100 Days of Carbon Clean Up

Greening Your Lifts
Wednesday 23rd August 2006

Energy saving strategies

and energy models

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Presented by

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- Arup (1987 to 1997)
- Peters Research Ltd from 1997
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Brunel/Surrey University Environmental Technology EngD Programme

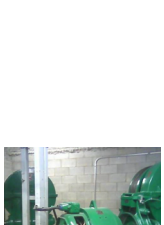
Vertical Transportation Planning in Buildings

1993 - 1997

Richard D Peters
BSc CEng MIEE MCIBSE

sponsored by
The Ove Arup Partnership and
The Chartered Institution of Building Services Engineers

Green Lifts?



Green Lifts?

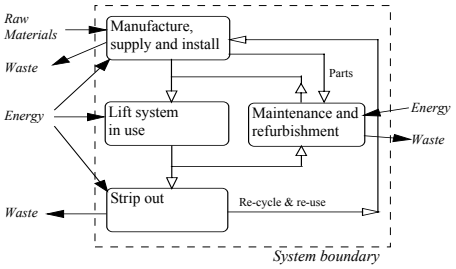
lift systems that deliver good passenger service at an acceptable cost while incurring minimum environmental impact

What impact does lift have?

Life Cycle Analysis

- includes burdens during entire life
  - resource extraction materials for manufacture
  - manufacture and installation
  - use of product
  - re-cycling and re-use
  - waste
  - transportation at all stages

Lift LCA



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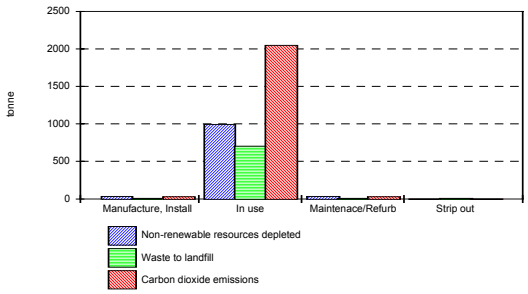
LCA Results



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EngD Research

- elevator traffic and energy simulation modelling
- improving understanding traffic and traffic analysis can lead to energy savings by avoiding over-design
- introduced the application of simulation models to test energy saving design and control strategies

9

But get the basics right first ..

- energy efficient (regenerative) drives and controls
- minimising inertia and other resisting forces
- car lighting
- accessible stairs

10

ELEVCON Istanbul 2004

The 14th International Congress on Vertical Transportation Technologies

Elevator Energy Simulation Model

Dr. Lutfi Al-Sharif
Al-Sharif VTC Ltd.,UK
Dr. Richard Peters
Peters Research Ltd., UK
Mr. Rory Smith
ThyssenKrupp Elevator Inc., USA

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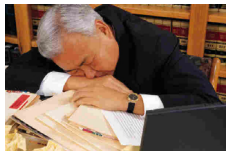
Let's not talk about maths behind the modelling



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Basic principles of energy transfer

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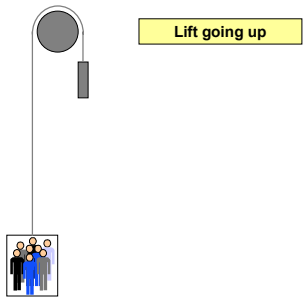
… in an ideal world



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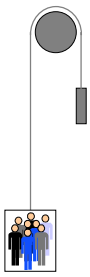
… in an ideal world



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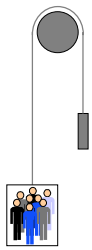
… in an ideal world



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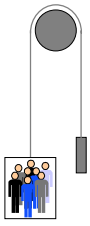
… in an ideal world



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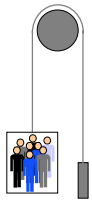
… in an ideal world



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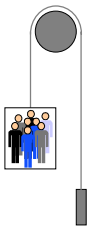

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… in an ideal world

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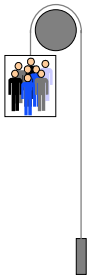
… in an ideal world



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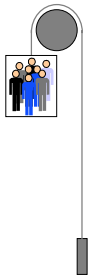

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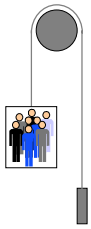

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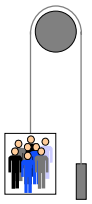

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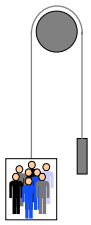

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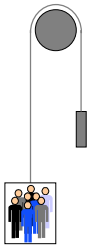
… in an ideal world



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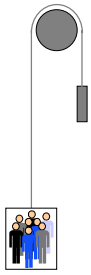

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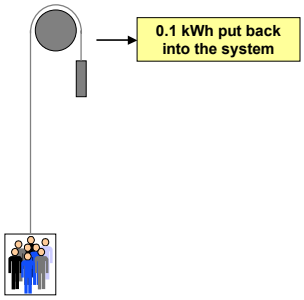

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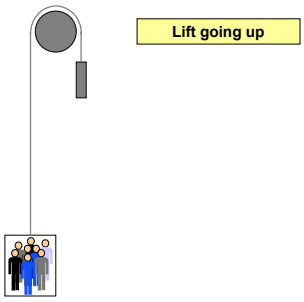
… in an ideal world

A lift does not use energy, it borrows it.

30

… in the real world



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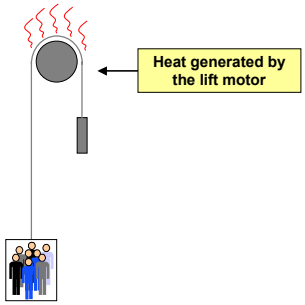
… in the real world



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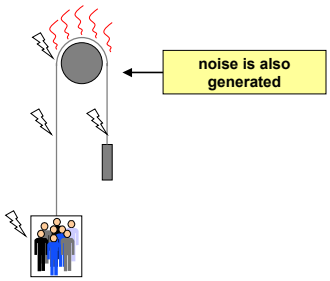

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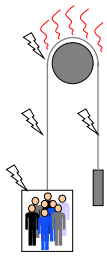

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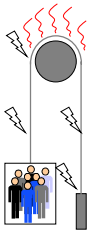

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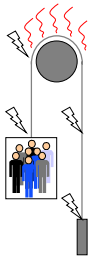

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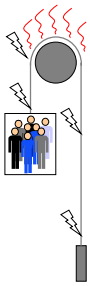

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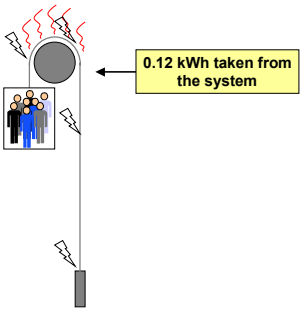

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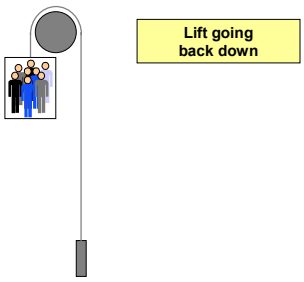

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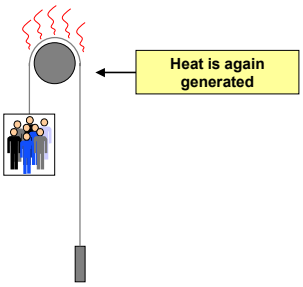

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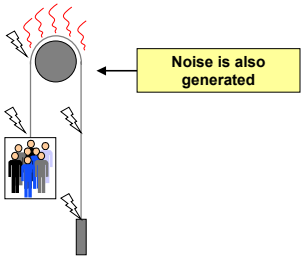

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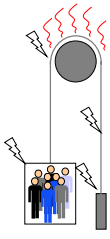

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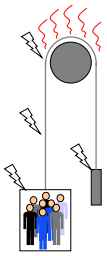

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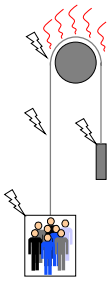

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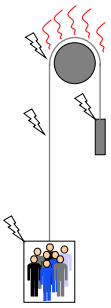

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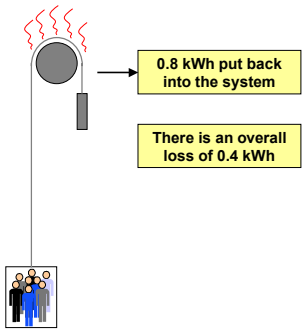

46

… in the real world

A lift does not use energy, it borrows it.

Interest is charged!

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Lift Energy Simulation Model

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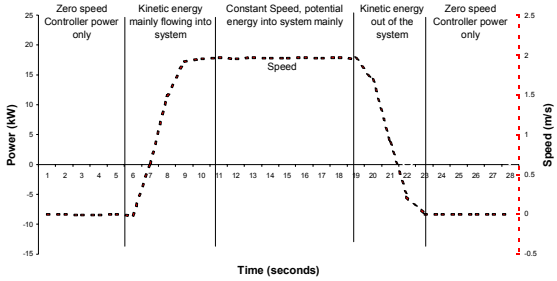
Speed and energy consumption of a lift carrying different loads



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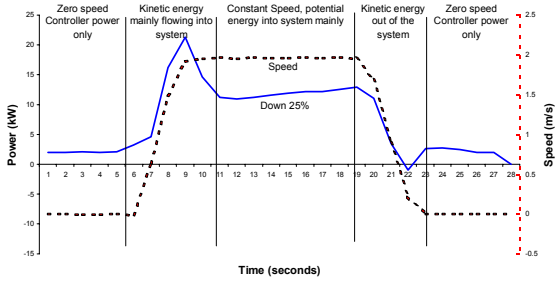
Speed and energy consumption of a lift carrying different loads



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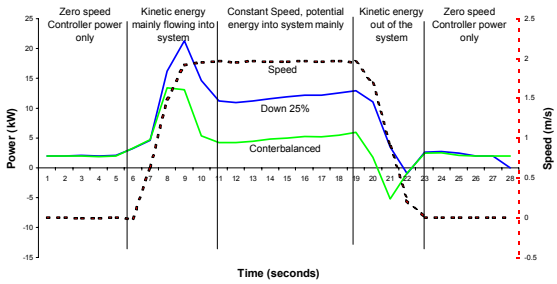
Speed and energy consumption of a lift carrying different loads



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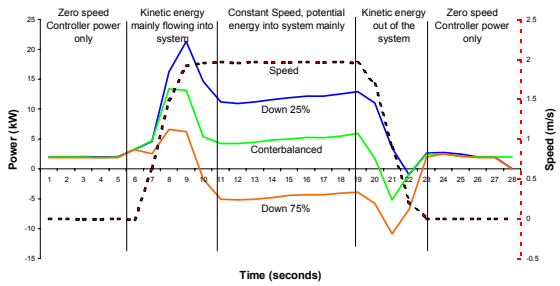
Speed and energy consumption of a lift carrying different loads



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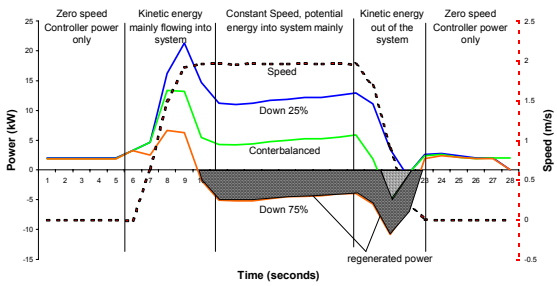
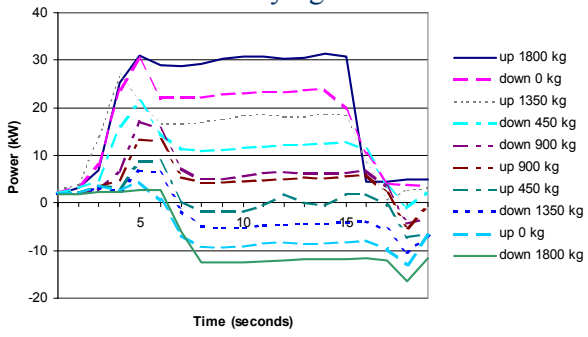
Speed and energy consumption of a lift carrying different loads



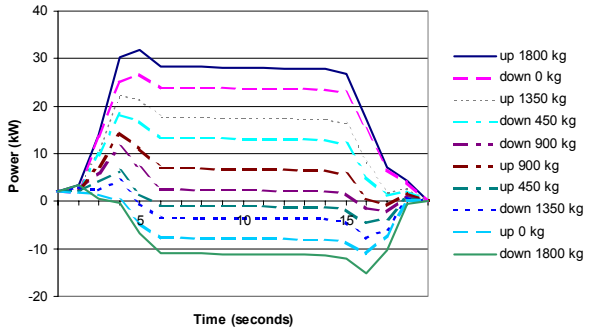
53

Measured energy consumption of an 1800 kg lift for trips in both directions with the lift carrying different loads



Calculated energy consumption

for the same lift trips



Some variables taken into account

- Type and efficiency of drive (motor)
- Whether the drive is regenerative or not
- Whether the installation is geared or gearless
- Roping arrangement including rope ratio and single/double wrap
- Rated load of the car
- Mass of the empty car
- Counterbalancing ratio
- Travel for each trip
- Speed, acceleration and jerk values

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Energy Simulation Model

- Separate hydraulic and electric models
- Implemented in Elevate
- Calibration based on measurements in London and Chicago

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… for a single lift trip we can model energy consumed almost exactly

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So used with a traffic simulation program we measure energy for any building, any traffic and any traffic control system

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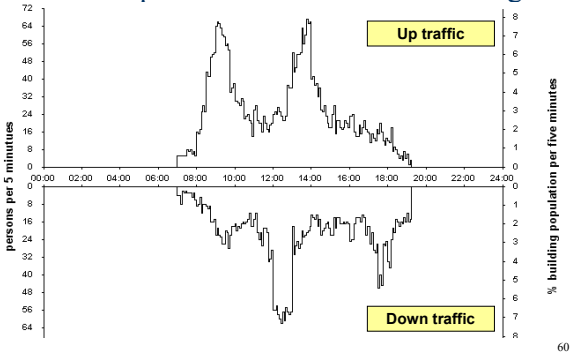
Graphical representation of traffic

in a sample multi-tenant office building



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Energy Simulation demonstration with ThyssenKrupp version of

ELEVATE

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Case Studies

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Case Study 1

- Office building, Denver, Colorado.
- Client asks: "How much energy saving will I achieve by changing from MG to a DC PWM drive?"
- "What is the effect of the different traffic group control algorithm?"

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Parameters

Parameter	Value
Travel	336 ft
Speed	700 fpm
Number of floors	20 floors
Capacity of each elevator	3500 lb
Car mass	5000 lb
Ropes	6 ropes of 5/8" diameter
Roping arrangement	1:1 roping
Wrap	Double wrap
Gearing	Gearless
Sheave	33" diameter
Guide shoes	Roller type
Compensated	Fully compensated
Type of drive	MG before mod/ 10k pwm after mod
Number of elevators	6 elevators
Daily traffic profile	Siikonen full day profile in elevate
Arrivals	1st floor (around 35% on 2nd, but not reflected in simulations)

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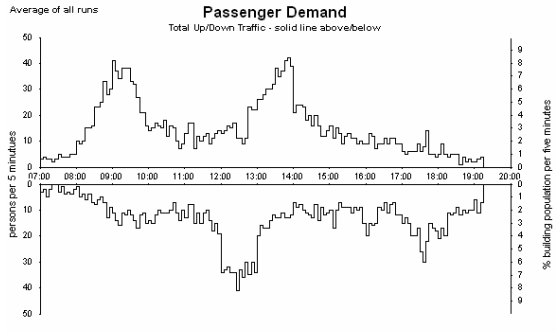
Traffic Pattern



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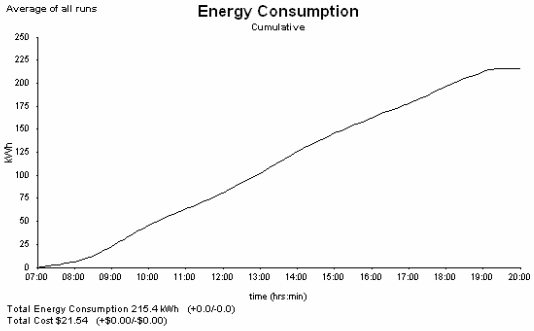
Results (new drive)



Case Study 1: Results

- MG set consumes 349 kWh per day per group.
- DC PWM drive consumes 215 kWh per day per group.
- Cost saving = 260 x 0.1 x (349.4-215.4)= $3484 (£1,847) per year per group of elevators

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Case Study 2

- Residential Building, Torronto, Canada.
- Client: "Is it worth me installing a Regenerative VVVF drive as opposed a non-Regenerative VVVF drive?"
- "Is it worth my investment?"
- "What is the pay-back period?"

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Parameters

Parameter	Value
Travel	375 ft
Speed	500 fpm
Number of condominiums	16 per floor, 1.5 persons per condominium
Number of floors	41 floors
Capacity of each elevator	2500 lb
Car mass	5000 lb
Ropes	7 ropes of 5/8" diameter
Roping arrangement	1:1 roping
Wrap	single wrap
Gearing	Geared at 57:1
Sheave	30" diameter
Guide shoes	Roller type
Compensated	Fully compensated
Type of drive	AC VVVF
Number of elevators	4 elevators

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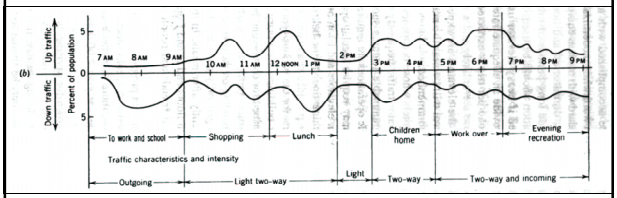
Traffic Pattern (residential, Strackosh)



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Case Study 2: Results (1)

- The non-regenerative case consumes 304.8 kWh per day, per group.
- Regenerative case consumes 197.5 kWh per day per group.
- Based on $0.1 per kWh, and assuming the same traffic exists for 365 days a year, the cost saving per year is:

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Case Study 2: Results (2)

- Cost saving = 365 x 0.1 x (304.8-197.5)= $3916.5
- If we assume that the cost of each regenerative unit per lift is $1500/unit, then the payback period (ignoring discounting is):
- Payback period = (4 x 1500)/3916.5 = 1.5 years

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The energy model …

- Provides tools for assessing
  - New lift installations
  - Modernisations
  - Payback, e.g. for Regen vs. Non-Regen
  - New energy saving technologies

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What's coming?

- Lifts which react to traffic conditions taking into account energy use including
  - Standby modes in off peaks
  - Energy saving control though dispatching and control of kinematics

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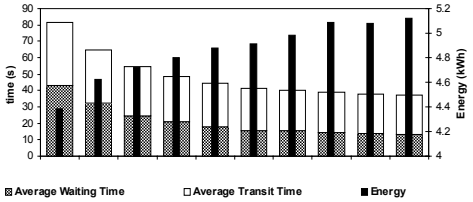
Energy Consumption is related to performance



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But get the basics right first ..

- energy efficient (regenerative) drives and controls
- minimising inertia and other resisting forces
- car lighting
- accessible stairs

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