Basics - What is Energy?

- Energy is the ability to do work
- Work = Force x Distance moved
- Force = Rope Tension, Torque, Voltage
- Power = Rate of doing work = Force x Speed
- Energy Consumption = Sum of all work accomplished over a measured period of time

Ft-Lbs, kg-m, Joules, Watt-Sec, BTUs, KiloWatt-Hours
**Basics - What is Energy?**

- The flow of energy is bi-directional
- Potential Energy is added to mass as it is raised against gravity (Force x Distance)
- Kinetic Energy is added to mass as it accelerates \((1/2 \times M \times v^2)\)
- Energy is removed as the elevator is stopped or the payload is lowered

Ft-Lbs, kg-m, Joules, Watt-Seconds, BTUs, KiloWatt-Hours

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**What Affects Energy Consumption?**

- Elevator mass & payload
- Elevator speed & distance traveled
- Frequency of use
- Hoist way efficiency
- Motor efficiency
- Power conversion efficiency
- Idle losses
- Regeneration Vs. resistor braking
Where Does the Energy Go?

- 1 Car Controller & Drive - Losses
- 2 Lift motor (& gearbox) - Losses
- 3 Traction sheave - Losses
- 4 Ropes / Cables - Losses
- 5 Car or Cab – Inertia absorption & PASSENGER MOVEMENT!
- 6 Rails & Guides - Losses
- 7 Counterweight – Inertia absorption
- Air column - Losses

Other Wasteful Effects

- Current harmonics
  - Causes voltage distortion, acoustic noise and extra heating in distribution lines & equipment
- Heat release
  - Must be removed by HVAC system
  - Includes that from resistor braking
- Low Power factor
  - Uses up distribution capacity
Regeneration

- Recovery or reuse of energy that would have been lost
- Every motor can act like a generator
- Some motor drive power converters can push energy back into the utility line… Regeneration
  Exception – Lower cost inverters with rectifier (diode) front-ends
- Important energy savings feature for high speed, high duty elevators

Where does the regenerated energy go?

- Braking resistor – Poor choice
- Other elevators in operation
- Other connected building loads
  Slows down the utility meter
Typical Building Distribution

Basics - What is Efficiency?

Efficiency = \frac{\text{Useful work output}}{\text{Actual work input}}

Being efficient minimizes energy waste
Elevator Efficiencies

- Car Controller – A few 100 watts of continuous consumption
- Solid State Motor Drive
  - 90-95% Power Conversion
- Motor - 75-92%
- Gearbox - 85% Motoring, 50% Regen
- Traction Sheave & Ropes, Rail Guides, Windage, etc. - 85-90%

Efficiencies of Motor Drives

For DC Motors
- M-G Set, 60-80%
- SCR-DC, 85-90%
- PWM-DC, 90-94%
- DC Motor, 88-92%

For AC Motors
- Variable Voltage, 40-60%
- V V V F Inv., 92-95%
- Induction Motor, 75-90%
- PM Motor, 89-92%

Gearbox – 85% motoring, 50% regenerating
Predicting Consumption

Equipment efficiency is only part of the issue

- What is the magnitude of the Power demand?
  The car is not always loaded to capacity
- How long will it last?
  Runs are variable length... Express vs Local
- How many times will it happen?
  Hospital vs Hotel vs Office vs Condo, etc.

Reducing Energy Consumption is what we are after

Find a way to predict consumption with variable loads and variable elevator cycling

Consumption Calculations

Estimate the average load, system mass, run distance and the number of runs per day / month / year

Fact: Whatever goes up eventually comes down

  Mechanical + electrical losses ARE the consumption

Averaged data yields the same consumption answer as the kWhr meter
Energy Consumption Calculator

www.elevatordrives.com

Click on Energy Savings Calculator
Sign up to be a registered user
Energy Consumption Calculator

<table>
<thead>
<tr>
<th>Drive / Mtr Type</th>
<th>kWh / day estimate</th>
<th>Heat Release BTU / day (1,000's)</th>
<th>$ per Year estimate</th>
<th>Relative kWh Consumption</th>
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<tr>
<td>m-g DC (Regen)</td>
<td>132</td>
<td>451</td>
<td>$4,136</td>
<td>1.000</td>
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<tr>
<td>SCR-DC (Regen)</td>
<td>123</td>
<td>420</td>
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<td>Quattro PWM-DC(regen)</td>
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<td>236</td>
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</tbody>
</table>

780 3rd Ave, NYC

Hi-Rise, 1,200 fpm, 3,000lbs, DC Gearless, (each of 3 cars)
- Lobby express to floors 35-48
- M-G-DC consumption: 131 kWhr/day, 446 BTU/day
- Quattro-DC consumption est: 65 kWhr/day, 221 BTU/day

51% Energy Savings with Quattro!
780 3rd Ave, NYC

**Mid-Rise**, 1,000 fpm, 3,000lbs, DC Gearless, (each of 3 cars)
- Lobby express to floors 19-35
- M-G-DC consumption: 91.8 kWHr/day, 313 BTU/day
- Quattro-DC consumption est: 37.9 kWHr/day, 129 BTU/day

59% Energy Savings with Quattro!

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**Low-Rise**, 800 fpm, 3,000lbs, DC Gearless, (each of 3 cars)
- Lobby to floor 19
- M-G-DC consumption: 69.5 kWHr/day, 237 BTU/day
- Quattro-DC consumption est: 25.2 kWHr/day, 86 BTU/day

64% Energy Savings with Quattro!
Total Energy Savings (all 9 cars)

492 kWh/day or 128,000 kWh/year!

Energy Monitoring

- Best way to capture real energy savings
- **Need before and after modernization data**
- Measure total energy consumption to each elevator or a whole elevator bank – Must be same average duty cycle
  - KiloWatt-Hrs Input
  - KiloWatt-Hrs Returned (Regenerated)
  - kVA-Hrs
- Run Cycle & Elapsed Time counters
- Minimum of 14 days of continuous operation, 24/7
Modernization

- Why keep a DC machine?
  - Large gearless DC machines cannot be easily replaced with AC equivalents
  - DC Motors and Machines are in Good Working Order to Provide Excellent Ride Quality and Years of Additional Service
  - Difficult Machine Room Access

Elevator Machines – 99 High St., Boston

Hi-Rise
Otis
219HT
1,000 fpm
3,500 lbs.
Emily Morgan Hotel
San Antonio, TX

GE
Type 722
(1927)

35 hp
65 rpm

600 fpm
2,500 lbs.

Conclusions

- Regenerative Drives will save the most energy and achieve the most LEED points
- Contact the local utility about energy saving incentives and rebates
- Investigate state or city incentives
- Look also for tax incentives
Conclusions

- Use the Energy Consumption Calculator to Compare Motor & Drive Systems
- Measure energy consumption to gain confidence of calculated estimates
- Energy savings alone will not pay for elevator modernization, but using more efficient equipment makes a large impact on energy use with a relatively small incremental cost

Incentive Rebate Programs

- Will require application paperwork
- Separate or “custom” category for elevators
- Will require an energy savings estimate
- May require third party verification including a baseline measurement
Energy Monitoring

What’s next?

Interest developing in monitoring elevator consumption via the Building Management System (BMS)

Siemens, Johnson Controls, et al

Questions?

Please visit

www.elevatordrives.com

for Magnetek’s Energy Savings Calculator and additional product information.