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People Flow Solutions to Enhance Building Performance
提升建筑性能之人流方案

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Johannes de Jong M.Sc. Eng. is presently Head of Technology for KONE Major Projects globally. Due to his exceptionally wide technical expertise he functions as one of the senior vertical transportation advisors globally. He has received several awards and mentions for his work. He is a member of the advisory group of the CTBUH and a member on several technical workgroups of the European Elevator Code committee. Johannes holds over 500 different patents and he has also been involved in many of the world's tallest buildings.

约翰尼斯·德·琼，工程理学硕士，现任通力集团全球重点项目技术总监。凭借极为广泛的技术专业知识，其成为了全球垂直运输高级顾问之一，并因出色的工作获得了若干奖项及提名表扬。高层建筑与城市住宅委员会（CTBUH）顾问成员之一，也是欧洲电梯规范委员会多个技术工作组成员之一。约翰尼斯持有500项不同专利，并参与过诸多世界最高建筑项目。

Abstract

Vertical transportation plays an important part in the logistics of high rise buildings. Correct vertical transportation planning can dramatically improve your revenue at any stage of your building's lifecycle. Early focus on vertical transportation can increase the net rentable income; extra revenue over the life of the building can be more than the investment. Selection of efficient technology can reduce energy consumption costs of vertical transportation by up to 50% and in modernization cases by up to 80%. In construction the main bottleneck is moving people and materials around the site efficiently. Again, well-planned vertical transportation can considerably improve labor efficiency, thus reducing construction coststime. KONE JumpLift technology has reduced construction time by up to 20% on projects such as Marina Bay Sands in Singapore, the Elite Tower in Dubai and the Shard in London.

Keywords: Vertical Transportation, Destination Control, Energy Efficiency, JumpLift

摘要

垂直运输在高层建筑日常物流方面起着至关重要的作用，合理的垂直运输规划可在建筑生命周期的任何阶段使收入大幅增加。对垂直运输的早期重视可增加租赁净收益，使建筑生命周期内的额外收入远远高于投资额。选择高能效技术可减少垂直运输的能源消耗成本达50%，对现代化的实例能减少达80%。人员及物料在现场附近的高效移动是施工过程中的主要瓶颈。因此，精心规划的垂直运输可大大提高劳动效率，从而减少施工成本和缩短周期。通力跃层电梯（Jumplift）技术已成功使新加坡滨海湾金沙酒店、迪拜精英塔及夏德伦敦塔等项目的施工周期缩短达20%。

关键词：垂直运输、目的层选控、双层轿厢、能源效率、跃层电梯

Introduction

Vertical Transportation costs are typically between 2-8% of the construction cost, this is low compared to the impact. Still buildings are often under dimensioned. Vertical transportation is crucial for the way the building will operate. A building with an under dimensioned people flow system will react similarly to a human body with an inadequate bloodstream. It simply does not feel right.

During construction a lot of people and materials need to be transported. Long queues lasting for hours at the beginning of a shift can be found on many high-rise sites. It seems to be acceptable that thousands of hours are wasted every day, waiting to get up or down. Often we see construction workers with materials walking on the stairs. Though stairs are considered healthy, they are notoriously dangerous for work safety, while productivity is also seriously reduced.

Energy costs of vertical transportation accounts for 2-10% of the building energy costs. What is planned in the early design phase will be realized in the occupation phase. If an inefficient system is selected

简介

垂直运输成本一般为建筑成本的2-8%，相对于其所带来的效果，此项成本较低。然而许多建筑往往尺寸过小，而垂直运输却是影响整个建筑运作方式的重要因素。因此客流系统尺寸过小的建筑如同供血不足的人体，不只是会感觉不适。

施工期间需要运输大量的人员及物资。在许多高层建筑施工现场，经常可以看到工人们排着长队等待几小时的情况，每天浪费数千小时等待上上下下似乎是司空见惯的事情。我们经常看到建筑工人们扛着物料走楼梯上下。虽然爬楼梯有益健康，可这种方式对于工作安全来说非常危险，而且大大降低了生产效率。

垂直运输的能源消耗成本占建筑能源消耗成本的2-10%。若在早期设计阶段进行此能源消耗规划，那么其将在使用阶段得以体现。若在设计或采购阶段选择了低效系统，那么整个使用阶段将面临一系列不良后果。

到2020年，要符合450 ppm轨迹要求（全球减排目标）（美国国际开发署彼得·都彭（1））并保持低于哥本哈根峰会提出的2度温度上升范围（见图1），效率措施将帮助减少三分之二的碳排放。因此，注重效率至关重要。考虑垂直运输方案时，设计效率、施工效率及运作效率显得非常重要。

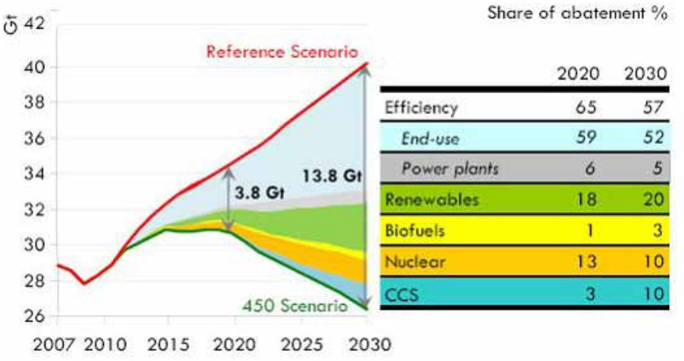

Figure 1. Share of abatement (Source Peter du Pont, USAid).
图1. 减排份额（来自美国国际开发署彼得·都彭）

Number of floors N, above MT	H and S values for rated capacity (80% capacity shown in parentheses)													
	6 (4,8)		8 (6,4)		10 (8,0)		13 (10,4)		16 (12,8)		21 (16,8)		26 (20,8)	
	H	S	H	S	H	S	H	S	H	S	H	S	H	S
5	4,6	3,3	4,7	3,8	4,8	4,2	4,9	4,5	4,9	4,7	5,0	4,9	5,0	5,0
6	5,4	3,5	5,6	4,1	5,7	4,6	5,8	5,1	5,9	5,4	6,0	5,7	6,0	5,9
7	6,2	3,7	6,5	4,4	6,6	5,0	6,8	5,6	6,8	6,0	6,9	6,5	7,0	6,7
8	7,1	3,8	7,4	4,6	7,5	5,3	7,7	6,0	7,8	6,6	7,9	7,2	7,9	7,5
9	7,9	3,9	8,2	4,8	8,4	5,5	8,6	6,4	8,7	7,0	8,8	7,8	8,9	8,2
10	8,7	4,0	9,1	4,9	9,3	5,7	9,5	6,7	9,7	7,4	9,8	8,3	9,9	8,9
11	9,6	4,0	10,0	5,0	10,2	5,9	10,5	6,9	10,6	7,8	10,8	8,8	10,8	9,5
12	10,4	4,1	10,8	5,1	11,1	6,0	11,4	7,1	11,5	8,1	11,7	9,2	11,8	10,0
13	11,2	4,1	11,7	5,2	12,0	6,1	12,3	7,3	12,5	8,3	12,7	9,6	12,8	10,5
14	12,1	4,2	12,6	5,3	12,9	6,3	13,2	7,5	13,4	8,6	13,6	10,0	13,7	11,0
15	12,9	4,2	13,4	5,4	13,8	6,4	14,1	7,7	14,3	8,8	14,6	10,3	14,7	11,4
16	13,7	4,3	14,3	5,4	14,7	6,5	15,0	7,8	15,3	9,0	15,5	10,6	15,7	11,8
17	14,5	4,3	15,3	5,5	15,6	6,5	16,0	8,0	16,2	9,2	16,5	10,9	16,6	12,2
18	15,4	4,3	16,0	5,5	16,6	6,6	16,9	8,1	17,1	9,3	17,4	11,1	17,6	12,5
19	16,2	4,3	16,9	5,6	17,4	6,7	17,8	8,2	18,1	9,5	18,4	11,3	18,5	12,0
20	17,0	4,4	17,8	5,6	18,2	6,7	18,7	8,3	19,0	9,6	19,3	11,6	19,5	13,1
21	17,9	4,4	18,6	5,6	19,1	6,8	19,6	8,4	19,9	9,8	20,3	11,7	20,5	13,4
22	18,7	4,4	19,5	5,7	20,0	6,8	20,5	8,4	20,9	9,9	21,2	11,9	21,4	13,6
23	19,5	4,4	20,4	5,7	20,9	6,9	21,4	8,5	21,8	10,0	22,1	12,1	22,4	13,9
24	20,3	4,4	21,2	5,7	21,8	6,9	22,4	8,6	22,7	10,1	23,1	12,3	23,3	14,1

Figure 2. The number of probable stops and the reversal floor as a function of the car size and the number of floors above grade
图2. 可能预停站数及返回楼层数（通过轿厢尺寸与底楼以上楼层数的函数值得出）

in the design or procurement phase, one has to live with the consequences over the entire occupation phase.

Efficiency measures account for two-thirds of abatement in 2020 needed to meet the 450 ppm trajectory (Peter du Pont of USAid (1)), to stay below the 2 degree temperature rise, set by the summit in Copenhagen (see figure 1). Focus on efficiency is therefore essential. Efficiency in design, efficiency in construction and efficiency in operation are important when considering your Vertical Transportation solutions.

People Flow Efficiency In Design

Core design

The commonly used ways to reduce core space are: Zoning (reducing stops), Double Deck Elevators (stacking of elevator cars) and Sky lobby arrangements (stacking of buildings).

These different methods will be explained in detail.

- **Zoning**

  The Up-Peak method is traditionally used to analyze an elevator group. In the Up-peak an elevator will make a certain number of probable stops on the way up, reverse at the highest reversal floor and then return empty to the lobby. The number of probable stops made by an elevator in an up-peak was formulated by Basset Jones (2) in 1923.

$$S = N\left[1-\left[1-\frac{1}{N}\right]^{P}\right]$$ Formula 1 Probable stops

  Where: S = Number of Probable stops, N = Number of floors above the main terminal, P = Number of passengers inside the car. Joris Schröder (3) 1955, described a formula for the highest reversal floor in an up peak.

$$H = N - \sum_{i=1}^{N-1}\left(\frac{i}{N}\right)^{P}$$ Formula 2 Highest reversal floor

  Where: H = Highest reversal floor, N and Pare the same as for formula 1.
  Formula 1 and formula 2 are both valid for floors with equal population. Sorsa, Hakonen and Siikonen (4) enhanced the above formulae for more complex situations. Formula 1 and 2 serve the purpose of this document.
  Figure 2 shows a table with the number of probable stops and the highest reversal floor for different configurations.
  This table is very useful to understand what will happen when elevators are zoned.
  Figure 3a shows a six car group with 16 stops above grade.

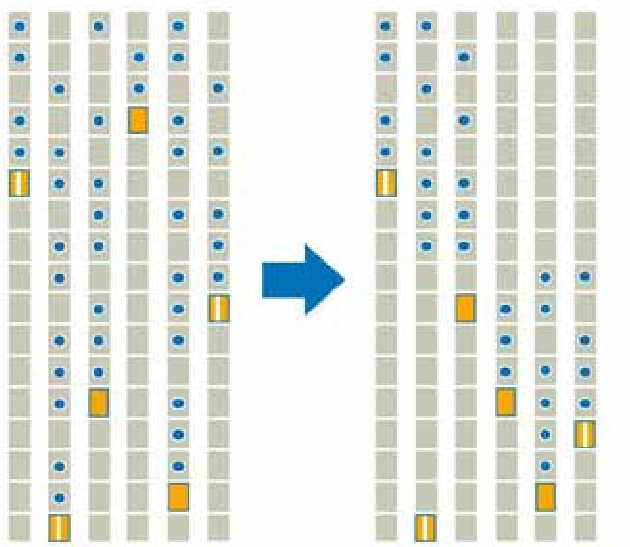

Figure 3. (a) single zone, (b) zoned arrangement
图3. (a)单区设置，(b)分区设置

客流效率设计

设计核心

缩小核心空间的常用方法有：分区制（减少预停站），双层电梯（轿厢叠加法）和空中大堂设计（建筑叠加法）。

关于以上方法的详细说明见下文。

- **分区法**

  上行高峰法常用于分析电梯群。在上行高峰模式下，电梯上升过程中会有若干预停站，到达最高返回楼层后空载返回大堂。上行高峰模式下电梯预停站数可通过1923年巴赛特约翰（2）公式计算。

$$S = N\left[1-\left[1-\frac{1}{N}\right]^{P}\right]$$ 公式1预停站数

  注：S = 预停站数，N =主终端以上楼层数和P =轿厢内乘客数量，1955年乔里斯·施罗德（3）中描述上行高峰模式下最高返回楼层公式。

$$H = N - \sum_{i=1}^{N-1}\left(\frac{i}{N}\right)^{P}$$ 公式2最高返回楼层

  注：H =最高返回楼层，N和P所指代内容同公式1。
  公式1及公式2适用于人数相同的楼层。索萨、哈克农、斯科南（4）加强了以上公式在更复杂情况中的应用。公式1

Number of floors N, above MT	H and S values for rated capacity (80% capacity shown in parentheses)													
	6 (4,8)		8 (6,4)		10 (8,0)		13 (10,4)		16 (12,8)		21 (16,8)		26 (20,8)	
	H	S	H	S	H	S	H	S	H	S	H	S	H	S
5	4,6	3,3	4,7	3,8	4,8	4,2	4,9	4,5	4,9	4,7	5,0	4,9	5,0	5,0
6	5,4	3,5	5,6	4,1	5,7	4,6	5,8	5,1	5,9	5,4	6,0	5,7	6,0	5,9
7	6,2	3,7	6,5	4,4	6,6	5,0	6,8	5,6	6,8	6,0	6,9	6,5	7,0	6,7
8	7,1	3,8	7,4	4,6	7,5	5,3	7,7	6,0	7,8	6,6	7,9	7,2	7,9	7,5
9	7,9	3,9	8,2	4,8	8,4	5,5	8,6	6,4	8,7	7,0	8,8	7,8	8,9	8,2
10	8,7	4,0	9,1	4,9	9,3	5,7	9,5	6,7	9,7	7,4	9,8	8,3	9,9	8,9
11	9,6	4,0	10,0	5,0	10,2	5,9	10,5	6,9	10,6	7,8	10,8	8,8	10,8	9,5
12	10,4	4,1	10,8	5,1	11,1	6,0	11,4	7,1	11,5	8,1	11,7	9,2	11,8	10,0
13	11,2	4,1	11,7	5,2	12,0	6,1	12,3	7,3	12,5	8,3	12,7	9,6	12,8	10,5
14	12,1	4,2	12,6	5,3	12,9	6,3	13,2	7,5	13,4	8,6	13,6	10,0	13,7	11,0
15	12,9	4,2	13,4	5,4	13,8	6,4	14,1	7,7	14,3	8,8	14,6	10,3	14,7	11,4
16	13,7	4,3	14,3	5,4	14,7	6,5	15,0	7,8	15,3	9,0	15,5	10,6	15,7	11,8
17	14,5	4,3	15,3	5,5	15,6	6,5	16,0	8,0	16,2	9,2	16,5	10,9	16,6	12,2
18	15,4	4,3	16,0	5,5	16,6	6,6	16,9	8,1	17,1	9,3	17,4	11,1	17,6	12,5
19	16,2	4,3	16,9	5,6	17,4	6,7	17,8	8,2	18,1	9,5	18,4	11,3	18,5	12,8
20	17,0	4,4	17,8	5,6	18,2	6,7	18,7	8,3	19,0	9,6	19,3	11,6	19,5	13,1
21	17,9	4,4	18,6	5,6	19,1	6,8	19,6	8,4	19,9	9,8	20,3	11,7	20,5	13,4
22	18,7	4,4	19,5	5,7	20,0	6,8	20,5	8,4	20,9	9,9	21,2	11,9	21,4	13,6
23	19,5	4,4	20,4	5,7	20,9	6,9	21,4	8,5	21,8	10,0	22,1	12,1	22,4	13,9
24	20,3	4,4	21,2	5,7	21,8	6,9	22,4	8,6	22,7	10,1	23,1	12,3	23,3	14,1

Figure 4. The number of probable stops for a single zone versus a zoned arrangement.
图4. 单区设置与分区设置的可能预停站数之对比

Passengers entering the car at the lobby press the buttons on the Car Operation Panel (COP) inside the car. If the car is big, and there are a lot of floors above grade, a large number of buttons will be pushed.
All an elevator can do is to serve passengers in sequence of floors reached, resulting in a large number of stops and a long time for the elevator to return to the lobby. With an elevator speed of 3.5 m/s each stop will take about 8 to 10 seconds.
Figure 3b shows the same situation, but now 3 elevators serve the higher floors, while 3 elevators serve the lower floors. This zoned arrangement automatically reduces the number of floors served, and the number of stops.
From Figure 4 we can see that the number of stops on the way up reduces from 10.6 for the single zone to 7.2 for the zoned arrangement.
This reduction of 3.4 stops enables the elevator to return to the lobby approximately 30 seconds faster. This faster pace increases the handling capacity and fewer elevators are needed. Zoning typically reduces the number of elevators by 20-25%.

- **Double Deck Elevators**
  When the core needs to be squeezed further, the use of Double Deck elevators is the next solution (see figure 5).
  This stacked car arrangement allows twice the population in the same cross sectional area, while loading is faster than loading one big car.
  Double deck elevators require equal floor heights and dual lobbies. The upper lobby is usually a mezzanine level and escalators are needed to connect the lobbies. The lobbies are usually divided into one serving odd floors and the other serving even floors. Signage showing the odd/even division needs to be clear and visible.
  The disabled need to be considered carefully as the use of escalators might be restrictive. To serve the disabled, the use of platform elevators or conventional elevators might be needed between the lobby levels. If disabled passengers can enter from the lower lobby level, an extra high overhead may be needed to allow the lower car to serve the highest floor. Alternatively the disabled will need to transfer to an upper car, somewhere during the journey. This is not very user friendly.
  Interfloor traffic is allowed after departure from the lobby. One can freely travel between odd and even floors outside the lobby area, just as with conventional elevator arrangements. This will

及公式2适用于本文件。
图2为不同配置中的可能预停站数及最高返回楼层数。
此图非常有助于了解电梯分区后发生的情况。
图3a为6个轿厢群，共有16个预停站。乘客从大堂进入轿厢并按下轿厢操纵板（COP）上的按钮，若轿厢较大，且底楼以上楼层较多，那么按下的按钮将越多。
电梯会按照目的楼层顺序一一将乘客送达目的楼层，因此会有很多预停站，且电梯返回大堂的时间也会较长。若电梯速度为3.5m／s，那么到达每个预停站所需时间大约为8-10秒。
图3b同上。但不同的是其中3部电梯服务较高楼层，另外三部服务较低楼层。这种分区设置方式自动减少了电梯所需到达楼层数及预停站数。
从图4可看出电梯上升过程中的预停站数从单区设置的10.6个减少到了分区设置后的7.2个。
预停站数减少3.4个后，电梯返回大堂的时间会加快约30秒，这样就提高了运输能力，所需电梯数量也会减少。因此分区法可减少20-25%的电梯数量。

- **双层电梯**
  若核心空间需要进一步缩小时，下一种方案是采用双层电梯（见图5）。
  这种轿厢叠加法使相同横截面面积的可载人数可翻一倍，而且运行速度相对较大轿厢更快。
  双层电梯要求楼层高度相同及双层大堂结构。上层大堂通常为夹层，并通过自动扶梯与下层大堂相连。双层大堂通常分为一个服务奇数楼层，另一个服务偶数楼层。标牌上的奇偶分布需清晰可见。
  残疾人使用自动扶梯具有限制性 ，因此需要慎重考虑。为方便残疾人使用，两层大堂间可能需安装升降平台或常规电梯。若残疾人乘客可从下层大堂进入轿厢，那么要使下层轿厢可到达最高楼层可能需要额外的高额费用。否则，残疾人乘客需要在行程中途某个位置转移到上层轿厢，这对于用户来说很不友好。
  离开大堂后，电梯可到达任意楼层，乘客可像常规电梯操作一样在大堂以外的区域进行奇偶楼层间的自由转换。因此，预停站数会增多，特别是在午餐时间，这就是为何双层电梯所使用井道数仅可比单层电梯井道数减少三分之二的原因。

Figure 5. Double Deck Elevators
图5. 双层电梯

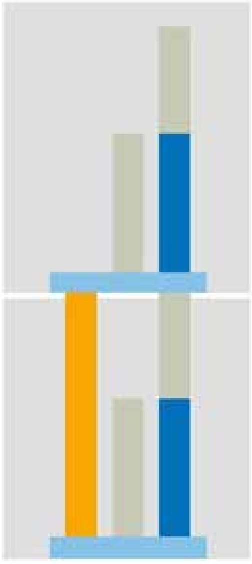

Figure 6. Sky lobby arrangements
图6. 空中大堂设置方法

add additional stops, especially during lunch traffic, and that is why the number of shafts can only be reduced by two-thirds compared to a single deck arrangement.
There are 3 types of double deck arrangements:
– Double Deck Shuttles
These Express Double Deck elevators connect ground to a Sky Lobby (see **Sky lobby arrangements**).
– Local Double Deck elevators
Double Deck elevators serving all floors in the zone.
– Mixed Use Double Deck elevators
Double Deck elevators with one passenger car, and one freight car. In normal conditions the freight car remains inoperative; the freight car is separately enabled when required for service, in that case the passenger car is inoperative. This saves a shaft for the freight car.

- **Sky lobby arrangements**
The elevator core tends to get too big when more than 4 zones are needed. To reduce the core one can split the building into multiple buildings stacked on top of each other (see figure 6). In Multi Use buildings different usages (office, hotel, residential) are also stacked. The different "smaller" buildings now have their own local elevators, while the building population is brought to the sky lobby with shuttle elevators. Local elevators of different buildings can now be stacked above each other, reducing the need for large amounts of cores all the way from ground.

Other mechanical ways to improve space efficiency

- **Machine Room Less elevators (MRL)**
In 1996 KONE introduced the MRL (see figure 7). With this concept traction elevators no longer need the hump on the building. In situations with height restrictions this allowed an additional floor within the restrictions. These elevators improved construction efficiency dramatically and we also saw reductions in energy consumption of about 50% compared to conventional geared elevators. Compared to hydraulic we saw energy consumption reductions of up to 75%.

- **Counterweight Less elevators**
The Counterweight less elevator (see figure 8) was introduced by KONE in Europe in 2006. Europe has a large number of very small elevators with swing type landing doors and no car

双层电梯共有3种设置方法：
－双层穿梭电梯
快速双层电梯由底层直通空中大堂（见**空中大堂设置方法**）。
－本区域双层电梯
可到达本区域所有楼层的双层电梯。
－混合双层电梯
此双层电梯其中一层为载客轿厢，另一层为载货轿厢．通常情况下载货轿厢为禁用状态。若有载货需求时，可单独启动载货轿厢，这时载客轿厢会被禁用。通过这种方式载货轿厢可节省一个井道。

- **空中大堂设置方法**
若需要4个以上分区，则电梯核心空间需求往往过大。为了减小核心空间，可将建筑分割为叠加在彼此顶部的若干建筑（见图6）。在多功能建筑中，不同功能区（办公、酒店、住宅）也采用叠加法。当穿梭电梯载客到达空中大堂时，每个“小”建筑都有本区域电梯．且为了减小电梯在底层所需核心空间，不同建筑的本区电梯可叠加在彼此顶部。

Figure 7. MRL elevator
图7. 无机房电梯

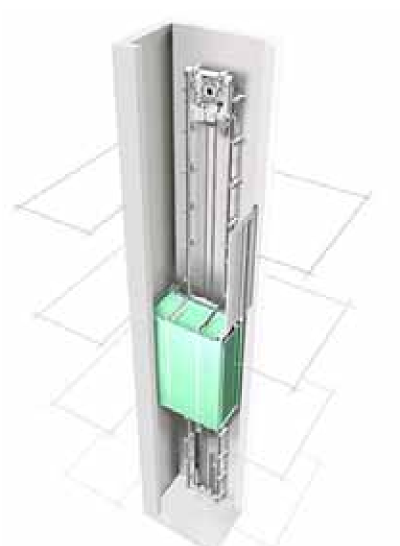

Figure 8. Counterweight Less elevator
图8. 无对重电梯

doors. These elevators are practically inaccessible for people in wheelchairs. By omitting the counterweight, the car size was able to be increased, while improving safety by adding automatic car and landing doors. This enabled people in wheelchairs to have access to the elevators without external help. The Counterweight less elevator became an instant refurbishment success.

Intelligent ways to improve elevator efficiency

Since the micro-processor was first introduced in elevators in the late 1970's, elevator algorithms have become very complex improving efficiency.

- **Traditional intelligent ways to improve elevator efficiency**
  Modern elevator use complex mathematical algorithms, such as Artificial Intelligence, Fuzzy Logics, Genetic algorithms and Neural networks. These complex algorithms especially improved passenger waiting times. They work fantastically in complex mixed traffic conditions where intelligent decisions can be applied.
  The up-peak however remained a problem as the control system could hardly use any intelligence. All it could do was to drop off passengers in the same sequence as the buttons pushed on the COP. The only intelligent thing a controller could do in an up peak was to keep elevators equally spaced over the building so they would not bunch. Though improvements in average daily waiting times were visible with each new algorithm, the improvements were gradually reaching saturation, very similar to the speed of modern day aircraft. The elevator industry needed a new technology.

- **Destination Control Systems (DCS)**
  The new technology desperately needed came with Destination Control (DCS).
  Instead of entering the call on the COP inside the car; the user now entered his destination on the landing on a Destination Operation Panel (DOP). The user was informed which car to use on the DOP display.
  Earlier the control only knew the direction in which the user was planning to move, and some statistical predictions of possible destinations the passenger might want to go to. The exact destination was first known when passengers where inside the car.
  With DCS the elevator knows the source floor and the destination floor of the passenger before arriving. This enables the system to put passengers with the same destination into the same car. This considerably reduces the number of stops an elevator will make (see figure 9).
  For the case with 6 elevators and 16 floors, the number of floors served above grade with DCS becomes approximately the number of floors divided by number of elevators = 16/6 = 2.67. Though figure 4 does not go lower than 5 one can interpolate that the number of probable stops will be approximately 2.5, compared to 10.6 with traditional control. The elevators return to the lobby about 70 seconds faster with Destination Control. Figure 10 shows a diagram published by Sosa, Hakonen and Siikonen (4). This diagram shows that DCS with six cars and 16 floors has about 1.85 times the up-peak handling capacity of a similar group using conventional control. Improvements during other traffic conditions such as lunch are not as dramatic as in the up-peak. Typically one can expect 20-25% fewer elevators with DCS compared to conventional control. It is advisable to always ask for a lunch time simulation when DCS is applied.

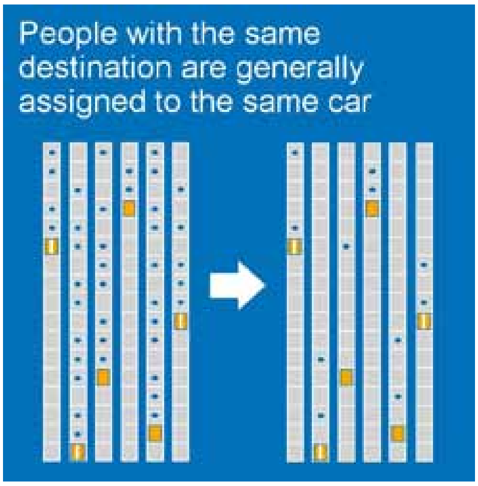

Figure 9. Reducing stops with DCS
图9. 通过目的层选控系统（DCS）减少预停站数

提高空间效率的其它机械方法

- **无机房电梯（MRL）**
  1996年，通力推出了无机房电梯（见图7）。在此概念中，曳引式电梯不再需要占用建筑中除井道以外的空间。遇到高度限制情况时，采用此电梯还可在限制范围内增加一层．这种电梯大大提高了施工效率，而且相比常规齿轮驱动电梯，其能源消耗减少约50%，相比液压驱动电梯，其能源消耗减少达75%。

- **无对重电梯**
  2006年，通力在欧洲推出了无对重电梯（见图8）。此前，欧洲很多超小型电梯采用旋转式层门且无轿厢门，残疾人根本无法使用．通过省略对重，通力能够增大轿厢尺寸，并且通过增加自动轿厢门及层门提高了安全性。这样，残疾人在不需要外界帮助的情况下也可使用这类电梯。无对重电梯即刻获得了成功。

提高电梯效率的智能方法

自20世纪70年代末首次推出微处理器以来，为提高效率，电梯电子计算法则已变得非常复杂。

- **提高电梯效率的传统智能方法**
  现代电梯采用复杂的数学算法，如人工智能法、模糊逻辑法、基因演算法及神经网络法。这些复杂算法改进了乘客等待时间。在可采用智能决策的复杂混合交通状况下，这些方法的效果非常好。
  然而，在上行高峰模式下仍然是一个问题，因为控制系统几乎无法使用智能方法。其只能按照轿厢操纵板（COP）上已按下按钮的顺序将乘客送达目的楼层。在上行高峰模式下，控制器唯一能执行的智能操作就是保持各个电梯的间距相等以避免聚集。虽然随着新算法的推出，日平均等待时间已经得到显著改善，但这种改善已日趋达到极限，正如现代飞机速度一样，电梯工业亟待开发新技术。

- **目的层选控系统（DCS）**
  急需开发的新技术为目的层选控系统（DCS）。
  乘客无需进入轿厢在轿厢操纵板（COP）输入命令，而只需在层站的目的层操纵板（DOP）输入目的层即可。目的层操纵板（DOP）显示器将告知乘客乘坐哪台电梯。
  早期，控制器仅知道乘客可能移动的方向及可能希望到达目的层的统计预测，只有当乘客进入轿厢后方可知道具体目的层。
  推出目的层选控系统（DCS）后，电梯可在乘客到达之前获知其起始层及目的层，便可将同一目的层的乘客分配到同一个轿厢，从而大大减少电梯预停站数（见图9）。

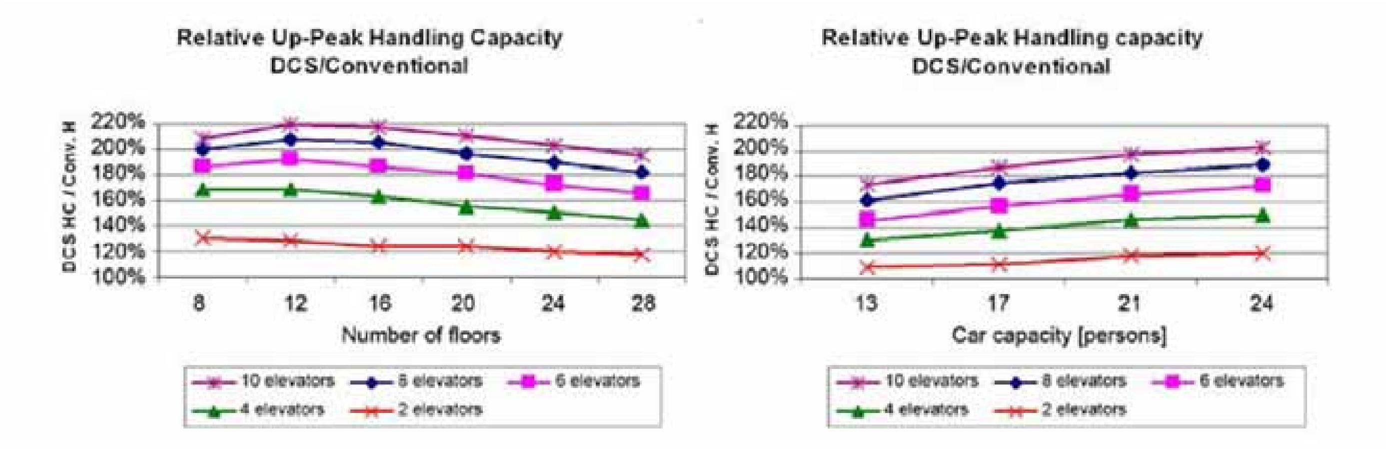

Figure 10. Relative effects of elevator group parameters on DCS boosting
图10. 电梯群参数对目的层选控系统改进的相关影响

The lunch time handling capacity should be at least 12% of the zone population in 5 minutes, to ensure that lunch will work properly in office buildings.

- **Hybrid Destination Control**
  The use of DOP's is very efficient when the majority of the traffic is departing from a heavily used floor. All parameters are known, and stops can be efficiently reduced. When traffic is moving towards a heavily used floor (e.g., a restaurant floor), traffic from intermediate floors arrives randomly. What first looked like a good assignment might not be the optimum assignment anymore when another random call is entered from another intermediate floor. Traffic towards a heavily used floor is quite unpredictable. One needs a lot of intelligence and very good forecasters to improve prediction.
  As traffic towards a heavily used floor is difficult to predict, a re-allocation system would actually give a better result. Re-allocation is only possible through the use of conventional pushbuttons. This is why KONE introduced Hybrid DCS, with DOP's on heavily used floors and normal pushbuttons on floors with less traffic. This arrangement is also more economical and more energy efficient as fewer DOP's are needed. Hybrid DCS combines the best parts of Traditional DCS and Conventional Pushbutton Control.

- **Future DCS**
  The main setback with DCS is the fact that communication with the user is lost when the users walks away from the DOP. In future destination systems the user will stay in contact with the system. Mobile phones are excellent tools to make this happen. Where Traditional DCS could not re-allocate the user, future DCS will be able to re-allocate as communication is maintained. The user could also communicate a change of mind, even when already inside the car. As two-way communication is maintained, future DCS could also handle guidance and security throughout the journey. The possibilities are limitless.

People Flow Efficiency In Construction, Kone Jumplift

Vertical transportation is often a bottleneck during construction. The higher the building, the bigger this problem becomes. The traditional rack and pinion hoist is slow, and due to the costs often too few units are applied. Most construction companies do not use consultants to plan their people flow and it is not strange to see large queues when

如“双层电梯”一节中所述的6部电梯及16个楼层的情形，利用目的层选控系统（DCS），则底楼以上需到达楼层数约为楼层数与电梯数之商，即16 / 6=2.67。
虽然图4中的可能预停站数并不低于5个，但通过插入法其可能预停站数将约为2.5个，而传统控制模式下可能预停站数为10.6个。在目的层控制模式下，电梯返回大堂的速度也加快了70秒。
图10为索萨、哈克农、斯科南（4）发布的图表．该图表显示在6部轿厢及16个楼层中使用目的层选控系统后，相比常规控制系统下的同一电梯群，上行高峰运输能力高出约1.85倍，其他运输状况如午餐时间的改进并不像上行高峰时期那么大幅度．相比常规控制系统，采用目的层选控系统，电梯数可减少20—25%．建议应用目的层选控系统时，不断进行午餐时间模拟试验，午餐时间的运输能力至少应为5分钟内运载本区人数的12%，以确保办公人员正常的午餐时间。

- **混合目的层选控**
  在大部分客流从大量使用的楼层出发的情况下，目的层控制的使用非常有效。由于所有参数已知，因此可有效减少预停站数。当客流涌向大量使用的楼层（如饭店所在楼层）时，来自中间楼层的客流会随机抵达。当来自其他中间楼层的命令随机发出时，一开始看起来很好的分配可能并非最佳分配。因此大量使用楼层的客流量很难估计，要提高预测能力，则需要大量智能计算及准确预测系统。
  由于大量使用楼层的客流量难以预测，再分配系统可提供更好的预测结果，但再分配仅可通过使用常规按钮进行。这就是通力推出混合目的层选控系统的原因，在大量使用楼层安装目的层控制板，而在客流较少的楼层使用常规按钮，这样安排更经济，而且目的层控制板的减少可提高能源效率。混合目的层选控系统集传统目的层选控系统与常规按钮控制系统的优点为一体。

- **未来目的层选控系统**
  目的层选控系统的主要弊端在于，一旦乘客离开目标控制板，其将失去与乘客的通信．但在未来的目的层选控系统中，乘客将与该系统保持联系，而移动电话正是实现这一目标的卓越工具．传统目的层选控系统无法对乘客进行再分配，而未来的目的层选控系统由于能与乘客保持通信，因此可对其进行再分配，乘客甚至在进入轿厢后仍可改变主意并与系统通信。由于保持双向通信，未来的目的层选控系统可在整个旅程中进行引导并确保安全性。可能性是无限的。

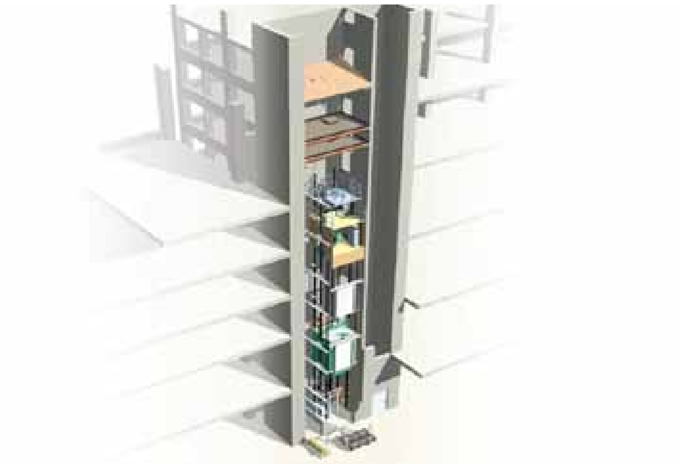

Figure 11. KONE JumpLift
图11. 通力跃层电梯

Figure 12. KONE Eco-Efficient solutions
图12. 通力高效节能方案

filling or emptying the building. Up to 30% of the labor time is often wasted waiting.

KONE with its third party certified JumpLift system can improve people flow efficiency dramatically. The JumpLift (see figure 11) is a self climbing safe conventional elevator system growing with the building.

The machine room is jumped as required, remaining close to the formwork. The KONE JumpLift can carry loads up to 4000 kg with speed up to 4 m/s, and it thus clearly outperforms any rack and pinion system. A study by the University of Hong Kong showed that construction efficiency increased by approximately 20% compared to traditional hoists, reducing construction time by several months. Rack and pinion hoists can also be removed much earlier, allowing closing of the façade at an earlier stage, and earlier fit out.

As the JumpLift operates in an enclosed hoistway, it also provides all weather operation.

On a 300 meter tower with 1,500 workers, working in two shifts, one can easily expect more than 400,000 hours saved over a 2 year construction and fit out period with JumpLift.

JumpLift was successfully used on sites like the Shard in London (First JumpLifts in the UK and the highest in Europe), Marina Bay Sands in Singapore (with 13 JumpLifts the biggest JumpLift site in the world) and the 400 meter Elite Tower in Dubai (the highest, fastest and largest JumpLift ever used in the world).

People Flow Efficiency In Operation

Eco-efficient people flow solutions

KONE has a wide range of Eco-efficient people flow solutions covering elevators, escalators and automatic buildings doors (see figure 12).

KONE elevators use highly efficient permanent magnet motors and regenerative drives, powering other building equipment with energy recovered during braking. KONE was the first to introduce energy regeneration with VVVF drives in 1991. Our elevator offering also includes low energy standby options and efficient LED lighting.

The German VDI 4707 code rates elevator energy efficiency in a similar A to G scale as used for home appliances. KONE was the first elevator company to reach A classification for all its elevator platforms. In 2006 KONE promised to reduce the energy consumption of its already efficient elevator systems by 50% in 2010. This was reached. KONE then promised to further reduce the energy consumption by 30% from the

施工过程中的客流效率与通力跃层电梯（JumpLift）

在施工过程中，垂直运输往往是一个瓶颈问题。建筑物越高，这个问题就越大．传统的齿轮齿条曳引速度缓慢，且由于成本较高，因此往往应用非常少。大部分建筑公司不会聘请咨询顾问规划客流，排长队装运或清空施工场地的现象也不足为其，由于等待而浪费的劳动时间达30%。

通力利用其经第三方认证的跃层电梯系统可大大提高客流效率．通力跃层电梯（见图11）是一种自升式安全常规电梯系统，可随建筑物升高而增强。

机房可根据需要跃层，以保证贴近施工需要．通力跃层电梯可以4m／s的速度载重达4000kg，因此，明显优异于任何齿轮齿条曳引系统。香港大学的一项研究表明，相比传统曳引系统，跃层电梯可提高施工效率约20%，缩短施工周期数个月。此外，齿轮齿条曳引系统还可以更早拆除，以便能够更早完成建筑物正面施工，更早进行装备。

由于通力跃层电梯在一个完全封闭的井道中运行，其可在任何天气条件下运行。

若1500名工人在300m高的塔架上按两班倒施工，在为期2年的施工及装备期间内，使用通力跃层电梯可轻松节省时间达400,000小时以上。

通力跃层电梯的成功应用案例有伦敦夏德塔（英国首部跃层电梯跃层电梯，欧洲到达楼层最高的跃层电梯）、新加坡滨海湾金沙酒店（世界最大的跃层电梯应用场所，共采用13部跃层电梯）及400m高的迪拜精英塔（世界到达楼层最高、最快且最大的跃层电梯）。

运行过程中的客流效率

高效节能客流方案

通力有一系列高效节能客流方案，涉及电梯、自动扶梯及自动建筑门（见图12）。

通力电梯使用高效永磁驱动及再生驱动，制动期间回收的能源可为其他建筑设备供电。1991年，通力率先推出了变压变频驱动能源再生技术。通力电梯同时提供低能耗待机功能及高效LED照明。

根据《德国VDI 4707规则》，电梯能源效率采用与家用电器类似的A-G等级进行评定。通力为首家所有电梯平台均达到A级标准的电梯公司。2006年，通力承诺在2010年将使其现有的高效节能电梯系统之能源消耗降低50%，其最终实现了这一目标。当时，通

2010 level for its standard elevators in 2012. The result achieved to date is no less than 35%.

For escalators KONE can provide the following Eco-efficient options: A Lubrication free step chain, regeneration of braking energy for escalators moving downwards, and Eco-efficient operation. Eco-efficient operation includes reduced speed and or total standstill when not in use. The eco-efficient operation options can reduce energy consumptions by up to 60%. The efficiency of the escalator can be further improved with a helical geared direct outer step band drive, which will also increase possible regeneration to maximum of 60-70% of the input power. LED lighting is of course also available.

KONE EcoMod enables modernization of escalators while keeping the existing truss, minimizing damage to the environment and improving the efficiency at the same time.

KONE also provides Eco-efficient solutions for automatic doors. When temperature differences are big between the inside and the outside, doors are not fully opened if passengers arrive sporadically. They are only opened fully when flows are larger. This saves large amounts of energy.

力承诺到2012年，其将在2010年现有水平的基础上进一步减少标准电梯30%的能源消耗。迄今为止，其所实现的节能成果不低于35%。

就自动扶梯而言，通力可提供以下高效节能选项：免润滑梯级链、自动扶梯向下移动时制动能源再生及高效节能运行。其中，高效节能运行包括不使用时减速及/或完全静止。高效节能运行选项可减少能源消耗达60%。螺旋齿轮梯级外部直接驱动可进一步提高自动扶梯效率，同时可增加能源再生最高达输入功率的60-70%。当然，还可提供LED照明。

通力EcoMod实现了自动扶梯的更新改造，同时保留现有构架、最小化环境破坏以及提高效率。

同时，通力还提供自动门高效节能方案。当内外温差较大，乘客较少时，门会半开。只有在客流量比较大时，门才会完全打开。这样可节省大量能源。

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