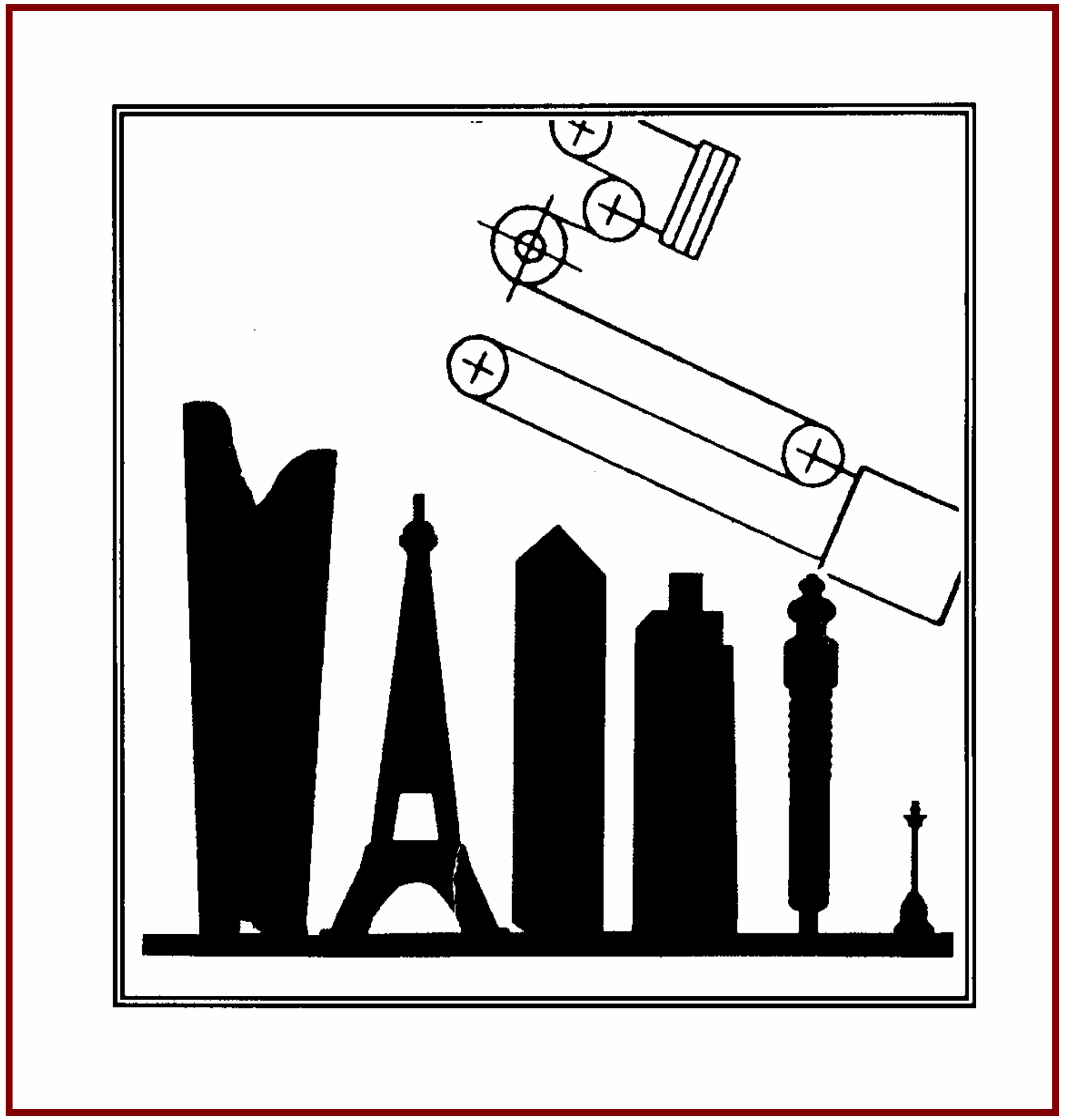
Gina Barney Associates



Independent vertical transportation consultants
PO Box 7, SEDBERGH, LA10 5GE

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

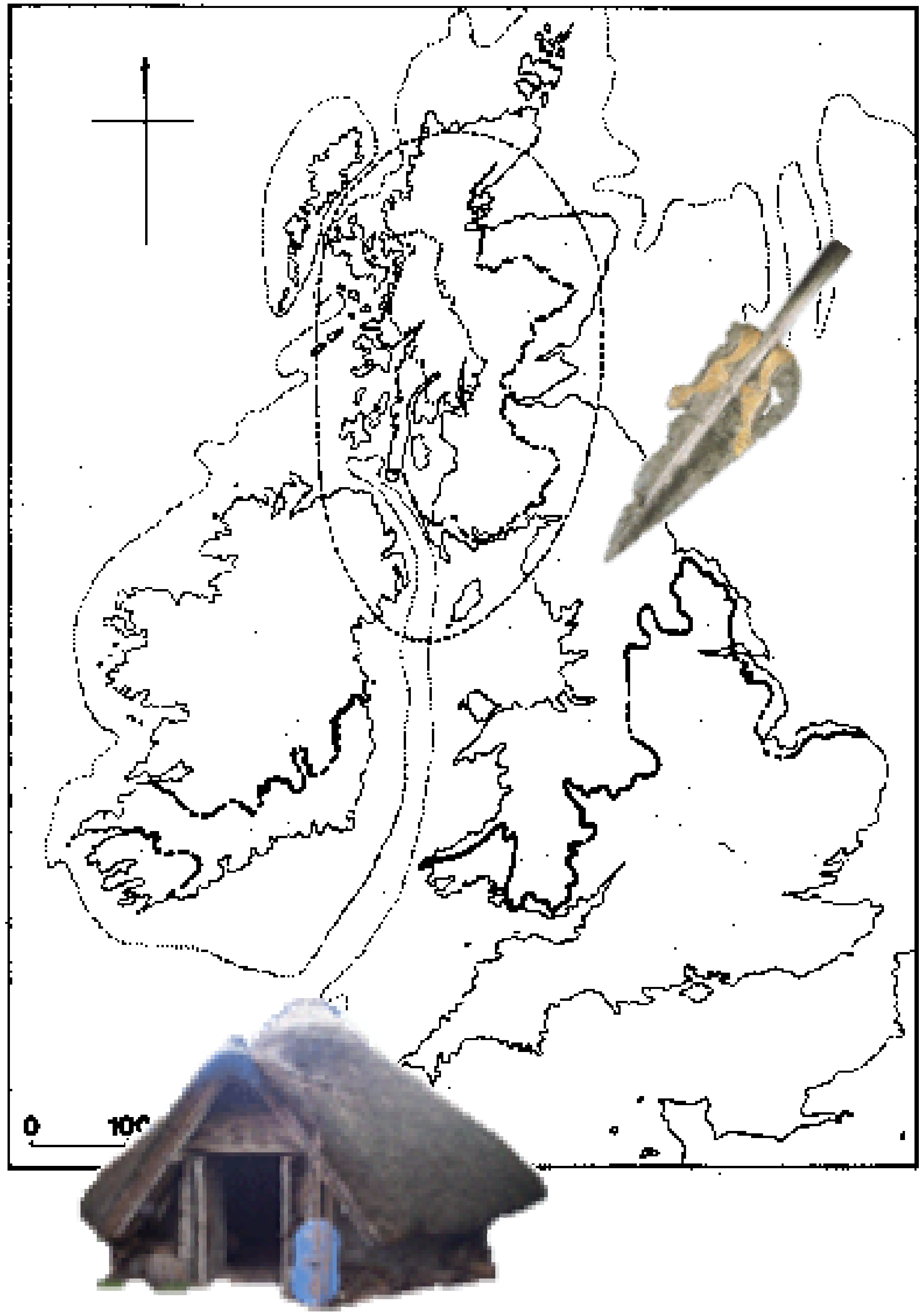
50 things you can do to make lifts energy efficient

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



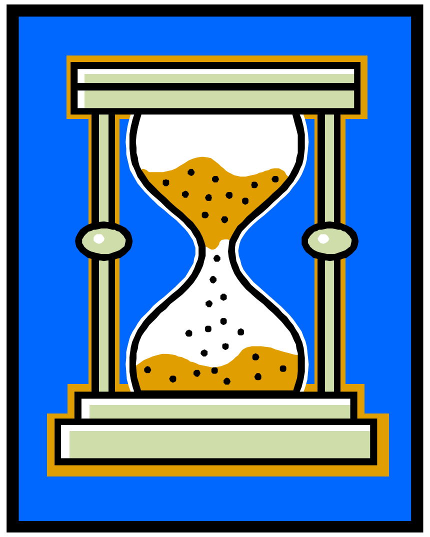
LIFT ENERGY CONSUMPTION

Lifts do not use much energy

UK estimate about 5% in an office.

Lifts are already very efficient !!!

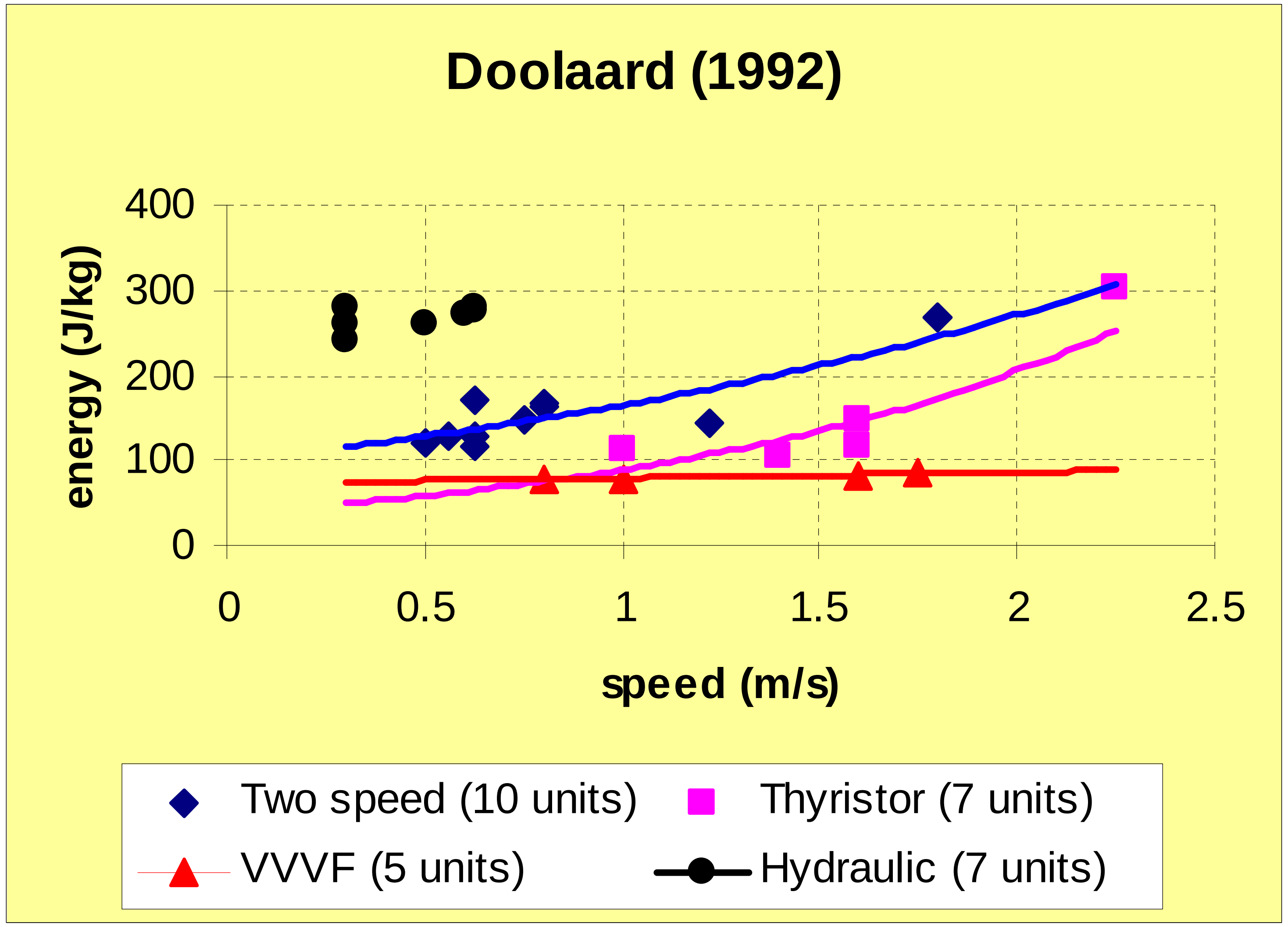
Let us look at the history



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)

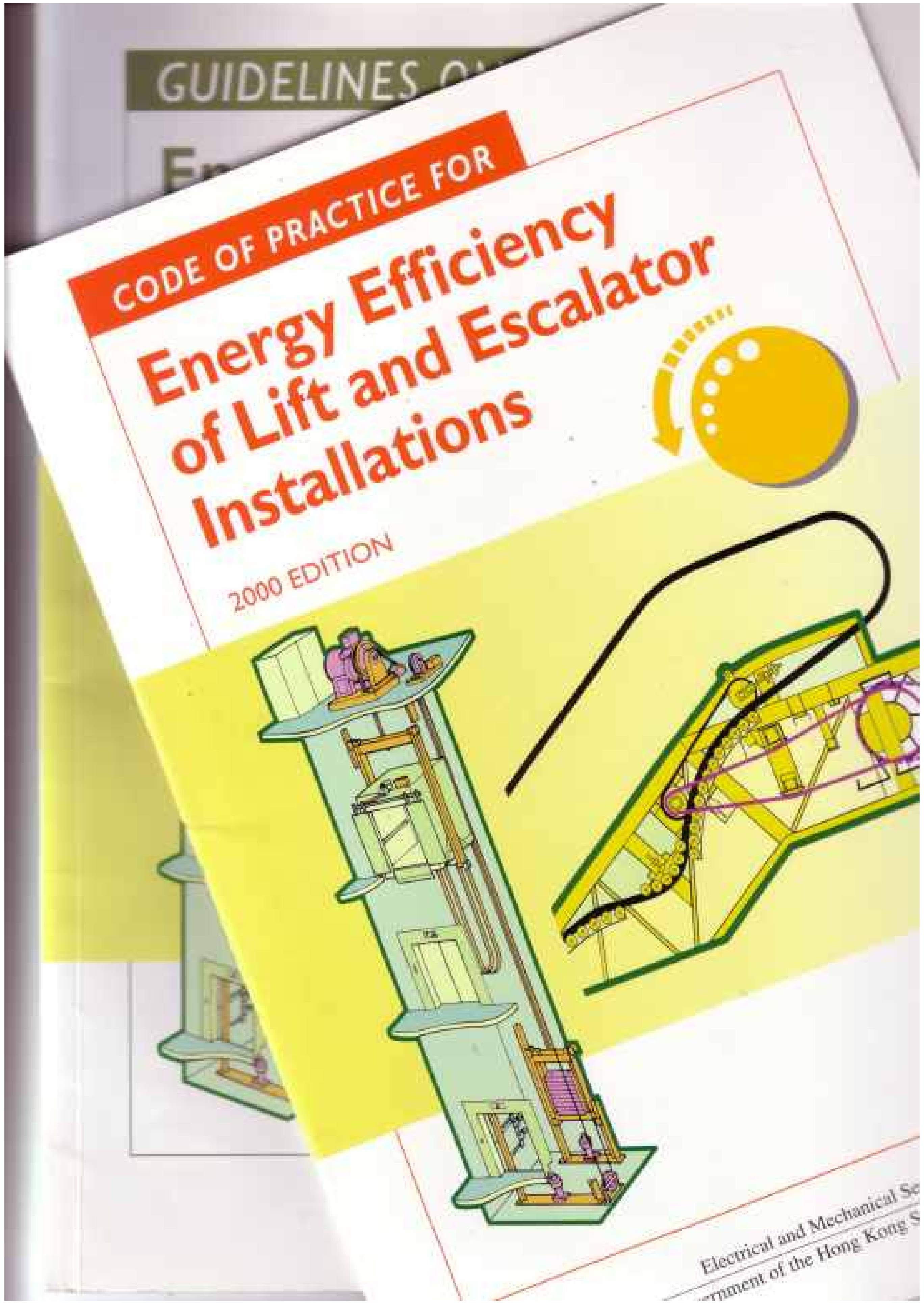
Jin, Jung-Yung et al: "An Investigation of demand side management perspectives of elevators - Electrical power consumption modelling and analysis", 1999.

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 hours	Intensity index		
		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 Load (kg)	Maximum Allowable Electrical Power (kW) of Traction Lift Systems for various Ranges of Rated speed (V_c) in m/s				
	V≤1	1<V≤1.5	1.5<V≤2	2<V≤2.5	2.5<V≤3
L≤750	7	10	12	16	18
750<L≤1000	10	12	17	21	24
1000<L≤1350	12	17	22	27	32
1350<L≤1600	15	20	27	32	38
1600<L≤2000	17	25	32	39	46
2000<L≤3000	25	37	47	59	70
3000<L≤4000	33	48	63	78	92
4000<L≤5000	42	60	78	97	115

Example: **Rated speed** 2.50 (+0.01−0) m/s
Rated load 2000 (+0.01−0) kg

We get four possible selections:

2000 kg, 2.50 m/s =39 kW, 2.51 m/s 46 =kW
2001 kg, 2.50 m/s =59 kW, 2.51 m/s 70 =kW

Motor size calculation for 80% efficiency

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

HONG KONG Hollywood Road Park

photo miss chris

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

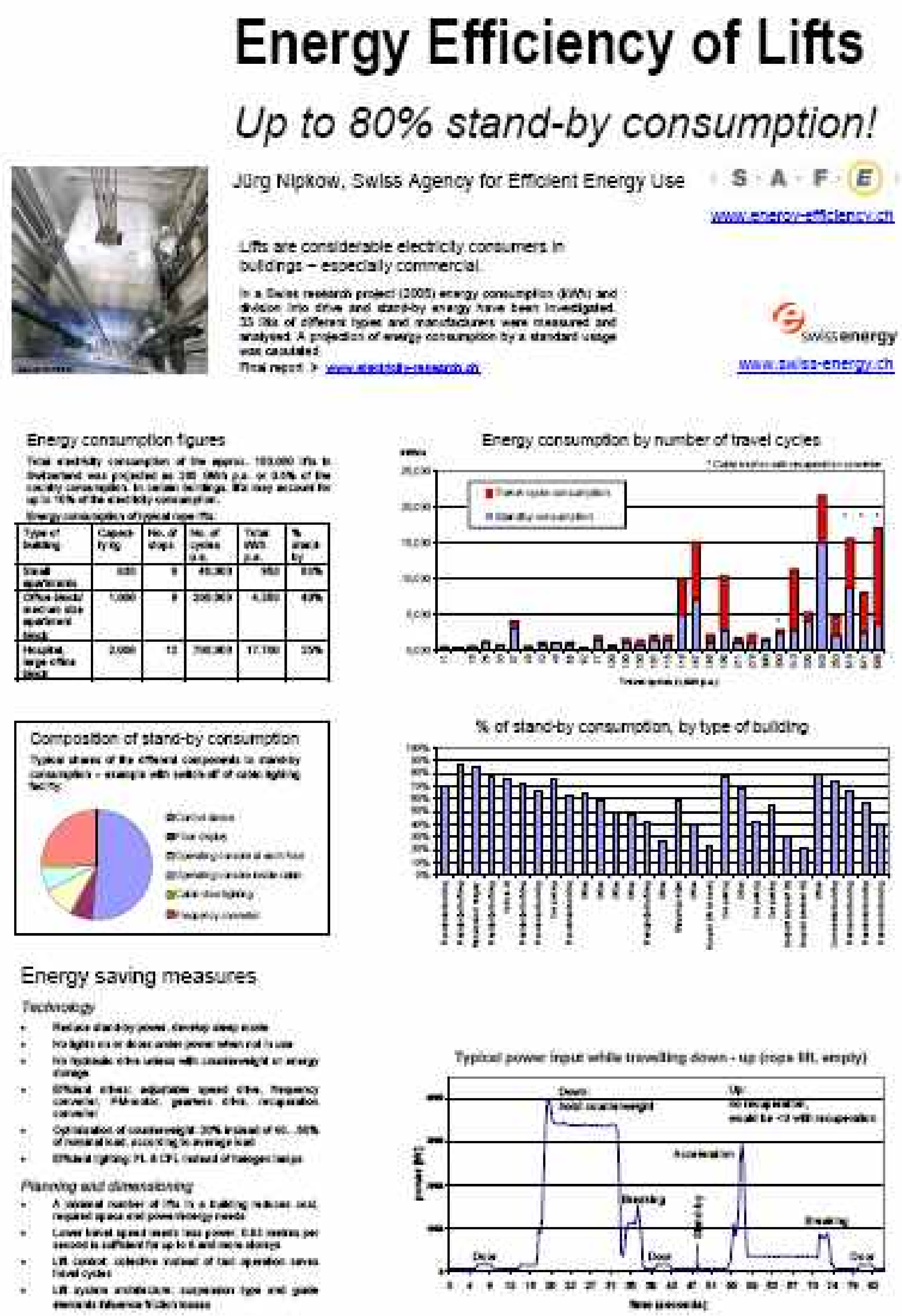
The 5,000 residential lifts in the Hong Kong Housing Authority use 100 million kWh per year.
The average monetary cost is £2,000 per lift per year (at £0.1 per kWh) seems high.
However residential buildings in HK are 60 or so storeys and only two/three lifts are installed.

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.**

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.

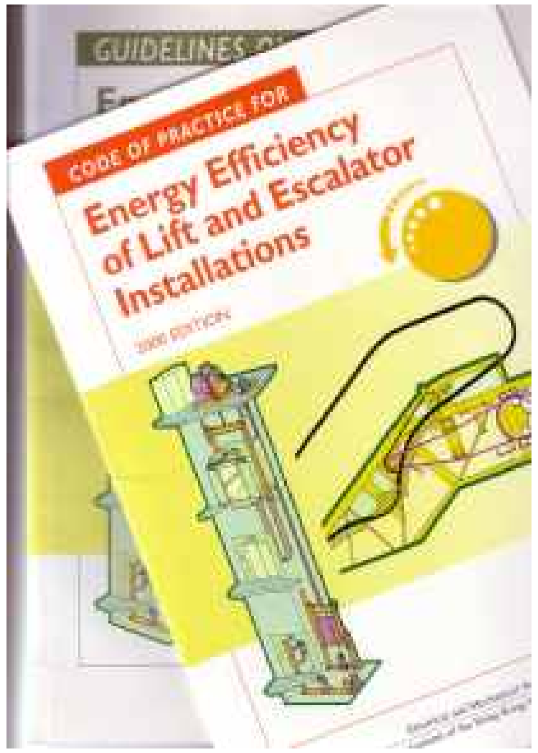
Part L states "vertical transportation systems are not currently subject to the requirements of Part L".

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

SUMMARY

Useful pointer (29 units)

Applicable to
S Korea only ?



Does NOT achieve purpose

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

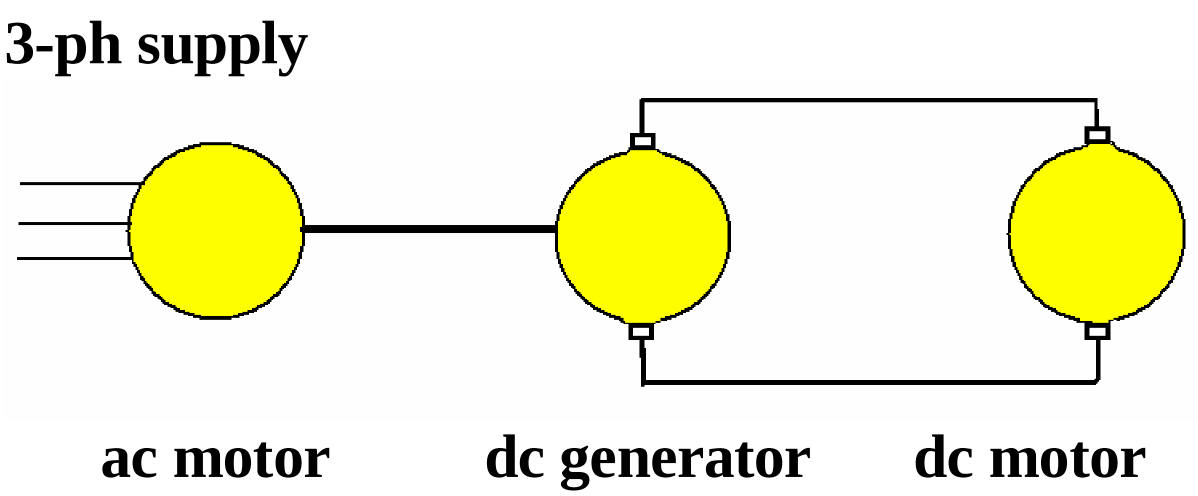
33 Installations measured.
65% housing.
Says 80% standby
Mainly Schindler lifts.

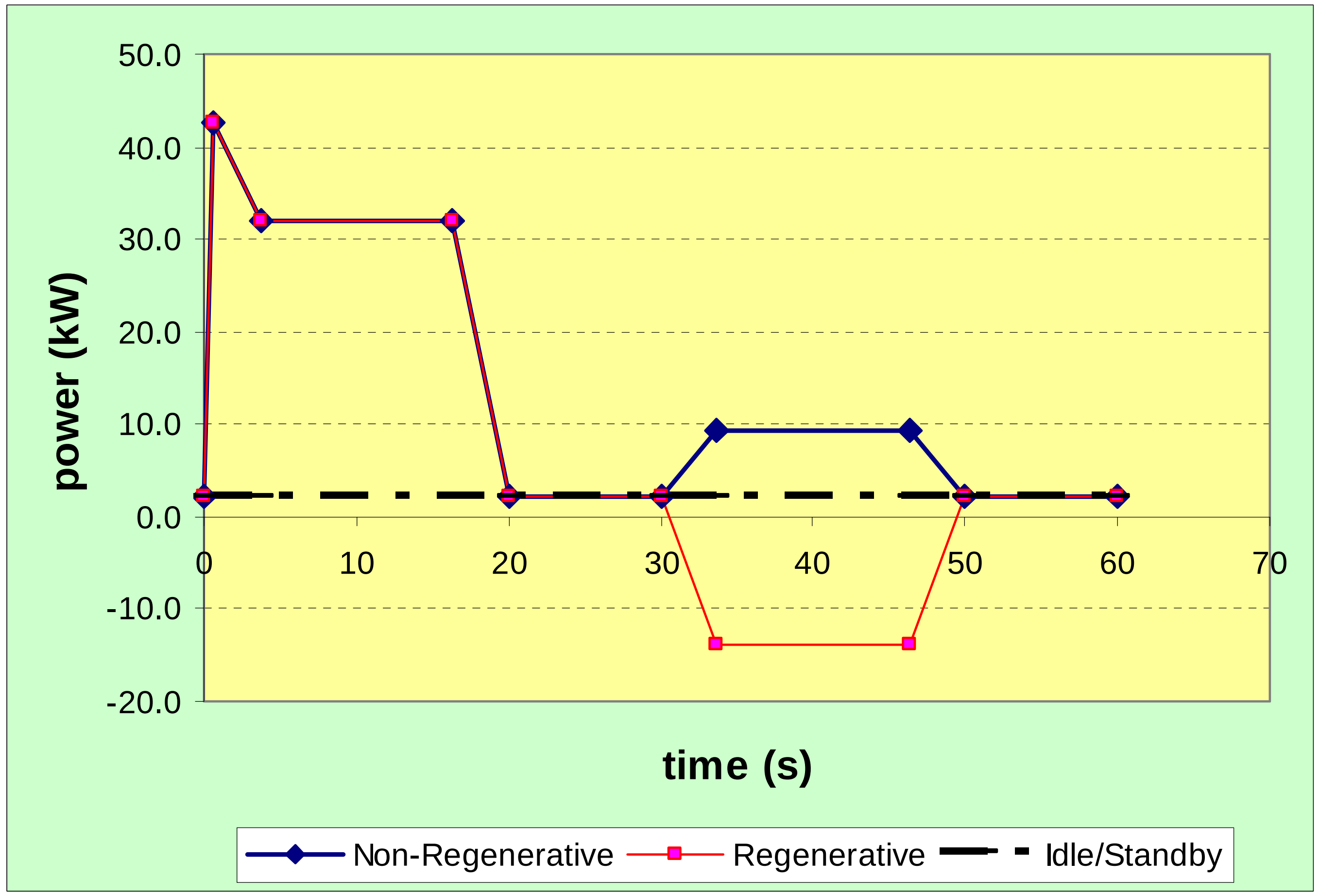
This is insufficient data to be authoritative, but does show the wide range of controller standby energy consumed.

Congratulations for Part L.

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: Yes	Regeneration takes place naturally, hoist motor becomes a DC generator, the DC generator becomes a motor, and the AC motor becomes an AC generator.
AC-single speed AC-two speed Regeneration: Yes	Regeneration takes place naturally, via the direct connection to the main supply.
ACVV (DC injection braking) Regeneration: No	Energy usually dissipated as heat in the low speed windings and rotor.
DC thyristor Regeneration: Yes	Regeneration is possible in 4-quadrant drives.
VVVF Regeneration: Yes	Regeneration is possible if special unit fitted.
VVVF Regeneration: No	Heat dissipated in chopper resistor/transistor 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 acceleration/deceleration/jerk.
	Equipment design
9	Traction lifts almost always more efficient.
10	Select counterbalancing/accumulation 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.
19	Ensure guide rails are plumb and fixed at 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 stationary.
26	Automatic oil tank temperature control.
27	Automatic lift well heater control.
28	Install hydraulic oil cooler.
29	Install hydraulic oil coolers outside machine room.

	Operation
30	Select best traffic control strategy.
31	Omit parking feature.
32	Initiate controller standby after idle period.
33	Turn off car lights when on standby
34	Turn off car fan/HVAC when on standby
35	Provide automatic car fan control.
36	Provide automatic machine room temperature control
37	Recover waste heat from lift motor room.
38	Provide machine room thermal insulation.
39	Automate opening of well vent (if provided).
	Maintenance
40	Ensure regular preventative maintenance.
41	Adjust all critical operating parameters during maintenance.
42	Set acceleration/deceleration to lowest acceptable values.
43	Set levelling/creep distance to be small.
44	Ensure any motor blowers are switched.
45	Ensure machine room heating operates only below 6°C.
46	Ensure machine room cooling/ventilation operates only above operating conditions.
47	Ensure guide rails are adequately lubricated.
48	Turn off car top light when mechanic leaves
49	Turn off lift well lights when mechanic leaves
50	Ensure compensation/tie down systems are 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	**6.0**
Geared ac 2-speed	**10.5**
Geared acvv (high mass)	**8.5**
Geared acvv (low mass)	**6.5**
Gearless (MG)	**5.0**

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

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(0.5*N*) = the time, in seconds, for the lift to travel half the possible travel distance measured from doors closed to doors opening
R = motor rating (kW)
St = standby energy (kWh)

Assumptions

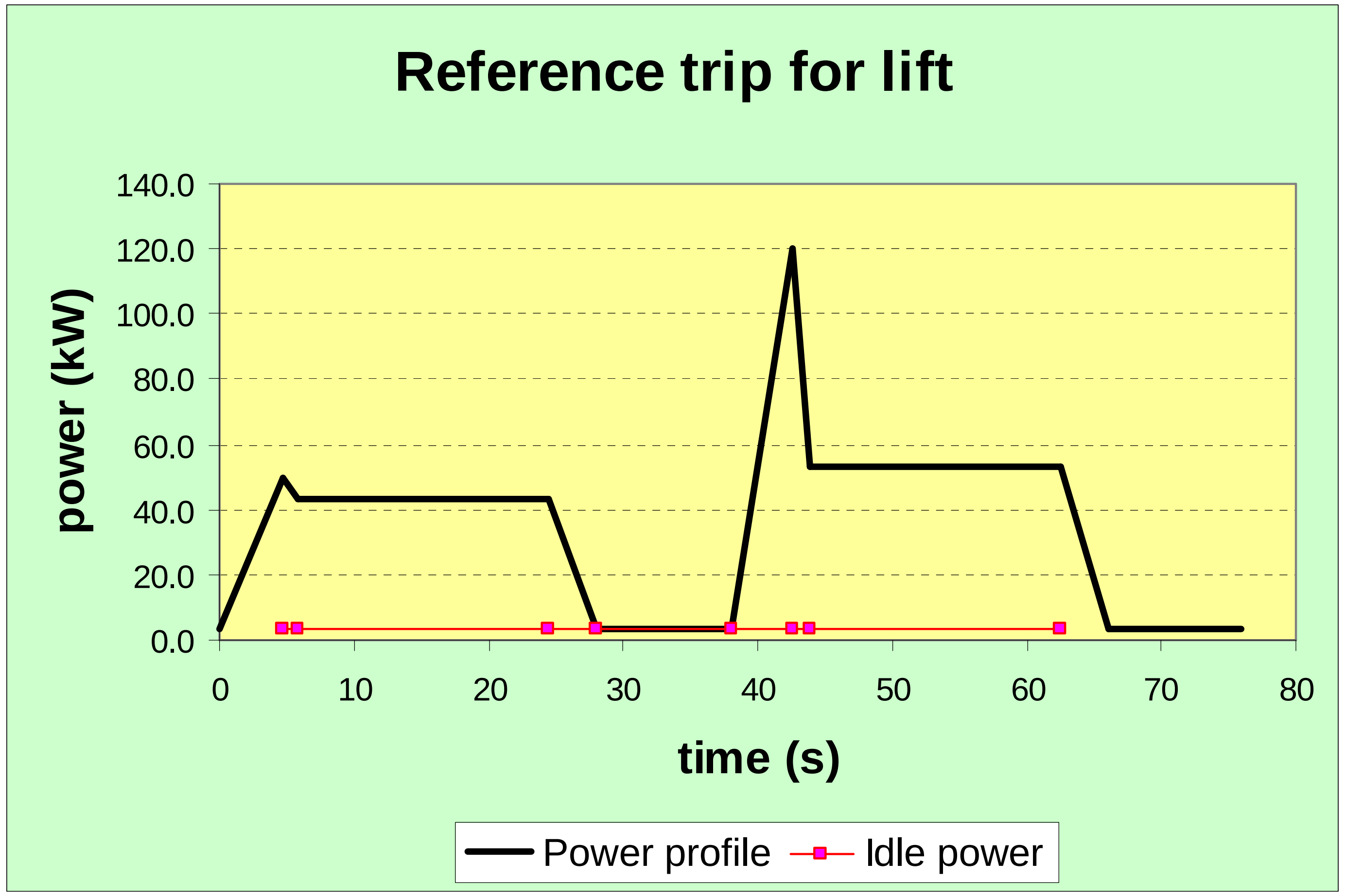
1 Average car occupancy is low (empty?).
2 The lift runs at rated speed over whole trip.
3 The average power load is the motor rating.
4 Distance of average trip is 0.5×*N*.
where: *N* is the total travel distance (m) of the lift
5 No allowance for regeneration
(reduce first term by 20% for regenerative systems).
6 No allowance made for traffic controller actions.

Guidance values

Lift Duty	Rating (starts/ hour)	Trips/ day	Examples (days/week)
Low	60	<100	residential care (7), goods (5), library (6), entertainment centres (7), stadia (intermittent)
Med -ium	120	300	office car parks (5), general car parks (7), residential (7), university (5), hotels (7), low rise hospitals (7), shopping centres (7)
High	180	750	office (5), airports (7), high rise hospitals (7)
Inten -sive	240	1000	HQ office (5)

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.

SOME EXAMPLES



* = geared unit   # = gearless unit

Rated load (kg)	Rated speed (m/s)	Possible travel (m)	Cycles per day	kWs per cycle	Cost per cycle @10p/kWh	Cost of cycles per year	Auxiliary power (W)	Cost auxiliary power per year
630*	0.63	18	100	136	0.4p	£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	4.0p	£4,000	900	£720

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

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.

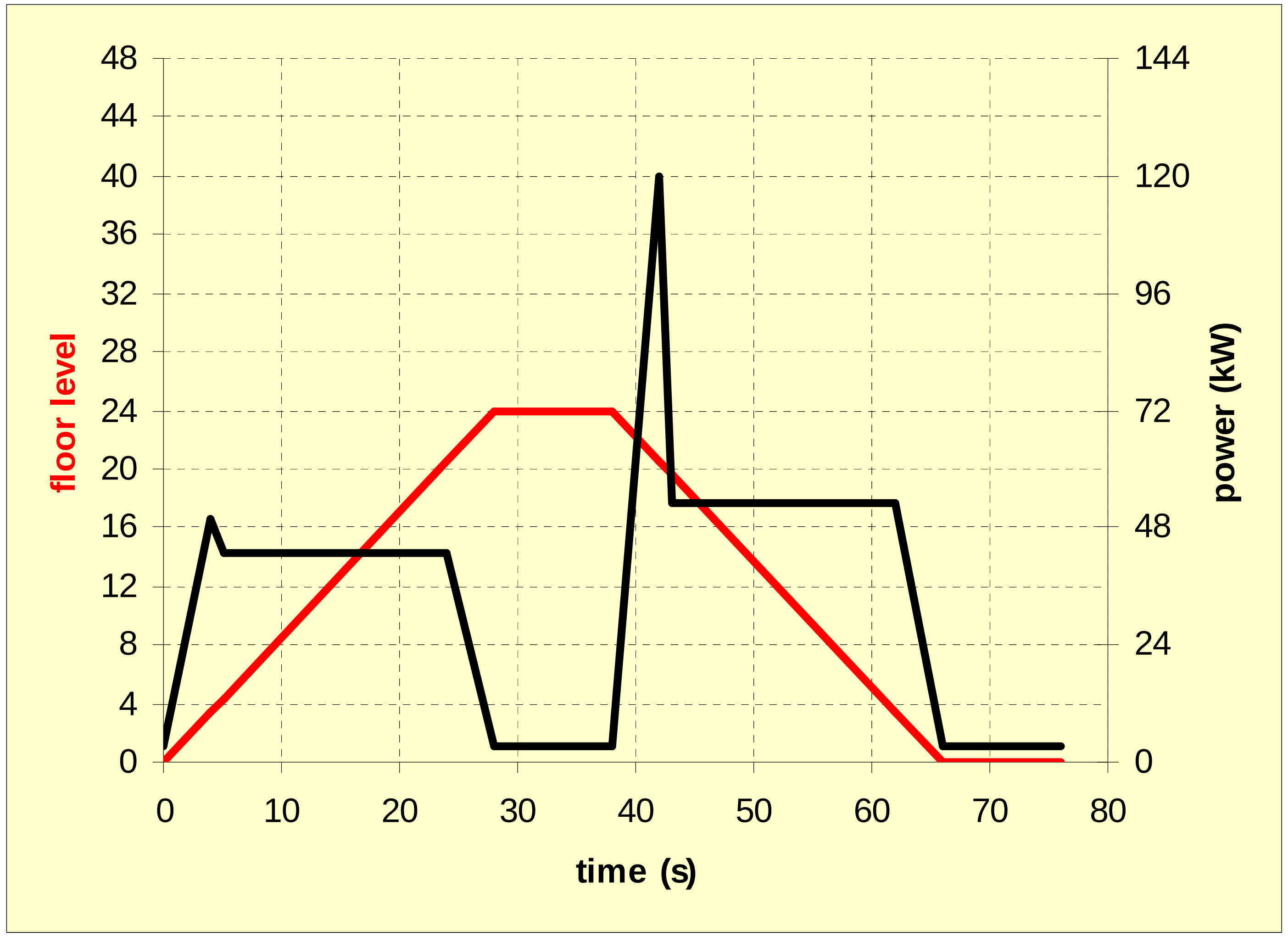
Regeneration …

● Helps efficiency by returning energy to the mains, provided there is a sink to use it.

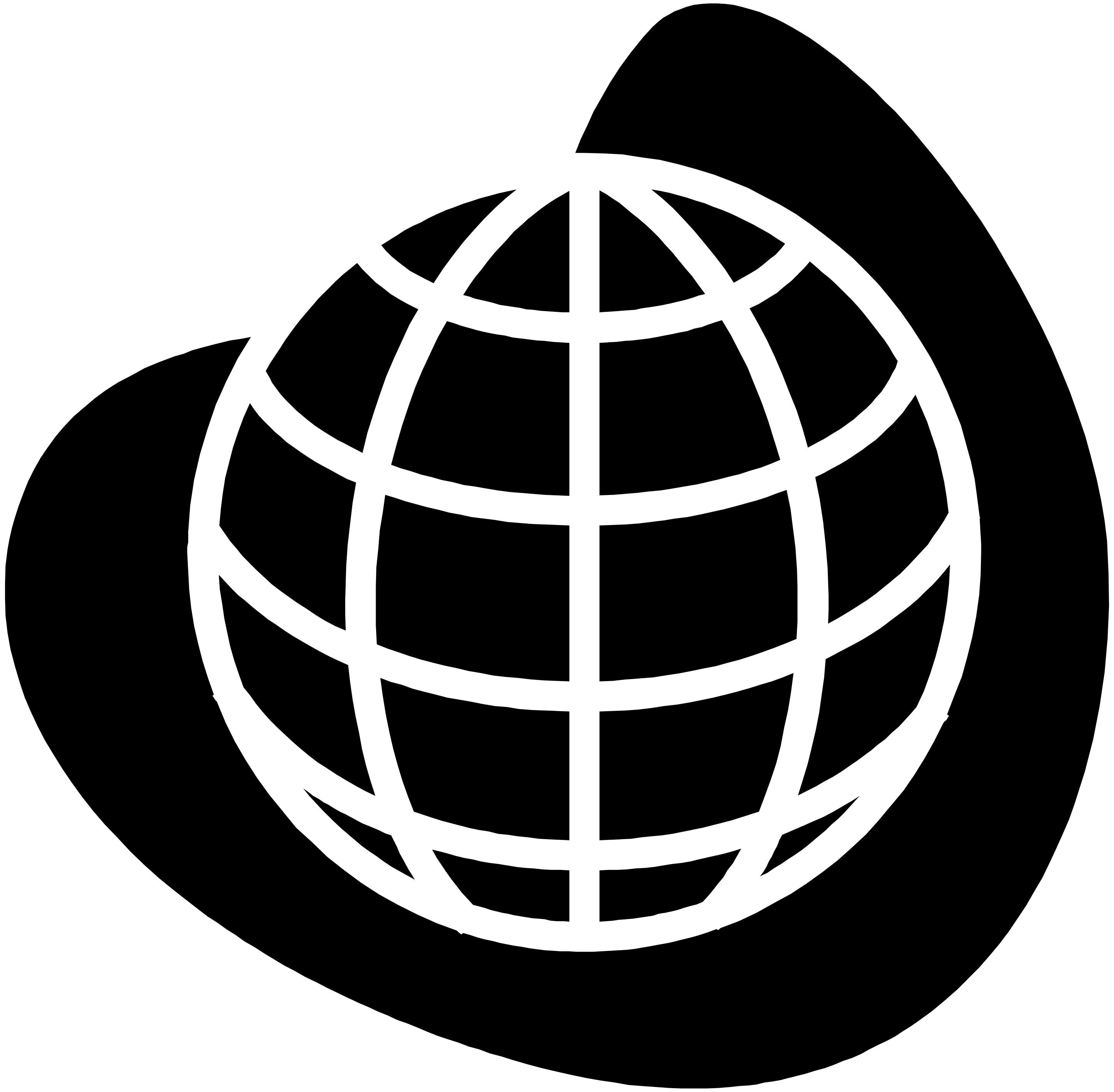
● The number of starts are important and some countries propose limits.

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:

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

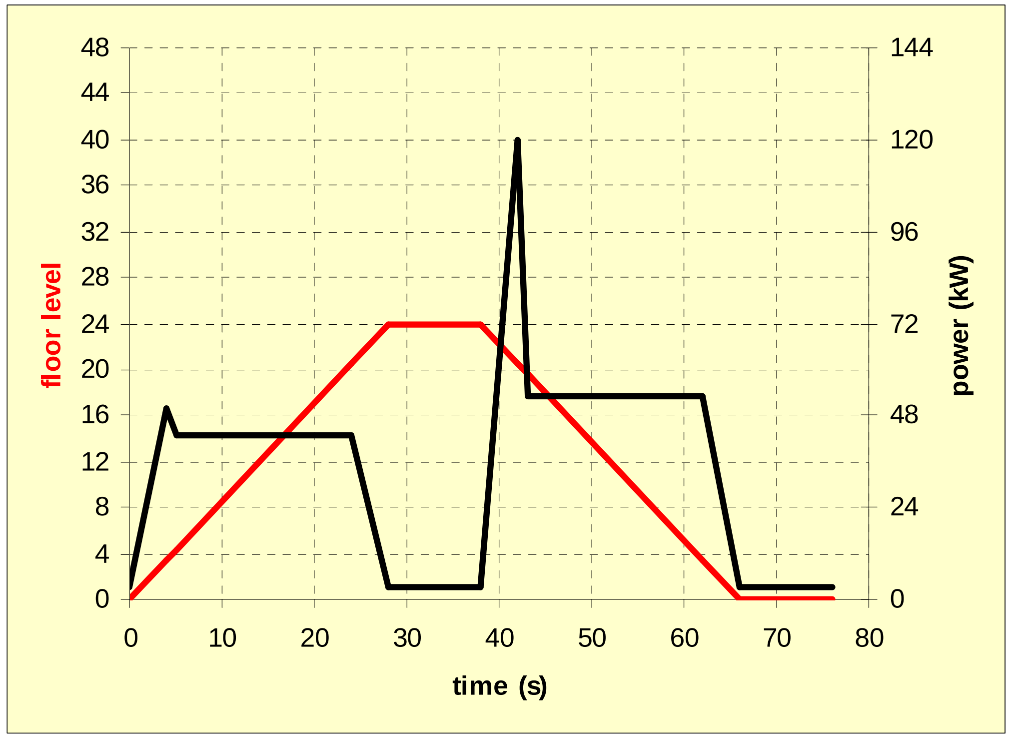
Terms:

- 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.

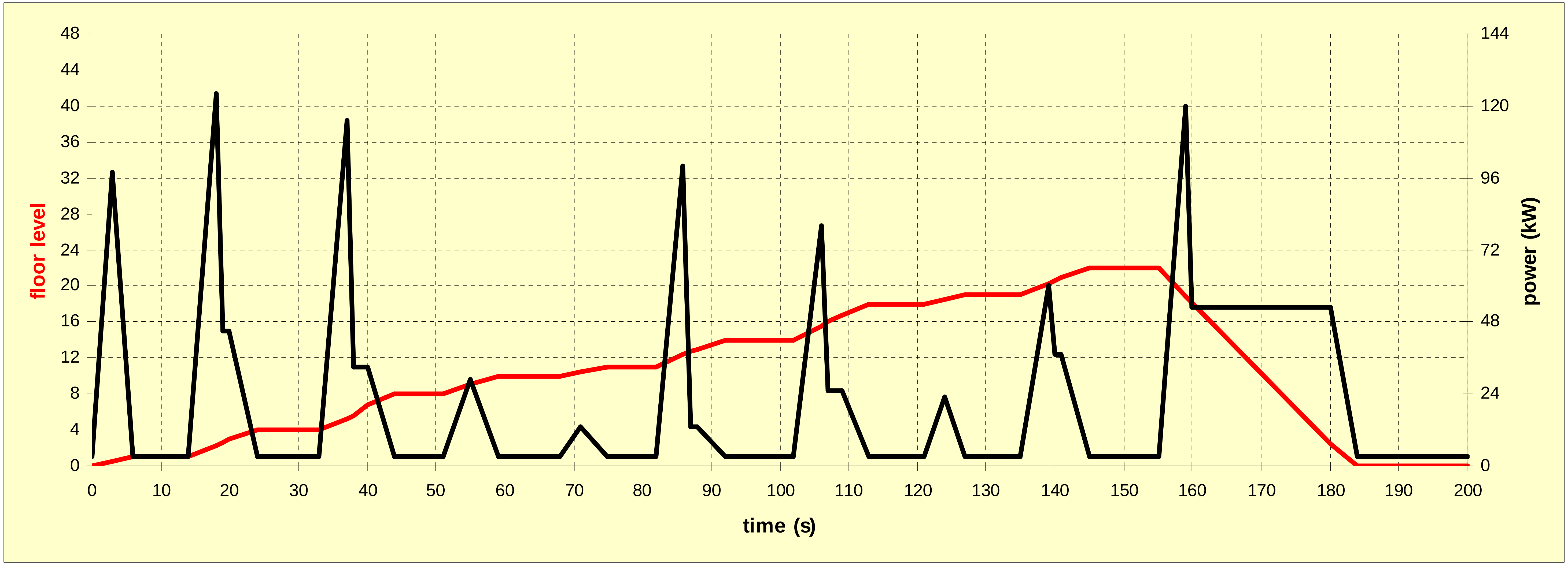
If the power used for each individual car load and each individual direction of travel were known then the simulator could estimate energy consumption.

ELEVATE

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.

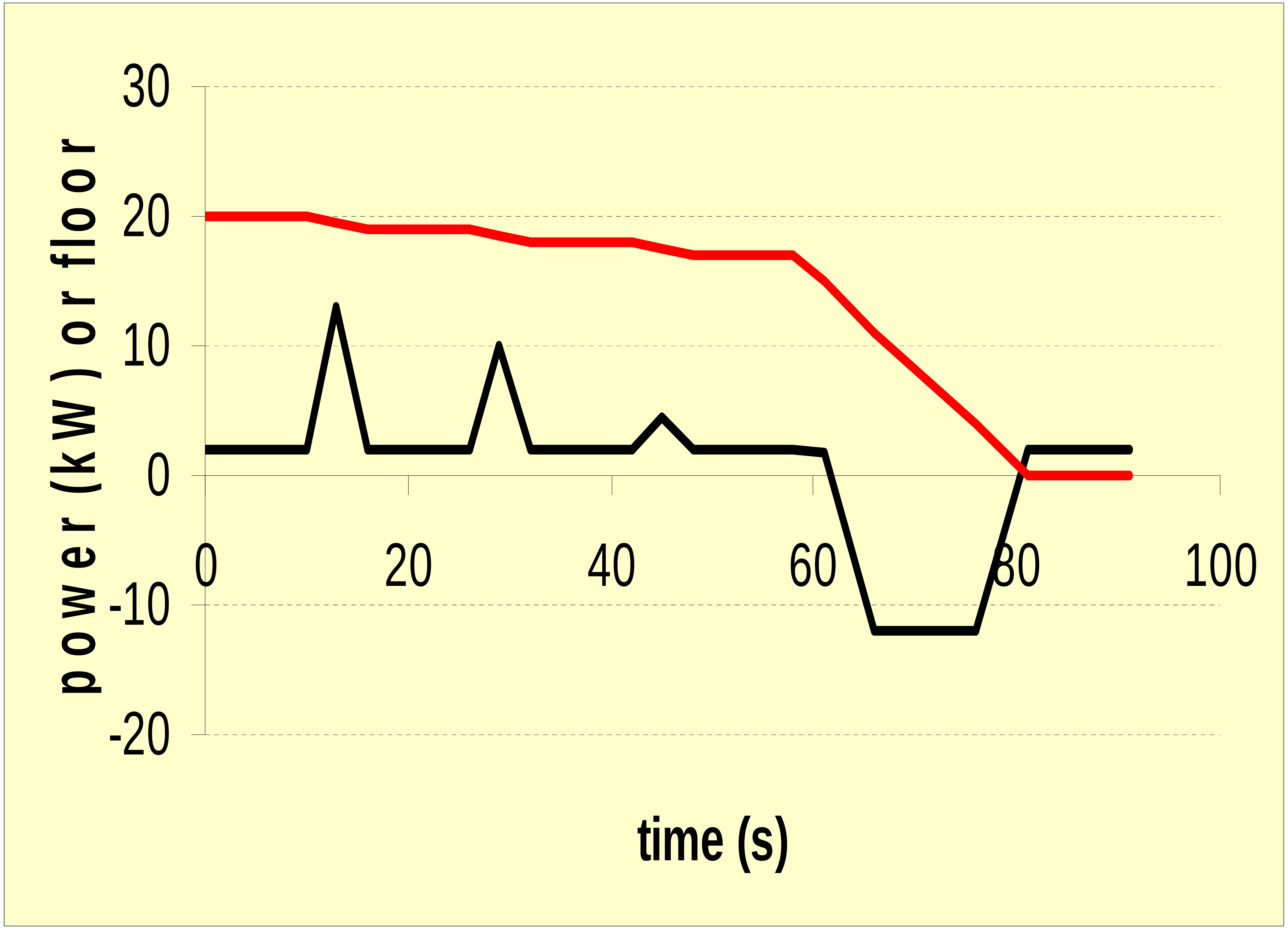
The lift moves one floor: 0>1, 10>11, 18>19, and rated speed is not reached.

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 17.

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