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WHITE PAPER

Eco-efficiency and elevator modernization

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1. Introduction

Buildings account for about 40% of global energy consumption, and elevators can account for 2-10% of energy consumption in a building. Eco-efficient elevator technology can therefore significantly reduce worldwide energy consumption, with a corresponding reduction in the environmental impact.

In this white paper can be seen how the environmental impact of elevators can be reduced. You will find an analysis of the energy consumption and environmental impact of all of the components and systems in an elevator, from hoisting and electrification to lighting and ventilation. There is also an examination of the elevator's entire lifecycle, from planning to ensure that the solution matches the requirements of the building; to maintenance so that the elevator always operates at peak efficiency; to modernization, to ensure that the latest technology is employed; and finally to replacement, including environmentally-friendly recycling or disposal of the old equipment.

Climate change is one of the biggest threats facing the planet today and affecting environmental stability. Greenhouse gases are among the big drivers behind global warming. Global greenhouse gas emissions due to human activities have grown 70% between 1970 and 2004.

Energy prices have increased rapidly in the 21st century. Over the last few years, oil prices have been at record high levels, and energy prices are expected to increase further in the long term. In addition to environmental concerns, the growing consumption in developing countries is increasing the upward price pressure.

Multiple stakeholders require businesses to concentrate on environmental management and to promote common global goals in environmental issues. Many businesses and organizations have already taken a proactive approach to environmental problems to minimize their environmental impact. Environmental stability requires sustainable use of materials, energy, water and land, enhanced recyclability, product durability, and closed material loops.

These trends have led to the search for environmentally sustainable methods of production and consumption. It is evident that companies can create economic wellbeing while taking the environment into account. According to the World Business Council for Sustainable Development definition, eco-efficiency is achieved through the delivery of competitively priced goods and services that satisfy human needs and bring quality of life while progressively reducing the environmental impacts of goods and resource intensity throughout the entire lifecycle to a level at least in line with the Earth's estimated carrying capacity.

A lifecycle approach is important when considering the environmental impacts of products and services (Figure 1). Lifecycle thinking includes raw material evaluation, production, distribution, use, reuse, recycling and disposal. Maintenance and modernization play a vital role in ensuring the environmental friendliness of products with a long lifecycle.

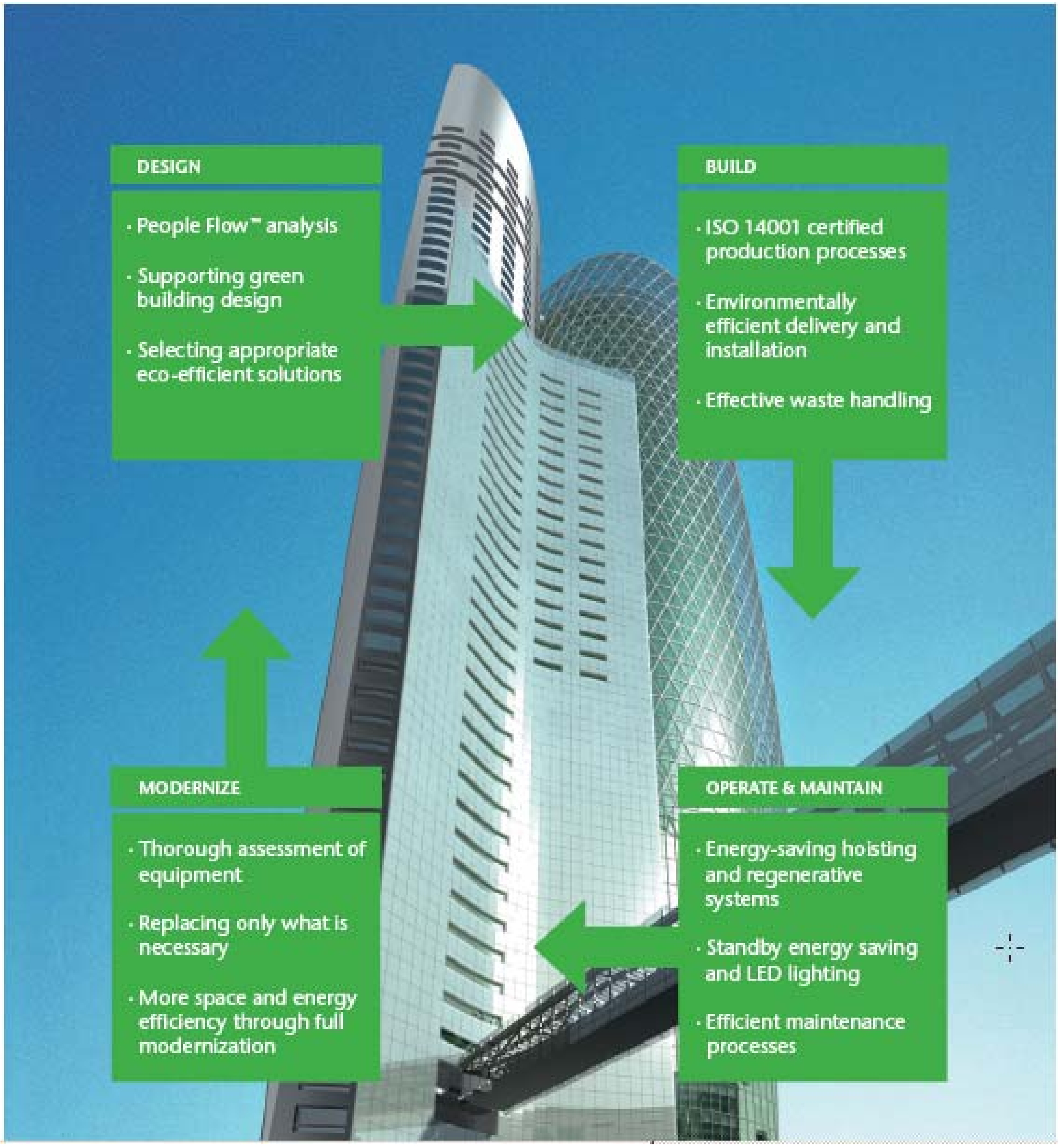

Figure 1. KONE's lifecycle approach for eco-efficient business

2. Buildings, elevators and eco-efficiency

2.1 Environmental impact of buildings

Buildings are responsible for at least 40% of the world's energy consumption and the building sector is constantly expanding. The real estate sector also has the largest single potential to improve energy efficiency. More than one fifth of current energy consumption could be saved by 2010 by applying more ambitious standards to new buildings and to major upgrades of existing buildings.

The growing number of Green Building Councils around the world also reflects the importance of eco-efficiency in the real estate market. Green Building Councils evaluate the energy efficiency of buildings and promote the importance of environmentally friendly construction.

Green building practices take into account the entire lifecycle of a building – from design and construction to operation and maintenance and finally removal. Green building practices cover e.g. the materials that are used in the construction of buildings and the use of resources, like energy and water, during the building's lifecycle.

2.2 Elevator energy consumption

Elevators account for about 2-10% of the entire energy consumption of a building. This percentage varies based on the elevator technology and the building profile. Elevators are also often designed for specific customer requirements, so their energy consumption may differ when comparing different installations.

The biggest impact on the environment occurs during the use of an elevator. Consequently, reducing the environmental impact of the equipment is most effective when the product is being developed and the optimal solution for each building is being planned. Planning includes elements like energy efficiency, cutting back on oil requirements and fuel consumption, and reducing noise levels.

The old elevator base does not meet today's expectations for environmental eco-efficiency. With elevator modernization it is possible to make elevators more energy efficient and reduce their environmental lifecycle impact. Modernization maximizes the performance of an old elevator and extends its lifetime.

3. Introduction to elevator types

3.1 Hydraulic elevators

Hydraulic elevators are operated by fluid. They use a hydraulically powered plunger to push the elevator upwards. Gravitation lowers the elevator when the oil from the cylinder is let out.

3.2 Traction elevators

Traction elevators use hoisting ropes which pass over the traction sheave. The hoisting ropes have the elevator hanging at one end and the counterweight on the other end. The traction sheave is driven by a motor, either directly (gearless) or through a reduction gear (geared).

In a traction elevator, the hoisting machine raises the elevator by means of hoisting ropes. The weight of the car is balanced by a counterweight at the other end of the hoisting rope.

4. Solutions to increase eco-efficiency with elevator modernization

It is essential to conduct a full analysis before starting an elevator modernization project. Comprehensive analysis reveals the modernization needs; based on the collected information, it is possible to create an accurate modernization plan. In order to meet the modernization needs identified in the survey, different levels of solutions are available, ranging from replacing individual elevator parts, to modernization packages consisting of complete functional entities, to full replacement solutions.

According to a major elevator provider, full elevator modernization is often the most energy-efficient solution and it can reduce energy consumption by as much as 70%. However, with modular modernization the energy-efficiency of individual equipment can also be improved. Modular modernization can concentrate for example on the hoisting system, signalization, control systems or drive technology. Modular modernization can save energy by reducing standby consumption, with energy-saving lighting and hoisting solutions, and by recovering energy. These issues are dealt with more fully in the following sections.

4.1 Importance of standby consumption

The elevator's standby consumption can count for 25-80% of the total energy consumption of the elevator, depending on usage and the elevator type. Thus reductions in standby consumption are vital when considering modernization and the energy efficiency of the elevator.

An elevator's standby energy consumption is a combination of several issues. One important factor is permanently lit cabin lights. If no attention is paid to lighting and energy consumption, the cabin lights are always on, even when the elevator is empty and not in use.

One way to reduce standby energy consumption is to automatically switch off the lighting when the elevator is in standby mode. For example, the car lighting can be switched off automatically at a predetermined time after the last call. The next time the car is called, the lighting is switched on automatically and it is safe for the passenger to step into the elevator.

The same switch-off method can also be extended to car fans. Using these two energy saving solutions – switching off the car lighting and the fan when the elevator is not in use – the energy consumption of the car lighting and fan can be decreased by up to 50 %.

4.2 Energy saving lighting solutions

Elevators must have appropriate car lighting. Energy consumption related to elevator lighting can be reduced mainly in two ways.

The first way to reduce energy consumption is to enable the elevator controls to turn off the lights, as already described in the previous chapter. Energy saving lighting solutions can also be used outside the actual elevator car, on landings in the immediate vicinity of the elevator. As the car stops at a specific floor, the corridor illumination control solution automatically illuminates the floor. This kind of additional energy saving solution does not directly reduce the elevator's energy consumption, but it reduces the overall energy consumption of the building.

The second way to reduce energy consumption is to choose efficient and long-lasting lighting solutions. If for example LED lights are chosen to replace the traditional halogen lights, they can reduce the energy consumption for lighting by up to 80%. LED lights also last much longer than normal halogen lights, so they reduce the amount of waste.

LED lights can reduce energy consumption by as much as 80% compared with halogen lights.

4.3 Energy-saving hoisting solutions

Hoisting solutions combining a certain type of motor and drive can yield impressive energy savings compared to old hydraulic technology. Revolutionary solutions consist for example of a permanent magnet synchronous hoisting machine, which is oil free and gearless. These solutions can be as much as 40% more energy efficient than traditional traction elevators and 60% more efficient than hydraulic solutions.

Item	Hydraulic	**Traction 2 speed**	Kone MonoSpace'
Speed (m/s)	0.63	**1.0**	**1.0**
Load (kg)	630	**630**	**630**
Motor output power (kW)	11	**5.5**	**3.7**
Main fuse size (A)	50	**35**	**16**
Typical energy consumption (kWh/y)	7000	**5000**	**1535**
Carbon footprint (kg CO_2/year)	2090	**1550**	**745**
Oil requirements (l)	200	**3.5**	**0**
Thermal losses (kW)'''	3.8	**3.0**	**0,8**
Elevator Machinery Weight (kg)	650	**430**	**230**
Typical machine-room area (m^2)	5	**12**	**0**

Figure 2. Comparison between different elevator solutions.

The basis for the calculation of KONE MonoSpace is 200,000 starts/year.
*) With energy saving options
**) 180 starts/h

4.3.1 Hydraulic versus traction elevators

Hydraulic elevators tend to be the least energy-efficient hoisting solution. In hydraulic elevators the energy is stored as potential energy when the car is lifted and dissipated as heat when the car is lowered.

The counterweight in traction elevators saves energy because the machinery does not need to pull the total combined weight of the elevator car, passengers and other loads.

4.3.2 Geared versus gearless machine

The motor drive system is either geared or gearless. Geared traction elevators use a reduction gear to control the elevator movement, with the drive sheave attached to the output of the gearbox. In gearless traction elevators the traction sheave is attached directly to the end of the motor.

In comparison with a conventional reduction gear mechanism, drive losses can be reduced by using gearless drives. Modernizing a geared hoisting machine with a gearless hoisting machine can result in significant improvement in the elevator's energy efficiency. Although the main intention is to reduce the size of the machine, the elimination of the gear improves the energy efficiency of the equipment. Furthermore, the gearless design vibrates less and provides a quieter ride for passengers.

4.3.3 Motor and drive type

The efficiency of the motor has a significant effect on the elevator energy efficiency. Motors that can be used for traction elevators are DC motors, AC asynchronous motors and AC synchronous motors. DC motors have good control characteristics and ride comfort but they are expensive and create motor operating noises. AC asynchronous motors do not have a really good power factor and the efficiency of the motor is below 70%. With the development of magnet materials, modern elevators are starting to have permanent magnet synchronous motors, which can yield impressive energy savings due to, for example, the high power factor.

Drive systems are technical solutions which provide energy to the hoisting motor and to regulate its speed. Most modern drive types are solid-state variable voltage, variable-frequency drives. These drive systems control the speed by regulating frequency and voltage. The variable frequency drive systems deliver a nearly sinusoidal waveform at any speed and virtually constant torque across the speed range.

4.4 Energy-conscious sizing of the modernization solution

It is important to take the building type and usage into consideration when defining and planning the appropriate modernization solution. The type and occupancy of the building, and the location and utilization patterns of the elevators are important considerations in the planning phase that affect the optimum elevator modernization. If, for example, the motor or car sizes are overestimated, the energy efficiency of the elevator will never be optimal.

4.5 Energy savings by regeneration

Regeneration means that the drive system recovers power back to the electrical network. Regenerative solutions can significantly improve the elevator's energy efficiency. They can recover up to 35% of the total energy used by the elevators.

In traction elevators, excess energy is generated because counterweights usually weigh about as much as an empty elevator car plus about half of its maximum load. Energy is needed when the full elevator is carrying people up and when an empty elevator descends because energy is used to lift the difference in the weight between the empty elevator and its counterweights. Potential energy is created when the full elevator descends and the empty one rises. This potential energy is dissipated as heat if it cannot be regenerated as electricity.

Regenerative systems recover this excess energy from the elevator and convert it for further use, for example in lighting the building. In one example solution the counterweight or the elevator car becomes the motor and the hoisting machine works as a generator drawing the energy back into drive. Regenerative drive recovers generated energy from the elevator and converts it electricity for use e.g. in lighting the building.

Amount of regenerated energy & energy saving is depending from efficiency of elevator system, so for example losses of gear in geared machine mentioned in chapter 4.3.2 are valid also for regeneration.

4.6 Indirect effects when increasing the energy-efficiency of elevators

The above-mentioned ways to increase elevator eco-efficiency refer to the direct eco-efficiency savings. In addition, elevator modernization increases the eco-efficiency of elevators in several indirect ways.

Elevator equipment dissipates generated energy as heat on braking resistor. The building has to have an air-conditioning system to regulate the air temperature.

When replacing the elevator equipment with a more energy-efficient solution that does not dissipate as much heat back into the building, the energy consumption of air conditioning can be reduced.

The requirement for oil usage is significantly lower in traction elevators than in hydraulic elevators. This means, first of all, that the need for oil is reduced but secondly that there is a smaller risk of oil leakage into the environment.

Thus the total impact of elevator modernization on eco-efficiency is more that just the direct impact of e.g. replacing the hoisting solution with a more energy-efficient solution.

Elevator modernization will also bring benefits in addition to energy efficiency. Depending on the scope of the modernization, it can also affect, for example, the accessibility, safety, aesthetics and performance of the elevator.

5. Summary

The old elevator base does not meet today's expectations for environmental eco-efficiency. This paper has discussed how elevator modernization decreases the environmental impact of elevators.

Modernization maximizes the performance of an old elevator and extends its lifetime. Either the whole elevator can be replaced or modular parts of it can be modernized.

The modernization solutions presented in the paper cover energy-saving hoisting solutions with a permanent magnet synchronous, oil free and gearless machinery, different lighting solutions including LED lights, regenerative drive system, and standby modes for elevator lightning and car fans.

As suggested in this paper, there are several ways to make elevators more energy-efficient. In addition to direct impacts, elevator modernization increases the eco-efficiency of elevators in several indirect ways.

KONE has set itself the goal to reduce energy consumption in its volume products by 50% by 2010 compared to the 2006 base.

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