Lift Systems in High-Rise Buildings: Handling Capacity and Energy Efficiency

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Abstract As more people have to live and work with limited available area, buildings are getting taller. Designers should provide sufficient handling capacity and acceptable quality of service should also consider energy. This paper compares the energy consumption of a system with two independent running cars in one shaft versus a double decker system in a local group.

1 INTRODUCTION

More and more people have to live and work with limited available area. Buildings are getting taller to concentrate these requirements in as little space as possible. These buildings have to be made accessible all the way to the top. Enough transport capacity for people and material flow have to be provided to enable optimal use of buildings. The waiting times and time to destination of the transport facilities should be as short as possible.

A good lift concept with sufficient handling capacity and acceptable quality of service should also consider energy. VDI 4707 [1] does not necessarily lead to the system or system combination, which provides the lowest energy consumption with the best quality of transportation service.

The use of the right lift system and controller types for the specific requirement is essential. In general a modern simulation program should be used. Traditional calculation or estimation methods using round trip time and interval calculations can lead to too many or too big lift cars; lift speeds often become too high. “Over-dimensioning” leads to high lift costs as the structural and electrical loads, together with the physical equipment dimensions have to be accommodated. This leads to increased costs and reduces the chance of an economical design for the building. Also energy costs of the building in use will increase.

2 PLANNING WITH DIRECT CONNECTION TO THE DESTINATION FLOOR

Most lift users prefer to reach their destination floor directly, without any transfer. With conventional lift systems, the planner will reach limits very quickly as building height increases.

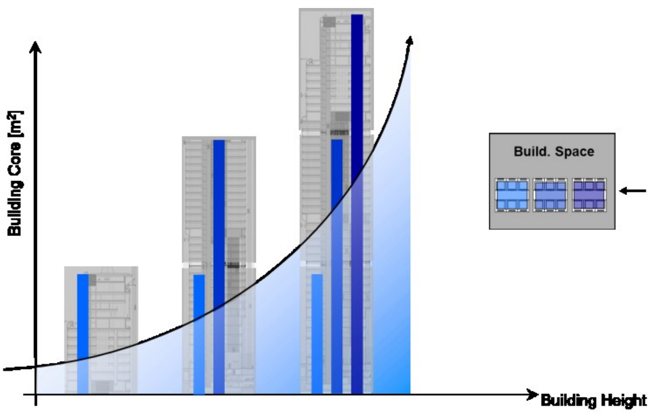

Figure 1: Building space requirements with low-mid- and high rise lift group (direct connection to destination floor)

As building height increases, the number of shafts required becomes too high (see Figure 1), the volume of the building core becomes too big and the available area for economical usage is dramatically reduced.

3 PLANNING WITH TRANSFER FLOORS

Planning with transfer floors [2] in the upper part of the building allows stacking of lift shafts in local areas. The shaft arrangement can be more economically as there are less shafts going through the whole building. The transfer floor (sky lobby) is served by shuttle lifts from the ground floor. These lifts can work at high speeds and provide a high handling capacity due to less or preferable no intermediate stops. With this arrangement fewer lifts will go down to the main lobby (Figure 2).

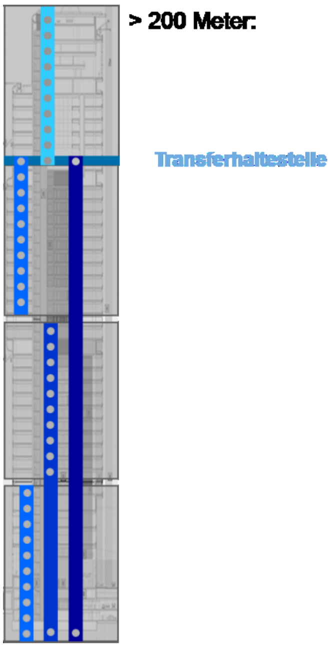

Figure 2: Lift arrangement with stacked shafts and shuttles

4 PLANNING WITH DOUBLE DECKER

Double Decker lifts can reduce the numbers of lift shafts needed [3]. A two-level-lobby is required to allow loading of upper and lower cars at the same time.

With Double Decker lifts the traffic flow in the entrance area has to be coordinated. Passengers who want to reach an even numbered floor must enter in the upper car via the upper lobby. Passengers who want to reach an odd numbered floor must enter to the lower car via the lower lobby.

By serving two floors at the same time during up peak traffic the number of stops during an average round trip is reduced. This results in less times losses.

Double Decker lifts in local groups should be used with destination control systems. The disadvantages of the Double Decker lifts are the big masses and big inertias. Car weights of more than 11000 kg (see Figure 3) and counterweight masses of 13500 kg can be reached easily (e.g. for capacity of two x 1600kg). Additionally there are big inertias associated with the machine, diverter pulleys and compensation ropes. Also the ropes themselves will have big masses when steel ropes are used. All these masses have to be accelerated and decelerated, even when only a few passengers are using the car. This causes high acceleration currents and high energy consumption.

The advantage of the Double Decker can be seen when even and odd floors are served at the same time. The available handling capacity is almost double compared to single deck lifts during peak traffic.

This disadvantage arises, when during peak-traffic and off-peak-traffic, calls from odd to even floors need to be served. Two connected cars have to be moved, even if only one of the cars can be used.

Passengers are also irritated when in-car-waiting-time occurs due to other deck loading / unloading.

Using conventional Double Decker lifts, architects have to plan the same floor to floor distances, which allows them less flexibility in their building. Flexible Double Decker lifts, which allow a limited adjustment for floor levels with different interfloor distances, require additional mechanical devices, which results in more masses to be moved.

Nevertheless we see the optimal usage of the Double Decker lift as a shuttle. Only the main lobby and sky-lobby have to be planned with the same floor to floor distance; all intermediate floors are not be served, so can be planned without fixed floor heights.

Using Double Decker as shuttles, the trips are always long distance. There are fewer stops which reduces the overall energy consumption.

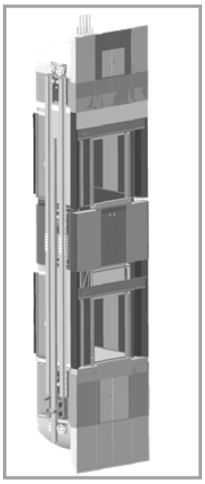

Figure 3: Double Decker Car with non-adjustable floor to floor distance
→ 9500kg – 12500kg (empty car weight, dependent on capacity)

5 PLANNING WITH TWO INDEPENDENT CARS RUNNING IN ONE SHAFT

With a system that runs two cars independently within one shaft [4], the number of lift shafts can also be reduced. Planning with a two-level-lobby gives the best performance, allowing the upper and lower cars to be loaded and unloaded at the same time.

The upper lobby is the entrance level to an upper zone within the lift group; the lower lobby is the entrance level to a lower zone within the lift group. Ideally zone are set so that upper and lower cars will have to serve the same number of people or floors, e.g. lower zone: floor 3 to 9; upper zone: floor 10 to 16.

During off-peak traffic the lifts can run without limitation, serving calls in both zones.

The flexibility of having two independent cars in a shaft is particularly evident during interfloor traffic. In buildings where tenants use multiple floors, more cars can be used for interfloor traffic compared to a Double Decker system. This is because the independent car system does not always require two cars to serve two adjacent levels at the same time.

The controller decides which destination call gets the highest or lowest priority to provide the best performance to the main traffic flow.

The inertias and masses of cars are the same as conventional lifts (single cars). To save energy, only the cars needed to provide the required quality of service are moved.

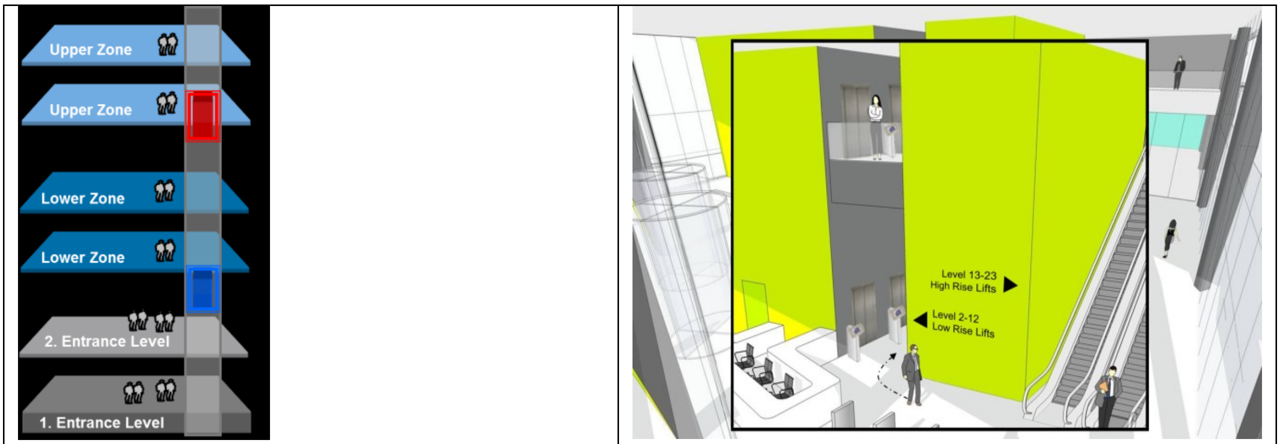

Figure 4: Two independent cars in one shaft with zoned arrangement

6 COMPARISON OF ELECTRICAL LOADS USING A SYSTEM WITH TWO INDEPENDENT RUNNING CARS IN ONE SHAFT VERSUS A DOUBLE DECKER SYSTEM IN A LOCAL GROUP

When comparing two lift groups with similar handling capacity and comparable quality of service, the electrical loads of Double Decker solution is nearly the double that of an installation with independent running cars. To demonstrate this, the results presented in Figure 5 were generated with the application an all-day office traffic template [5] in an industry standard simulation model [6] for a 100m project. The simulation software has been extended to include a sophisticated energy model [7]. The Double Decker solution requires much bigger electrical equipment, e.g. transformer, electrical cables, generators.

The energy consumption is approximately 20-30% higher for the Double Decker groups. Even if both lift systems can be provided with the same energy efficient class according to VDI 4707, the difference in energy consumption is huge. This is illustrated by the simulation results in Figure 6. Figure 7 helps understand the results by comparing the power consumption of a single trip for a double and single deck lift using a single trip model in Matlab [8]. The difference in energy consumption between the two systems is not highlighted by VDI 4707 as it does not consider the behavior of systems during daily usage. The Double Decker moves more cars during off-peak-traffic, which is most if the day. Therefore for best performance, and least wastage of resources, it is necessary to plan each system according the actual building usage.

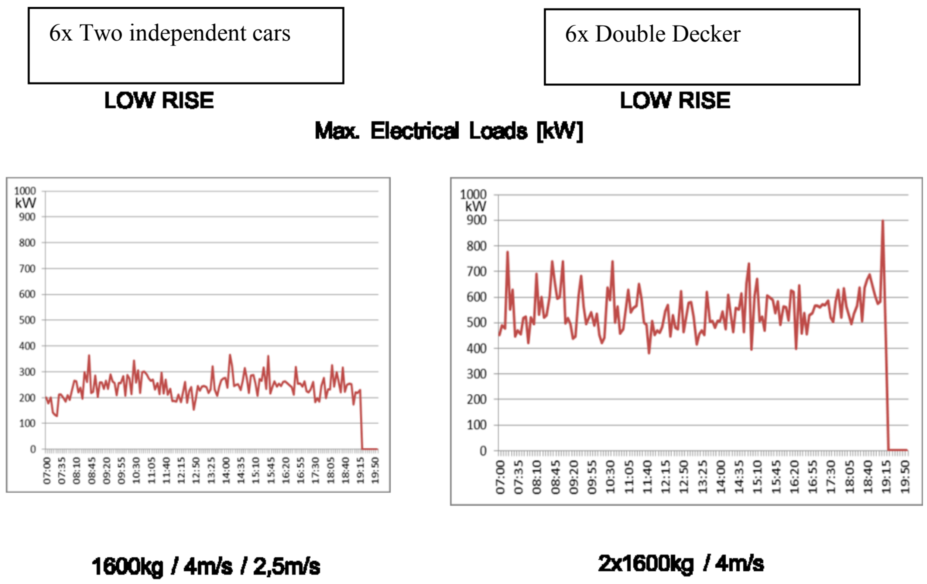

Figure 5: Electrical peak loads, 6 shafts with two independent cars vs. 6 Double Deckers

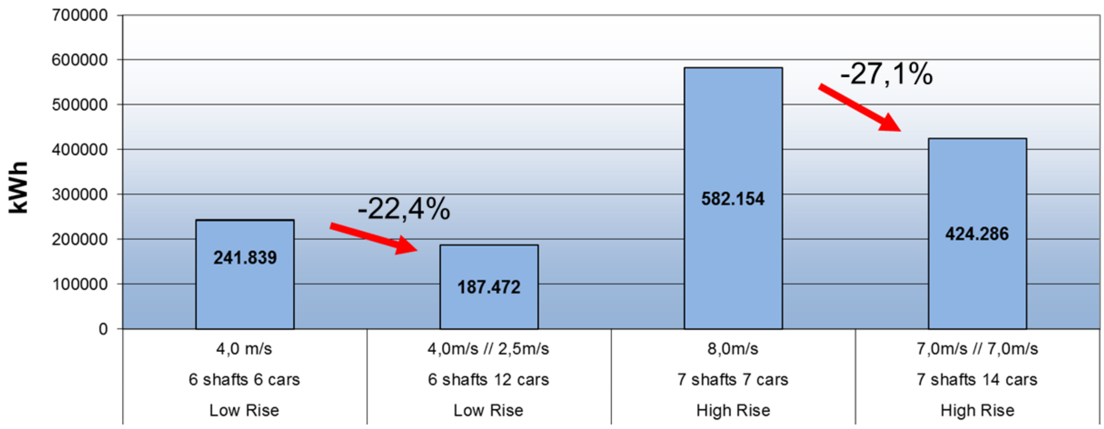

Figure 6: Comparisons of energy consumption system, two independent cars versus Double Decker lifts with same traffic demand and similar quality of service. Both systems have the same "Energy Efficiency Class" according to VDI 4707.

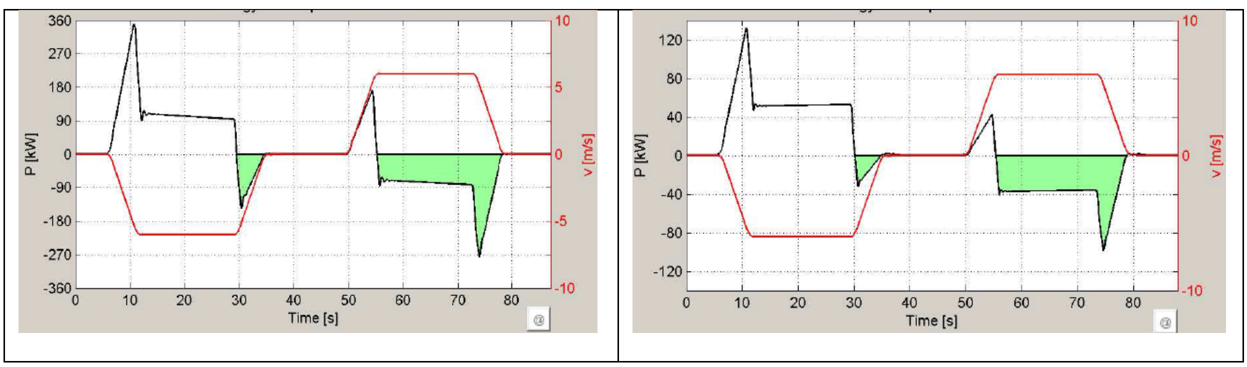

Figure 7: Double Decker power consumption (left diagram) / one independent car power consumption (right diagram) for VDI reference trip

7 CONCLUSIONS

The combination of Double Decker shuttle lifts and two independent cars running in shafts for local groups provides a space saving, and energy efficient solution for high rise buildings.

With this approach to planning, the building can obtain an economical shaft arrangement, offer the maximized usable area and still provide good handling capacity and quality of service.

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BIOGRAPHICAL DETAILS

Joerg Mueller studied Electrical Engineering and joined ThyssenKrupp Aufzugswerke in 1993. He worked in the testing division of R&D, managed the modernization department. |Since 2005 Joerg has been working as Senior Engineer and Head of Major Project Consulting for the factory in Germany. He supports Major Projects for New Installation and Modernization. He has developed together with his team new concepts for vertical transportation in high-rise buildings, considering space efficient planning, quality of service of lift systems and energy consumption; using modern simulation methods.