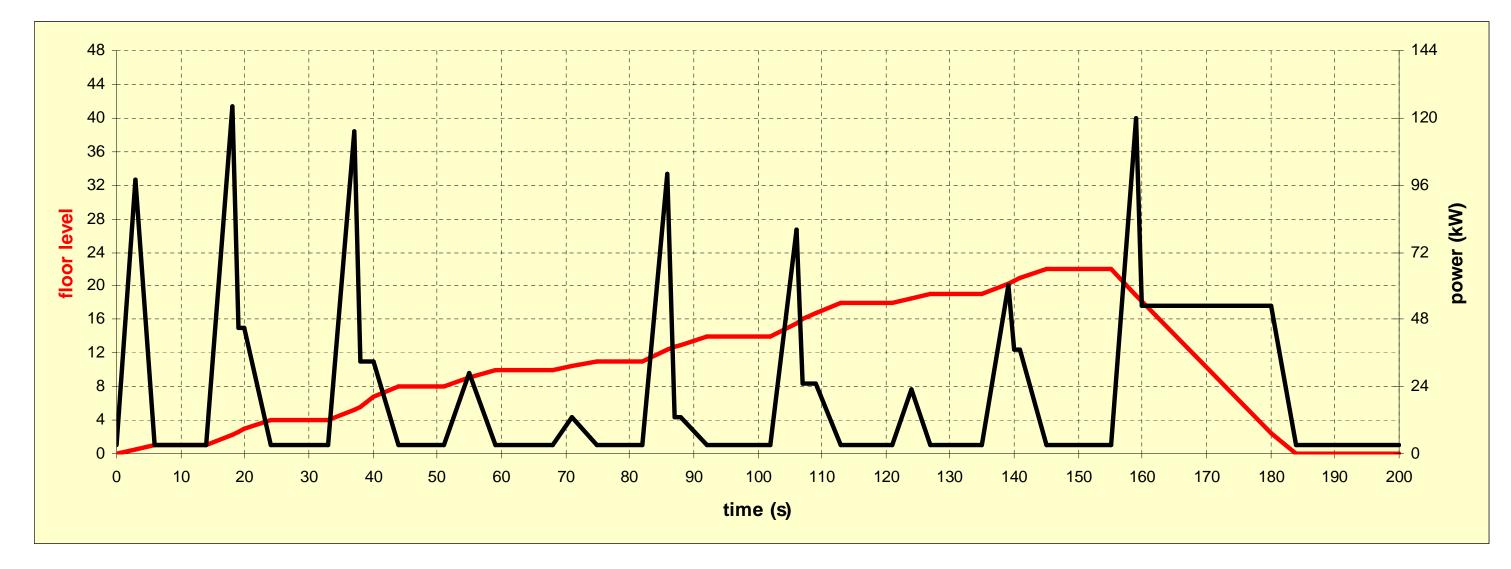




go to www.peters-research.com

ISO ENERGY MODEL

Uppeak illustration



The lift leaves Floor 0 with 20 passengers. Calls at nine floors.

The lift then returns empty to Floor 0. **Balance load is as the lift leaves Floor 11.**

The lift moves one floor: 0>1, 10>11, 18>19, and rated speed is not reached.

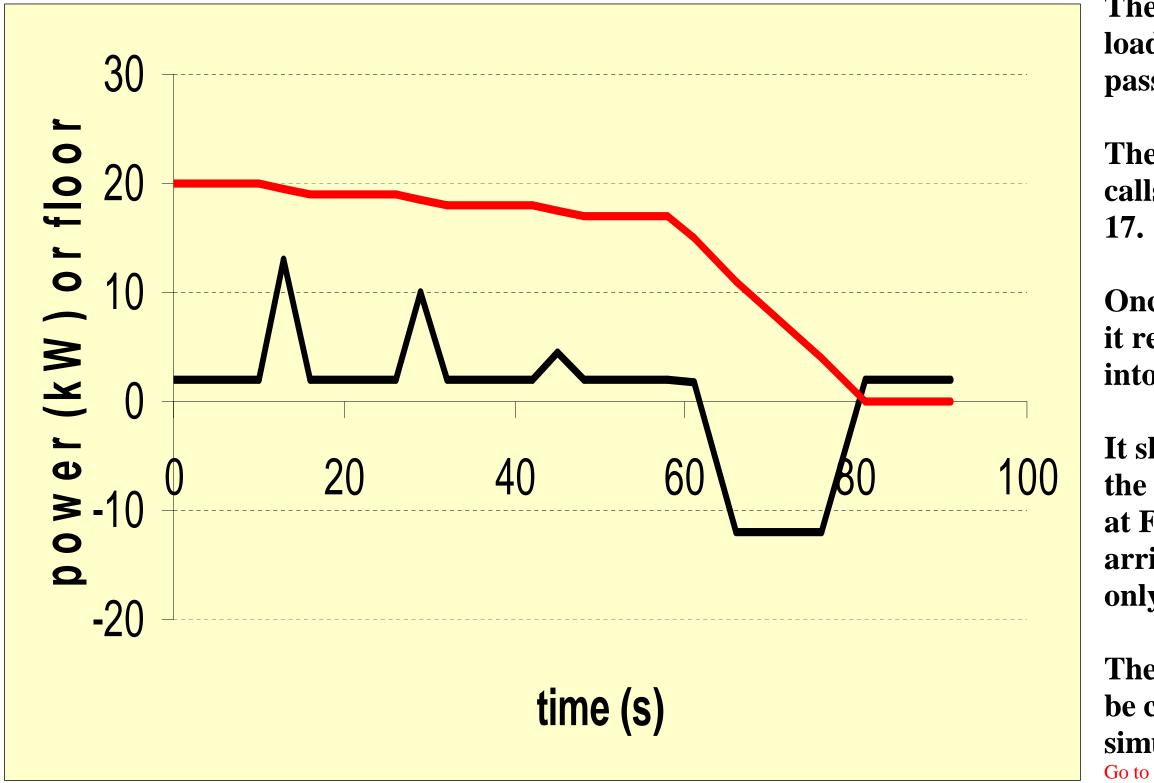
In all other cases the lift reaches rated speed

The energy profile is idealised.

The energy consumed is the area under the profile and can be easily calculated by a simulation program.

ISO ENERGY MODEL:

Down peak illustration



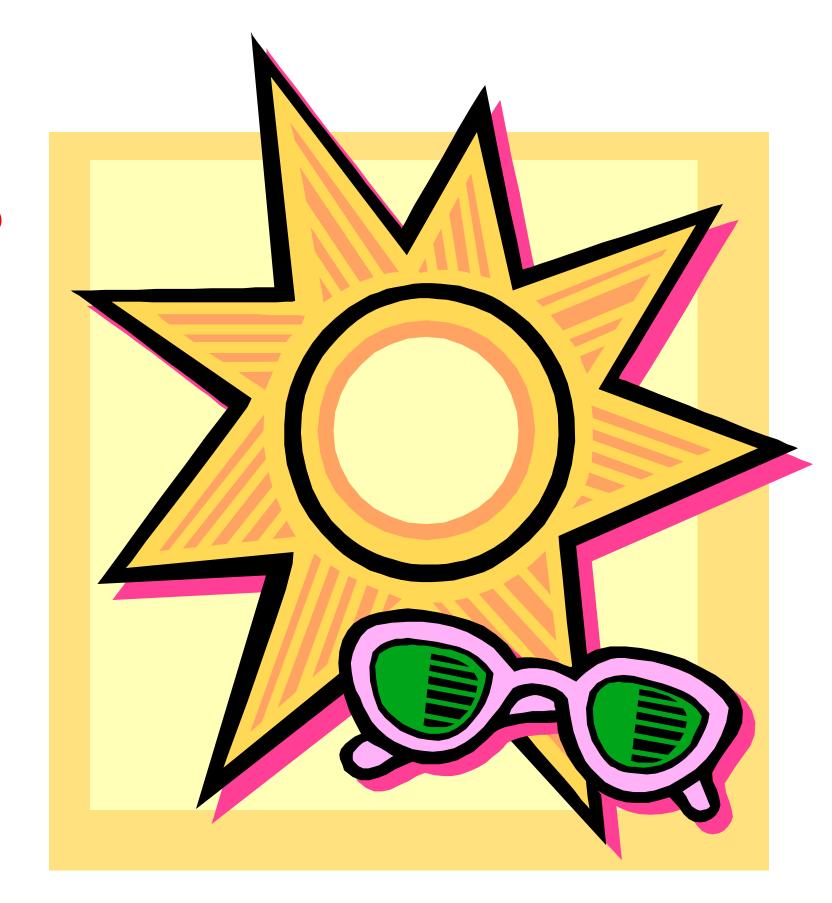
The graph shows a lift loading at Floor 20 with six passengers.

The lift then successively calls at Floors 19, 18 and

Once the lift leaves Floor 17 it regenerates power back into the mains supply.

It should be noticed that of the 80 seconds from loading at Floor 20 until the lift arrives at Floor 0, the lift is only moving for 40 seconds.

The energy consumed can be calculated by a simulation program. Go to simulation



For copy of presentation go to

www.cibseliftsgroup.org