The E4 Project and future perspectives to improve Energy Efficiency of Elevators and Escalators

Anibal T. De Almeida
ISR – University of Coimbra
E4 - Project

Major tasks:

1. Market characterisation
2. Monitoring campaign
3. Technology assessment
4. Evaluation of savings potential
5. Identification of barriers and strategies for market transformation
Electricity consumption shares in tertiary sector in the EU

- Lighting: 25%
- Electric Heating: 16%
- Circulation pumps and other heating auxiliaries: 14%
- ICT data centers: 9%
- Lighting street: 6%
- Refrigeration: 5%
- Ventilation and air-conditioning: 3%
- Misc. building technologies: 3%
- Hot water: 3%
- Cooking (in hotels, health): 2%
- Elevators: 1%
European Lift Market

Around 4,5 million lifts in the 19 countries surveyed
Around 115,000 lifts are installed in Europe each year
European Lift Market

Lift Distribution according to building type

- Residential: 64%
- Office: 14%
- Hospital: 5%
- Industrial: 4%
- Commercial: 4%
- Hotel: 2%
- Senior Residences: 1%
- Traffic: 1%
- Others: 1%
European Lift Market

Lift distribution according to the technology used. Since E4 gearless lifts have gained market share.
European Escalator Market

According to ELA, there were approximately 75,000 escalator units installed in the EU-27, of which 60,000 units in commercial buildings and the rest in public transportation facilities (train stations, airports, etc.). It is estimated that 3,500 new units are installed each year.
A monitoring campaign was carried out within the E4 project as a contribution to the understanding of energy consumption and energy efficiency of lifts and escalators in Europe.

– 74 Lifts
– 7 Escalators
Monitoring Campaign

- Residential buildings
- Office buildings
- Hotels
- Hospitals
- Industry
- Commerce
- Others

Legend:
- Escalators/Moving walks
- Hydraulic
- Gearless
- Geared
Running specific energy consumption of monitored lifts in the tertiary sector \([\text{mWh/kg.m}]\)
Running specific energy consumption of monitored lifts in the residential sector [mWh/kg.m]
Monitoring Campaign - Standby

Measured standby power in the lifts audited in the tertiary sector
Measured standby power in the lifts audited in the residential sector

Measured standby power ranges from 15 W to 710 W
Monitoring Campaign – Standby/Running

Proportion of standby and running mode to overall energy consumption of lifts in the tertiary sector
Proportion of standby and running mode to overall energy consumption of lifts in the residential sector
Escalator Monitoring Campaign

Annual electricity consumption of the monitored escalators

- DE_Esc1
- PT_Esc1
- PT_Esc2
- PT_Esc3
- PT_Esc4
- PL_Esc1
- PL_Esc2

Electricity Consumption [kWh/year]

- Standby Mode
- Running Mode
Estimation of Energy Consumption Lifts
- Annual Consumption 18 TWh
## Options to improve traction elevators efficiency

<table>
<thead>
<tr>
<th>Component</th>
<th>Basic</th>
<th>Intermediate</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoist drive</td>
<td>Motor-generator, or DC with silicon-controlled rectifiers</td>
<td>Pulse-width modulation, geared drives</td>
<td>Permanent magnet, gearless</td>
</tr>
<tr>
<td>Car lift</td>
<td>Wire rope</td>
<td>Wire rope</td>
<td>PU-coated belts, multiple rope</td>
</tr>
<tr>
<td>Controls</td>
<td>Electromechanical relays, group controller</td>
<td>Microprocessor</td>
<td>Software-defined, e.g., destination dispatch</td>
</tr>
<tr>
<td>Lighting, ventilation</td>
<td>Incandescent, halogen</td>
<td>CFLs, efficient fans</td>
<td>LEDs, efficient fans, occupancy sensors</td>
</tr>
<tr>
<td>Energy sources</td>
<td>Grid</td>
<td>Grid plus regeneration</td>
<td>Regeneration plus solar</td>
</tr>
<tr>
<td>Other considerations</td>
<td>Single operating mode, needs machine room</td>
<td>Standby mode, better power factor</td>
<td>Standby mode, variable door motors, power factor near 1, MRL, quick installation</td>
</tr>
</tbody>
</table>

Source: ACEEE, 2015
Efficiency levels in the IEC 60034-30-1 standard for 4 poled motors
Efficiency Classes of VSDs (EN50598-2)
IEC 61800-9-2 Being Developed
VSDs Real-life measured losses

Source: (Danish Technological Institute)
Running

• Assume the best available efficiencies for each of the components in the lift:
• Motor efficiency: 15% lower losses than IE3 in IEC60034-30
• (Super Premium or Permanent Magnet Synchronous Motors)
• Efficiency of helical gear – 96%
• Friction losses (5%)
• Efficiency of VSD (95%)
E4-Estimation of Potential Savings - Lifts

**Standby**

**BAT**
- LED Lighting (varies from 12 W for lift with load 320 kg to 18 W for 1,000 kg load lift)
- Electronic Controllers (25 W)
- VSD/Inverter (20 W)
- Door operators (5 W)

**BNAT**
- Consider turning off of all non-essential components which contribute to the stand-by energy consumption when the lift is not in use.
- Consider putting the controller and inverter into sleep-mode (1 W each).
A total reduction of **10 TWh** is achieved using the Best Technologies Available and of **12 TWh** when technologies that are currently being available but currently not used in the lift industry.
Ecodesign Working Plan 2015 - 2017

Assumptions for energy savings

<table>
<thead>
<tr>
<th>Product type</th>
<th>Possible savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential lift</td>
<td>40%</td>
</tr>
<tr>
<td>Tertiary lift</td>
<td>30%</td>
</tr>
<tr>
<td>Industrial lift</td>
<td>50%</td>
</tr>
<tr>
<td>Escalator and moving walkways</td>
<td>20%</td>
</tr>
</tbody>
</table>

Lower savings than E4 due to:
- considered technology shift in recent years
  Hydraulic -> Geared -> Gearless
- Lighting partially covered by existing regulation

Source: Preparatory study to establish the Ecodesign Working Plan 2015-2017
Bio by Deloitte
Long lifetime of 40 years was assumed (only 45% of stock rotated in 2030)

After complete stock rotation significantly larger savings would be achieved (~8 TWh)

<table>
<thead>
<tr>
<th>Market data (EU-27)</th>
<th>Year</th>
<th>Lifts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales (1,000)</td>
<td>2012</td>
<td>110,000</td>
</tr>
<tr>
<td>Stock (1,000)</td>
<td>2012</td>
<td>4,800</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>4,950</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>5,200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EU-27 Energy consumption</th>
<th>Year</th>
<th>Lifes (PJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life cycle</td>
<td>2012</td>
<td>5.2 PJ</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>5.4 PJ</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>5.9 PJ</td>
</tr>
<tr>
<td>Use phase (per year)</td>
<td>2012</td>
<td>18.6 TWh / 167.3 PJ</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>19.3 TWh / 173.9 PJ</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>20.7 TWh / 186.0 PJ</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EU-27 Energy savings</th>
<th>Year</th>
<th>Lifes (PJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use phase (per year)</td>
<td>2020</td>
<td>1.3 TWh / 12.0 PJ</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>3.1 TWh / 28.7 PJ</td>
</tr>
</tbody>
</table>
Estimation of Energy Consumption

Escalators – E4

According to ELA statistics, there were 75,000 escalators and moving walks installed in the EU-27. Based on the surveys conducted in E4 WP2, two assumptions are made:

- 75% of the escalators are installed in commercial buildings and the remaining 25% in public transportation facilities.
- 30% are equipped with a Variable Speed Drive (VSD)

Based on the measurements conducted in WP3, the average value for the electricity consumed during running and standby modes (slow-speed and stopped), is considered.

**Escalators energy consumption is estimated at 900 GWh per year**
For the estimation of energy savings it is considered that all of the escalators installed would be equipped with VSD. Furthermore, it is considered that when stopped, the controller and inverter only consume one Watt each.

A potential reduction in the electricity consumption of around **255 GWh (28%)** would be possible.

The Preparatory study to establish the Ecodesign Working Plan considered lower savings of **20%** due to a considered shift towards more efficient technologies in more recent years.
What are the barriers to energy-efficiency?

- No monitoring of energy consumption and energy costs of existing installations.
- Customers lack knowledge on energy efficient technology.
- Main source for information are manufacturers (and their sales departments).
- Installations are usually chosen without a (comprehensive) assessment of their energy consumption.
- An installation is often not chosen by the later operator/user of the installation; thus life-cycle approaches are neglected.
  - Maintenance and energy costs are usually divided between several occupants of a building.
  - The consumption of 2 to 8% of the whole energy consumption of a building may be too low to raise attention.
Existing Measurement and Classification Standards

**VDI 4707**
- **Part 1: Lifts; Energy efficiency** - specifies a method allowing to classify entire lifts according to their travel and standstill energy demands,
- **Part 2: Lifts; Energy efficiency; Components** - aims at allowing the classification of lifts on the basis of the energy efficiency of the lift components.

**ISO 25745** - Energy performance of lifts, escalators and moving walks:
- **Part 1:** Energy measurement and verification - 2012
- **Part 2:** Energy calculation and classification for lifts (elevators) – March 2015
- **Part 3:** Energy calculation and classification for escalators and moving walks – March 2015

*No Longer a barrier*
National and third country policies and labels

Transposition of EPBD in MS, with specific regulation on lifts in Portugal and Denmark:

- **Portugal**: specific requirements for new lifts as of 1\textsuperscript{st} January 2016 (VDI 4707 class B) – Commercial Buildings and mandatory:
  a) Cabin lighting control
  b) Sleep mode
  c) Regeneration from January 1st, 2019.

- **Denmark**: information requirements on power consumption in transport and standby

US ASHRAE 90.1 includes requirements for Cab lighting and ventilation, to be expanded to MEPS

Mexican label including requirements on energy consumption and noise levels
What needs to be done?
Recommended strategies and measures.

Regulation of Energy Efficiency of Elevators and Escalators: Huge Opportunity to save energy and create jobs.

Options:

• EPBD Directive
• Ecodesign Directive or Energy Labelling Directive
• Product Category Rules (PCR)
Main Conclusions of Ecodesign Working Plan Study

Measures that could be envisaged for lifts and escalators:

- Minimum requirements on energy efficiency in the use phase.

- An in-depth study, which could be either a preparatory study explicitly, or a general update of the E4 study with a clear focus on policy action, should clarify which of Ecodesign or EPBD Regulation is the most appropriate for lifts.

Source: Preparatory study to establish the Ecodesign Working Plan 2015-2017
Bio by Deloitte
Background Information
E4 – Project

Energy Efficient Elevators and Escalators

Project Partners

ISR – University of Coimbra

European Lift Association

Italian National Agency for New Technologies, Energy and Sustainable Economic Development

Fraunhofer Institute for Systems and Innovation Research

Polish National Energy Conservation Agency
European Lift Market

- Information was collected by means of a survey with the cooperation of 19 national lift and escalator manufacturers and installers associations.

- The purpose of the survey was to overcome the lack of information related to the lifts and escalators installed base.
Monitoring Campaign

Typical cycle of a traction lift
Typical cycle of a hydraulic lift
Travel cycle consumption of the lifts audited in the tertiary sector
Travel cycle consumption of the lifts audited in the residential sector.
Escalator Monitoring Campaign

Active power of an escalator in different operation modes
Combined information from:

- Market characterisation
- Monitoring campaign

Annual Consumption  18 TWh
1) Identify relevant barriers that are present in the European lift and escalator market
   - *Barrier*: a mechanism that inhibits a decision or behavior that is both energy-efficient and economically efficient
   - *Methodology*: literature review, expert interviews and validating group discussions

2) Develop strategies to overcome the barriers identified

3) Provide guidelines how to improve energy efficiency
What’s not a barrier?

- **Technology**
  - Energy-efficient technology is available on the market and it works well (no increased need for repair or maintenance).

- **Capital**
  - New installations: Split incentives may hinder investment into more efficient technology, however not a general lack of capital.

- **Legislation**
  - No conflict identified with existing guidelines/regulation/legislation.
  - More important: lack of legislative/regulative framework to support the dissemination of energy-efficient technology.

- **Comfort and safety**
  - Energy-efficiency is not seen in conflict with comfort and safety issues.
What needs to be done? Recommended strategies and measures.

- Raising awareness and enhancing knowledge
  - Main target groups
    - New installations: stakeholders involved in the planning and construction process of buildings
    - Existing installations: owners, users and operators
  - Measures
    - Labeling of equipment
    - Access to ‘objective’ information
    - Awareness campaigns for target groups

Does not solve split incentives barrier
How important is energy efficiency on the European lift and escalator market?

- The issue has been discussed for some time.
- The discussion is related to the societal debate around climate change.

The awareness for energy efficiency seems to be higher ...

- ... for manufacturers of lifts and escalators than for buyers of installations.
- ... for owners of grand scale installations (e.g. airports, high-rise segment) than for ‘normal’ customers (e.g. residential sector).
- ... for lifts than for escalators.
Is energy-efficient technology for lifts and escalators also economically efficient?

- Responses are ambiguous and even experts come to different conclusions (e.g. wide ranges regarding costs)
  - High complexity of the products (e.g. interaction between components)
  - Individually engineered installations rather than standardized products
  - Rapid technological advances

- Few general conclusions:
  - Assessment easier for new installations than for retrofits.
  - Switching off the cabin light if the lift is not operating seems to be the only measure that is (more or less) accepted to be efficient in terms of energy and costs.
Main Conclusions of Ecodesign Working Plan Study

Other environmental aspects of importance: oil leakage, noise, vibrations and end-of-life are issues that appear to be relatively minor as compared to energy consumption

Policy coverage: REACH applies to lifts, and national transpositions of EPBD may cap energy consumption of lifts. According to E4 study, one interesting option to explore would be the inclusion of lifts into EPBD

Appropriateness of Ecodesign or Energy Labelling: although subject to individual design and specifications, lifts may have their energy consumption measured by test standards ISO 25745 or VDI 4707. The decision between Ecodesign and/or EPBD remains to be addressed

Industrial competitiveness: the split of the lift industry between a few big players and many smaller manufacturers probably means that Ecodesign requirements would not be equally received by all obligated parties

Source: Preparatory study to establish the Ecodesign Working Plan 2015-2017
Bio by Deloitte