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Overcoming MEP and VT System Design Challenges in Three of the Tallest Buildings in China | 三大中国最高建筑克服MEP和VT系统设计的挑战

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谢锦泉负责亚洲/中国各项超高层及大型建筑项目的机电和垂直运输系统设计。主要负责的项目包括上海中心、武汉绿地中心（设计审核）、北京Z15中国尊、天津117、广州周大福中心、天津周大福中心、重庆来福士广场、新加坡金沙赌场及度假酒店等，其中大部分建筑高度超过500米。

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Herbert Lam has extensive professional experience in MEP and VTS design, project management, and the supervision of supertall buildings and mega-projects throughout the Asia Pacific Region, including Hong Kong, Singapore, Macau, India, and China. He has participated in the MEP and VTS design of Shanghai Tower, Wuhan Greenland Centre (design audit), and Guangzhou CTF – all of which are over 500 meters tall.

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他有超过18年机电及垂直运输系统设计领域和项目管理经验，参与包括香港，新加坡，中国大陆，乌克兰及英国的许多大型及超高层项目。他参与机电及垂直运输系统设计的项目包括重庆来福士广场，武汉600米超高层项目及伦敦Aykon Tower。

Abstract | 摘要

This paper will address the mechanical, electrical, plumbing and drainage, and vertical transportation system (MEP/VTS) design challenges encountered during the design development of three unique, iconic megatall and near-megatall buildings in three major cities in China: Guangzhou, Tianjin, and Wuhan. It will also provide insight into the innovative solutions that enable the delivery of world class buildings with high building efficiency, sustainability and reliability. The Guangzhou CTF Centre and Tianjin CTF Centre are mixed-use supertall buildings with heights of over 500 meters, comprising office, hotel, services apartment and retail podiums. A new development at Wuhan will consist of a megatall office tower, retail podium and several residential towers. All three of these buildings are owned by the Hong Kong-based New World Development Group. They are designed by different international architects and are located in different climatic zones of China.

Keywords: Design Challenges, Innovative Design, MEP, Sustainability, Vertical Transportation

本文描述了三座独特及地标性的超高层建筑中机电和垂直运输系统设计所遇到的挑战，这三座建筑分别位于中国三个主要的城市 – 广州、天津及武汉。本文也将介绍在设计具有高效性、可持续性及可靠性的世界顶级建筑中遇到困难时的创新解决方案。 广州周大福中心和天津周大福中心高度超过500米，是集办公、奢华酒店、顶级服务式公寓和商业零售于一体的综合性建筑。武汉新建超高层项目会包括超高层办公楼，商业零售和住宅楼。这三个建筑项目均属于香港新世界发展集团。这三个项目建筑设计是由不同的国际建筑设计公司负责，且项目位于中国不同的气候区域。

关键词：设计中的挑战、创新设计、机电、可持续性、垂直交通

Megatall Building Development In China

The era of the "megatall" building, defined by CTBUH as any skyscraper 600 meters in height or greater, is still growing due to the demand of landmark towers in all major world cities. Developers and city planners are constructing megatall buildings in order to be the landmark tower in these cities. According to a recent survey done on major cities in China/Asia, over 80 percent of tall buildings are mixed-use towers (Tse and Lam, 2013).

WSP | Parsons Brinckerhoff has been commissioned by the Hong Kong based New World Development Group for the MEP (Mechanical, Electrical & Plumbing) and VT (Vertical Transportation) systems design for the Guangzhou and Tianjin CTF (Chow Tai Fook) Centres and a megatall development at Wuhan. All the above towers are supertall and megatall mixed-use developments with a combination of retails, offices, hotels, serviced apartments and clubs. All three towers are of distinctive structure and appearance among each other and other supertall and megatall buildings since they are designed by different renowned architects. The owner required all

中国大型超高层建筑发展

由于世界各大城市对地标性建筑的索求，500–600米大型超高层建筑的时代已开启了一段时间了。开发商和城市规划者正在建造可以成为城市地标的大型超高层建筑。根据最近对中国和亚洲主要城市进行的研究结果显示，超过80%的高层建筑为多用途大楼（Vincent & Herbert，2013）。

科进|柏诚受香港新世界发展集团的委托，设计广州周大福中心，天津周大福中心及武汉超高层项目的机电及垂直运输系统。以上三座建筑均为超高层多用途发展项目，其中包括商业零售，办公，酒店，服务式公寓和会所。由于三座建筑为不同的著名设计师设计，他们均有与众不同的结构和外形，发展商亦要求三座大楼有着独特的标志性特征。这一复杂性增加了机电系统及垂直运输系统设计及运营的难度。下文将阐述三座建筑项目中机电系统及垂直运输系统设计遇到的困难及挑战。

Figure 1. Guangzhou CTF Centre (East Tower) (530m) (Source: WSP|PB)
图1. 广州周大福中心（东塔）（530米）（来源：科进|柏诚）

Figure 2. Guangzhou CTF Centre (East Tower) and nearby buildings (Source: WSP|PB)
图2. 广州周大福中心（东塔）及周边建筑（来源：科进|柏诚）

three towers to be designed individually with a unique and iconic feature. This complexity increases the difficulties in MEP and VTS design and operation.

The MEP and VTS design challenges for these three supertall and megatall buildings are described below in this paper.

Guangzhou CTF (Chow Tai Fook) Centre

The 530m Guangzhou CTF (Chow Tai Fook) Centre (GZCTF), formerly known as East Tower, is the tallest building in Guangzhou (Figures 1, 2 & 3). With a combination of Grade-A offices, luxury hotels, deluxe serviced apartments, restaurants, and retail spaces in one efficient tower, GZCTF possesses an image of an integrated vertical city, rather than just a symbol for the fast-growing pace of Guangzhou.

The VTS design for the entire building is classified it into four zones: low-zone office (zones 1 and 2), high-zone office (zones 3 and

Figure 3. Guangzhou CTF Centre (East Tower) and nearby buildings (Source: WSP|PB)
图3. 广州周大福中心（东塔）及周边建筑（来源：科进|柏诚）

广州周大福中心

广州周大福中心，高530米，原名广州东塔，是广州最高的建筑（图1–3）。该建筑为集甲级办公楼、奢华酒店、顶尖服务式公寓、餐饮和商业零售于一体的综合性大楼，不仅是广州迅猛发展的标志，更展示了综合垂直城市的发展方向。

该建筑的垂直运输设计分为四个功能区域：低区办公（区域1和区域2），高区办

Figure 4. Guangzhou CTF Centre – main office lift lobby at ground floor (Source: WSP|PB)
图4. 广州周大福中心 – 首层主要办公区电梯大堂（来源：科进|柏诚）

Figure 5. Guangzhou CTF Centre – lift lobby at a typical office floor (Source: WSP|PB)
图5. 广州周大福中心 – 办公标准层电梯大堂（来源：科进|柏诚）

Figure 6. Guangzhou CTF Centre – corridor at a typical office floor (Source: WSP|PB)
图6. 广州周大福中心 – 办公标准层走廊（来源：科进|柏诚）

4), serviced apartments and hotel zone (Figures 4, 5 & 6).

The office zone has an office sky lobby and is divided into four zones, which are all served by double-deck elevators. Zones 1 and 2 can be reached by 12 direct local elevators in total, 6 for each zone; whereas zones 3 and 4 are served by 6 shuttle elevators. Occupants of zones 3 and 4 have to transfer to local elevators at the office sky lobby for other floors. There are in total 6 local elevators serving zone 3 while 4 serve zone 4.

The designs for the serviced apartment area and hotel area are similar to zones 3 and 4 of the office area, except that all the elevators are of single-deck, with elevator transfers made at the serviced apartment sky lobby and hotel sky lobby, respectively. Four shuttle elevators serve the serviced apartment area and hotel area respectively. At the serviced apartment sky lobby, occupants of the apartment can transfer to 11 local elevators to reach each floor of serviced apartment. For the hotel area, four local elevators are available for occupants to reach the hotel floor and three shuttle elevators would transfer visitors from the hotel sky lobby to the hotel restaurant at roof level.

公（区域3和区域4）（图4–6），服务式公寓，和酒店区。

办公区域设计有空中大堂，并划分为四个区域，全部由双轿厢电梯运行。区域1和2可直接乘坐各区域6台（共12台）的直达电梯，而区域3和4则须搭乘共6台的穿梭电梯。区域3和4的使用者能在空中大堂换乘短程本区电梯到达目的楼层，前者有6台本区电梯而后者则有4台电梯服务。

服务式公寓和酒店区域设计与办公区域3和4的设计相似，但所有电梯为单轿厢运行，并可分别在服务式公寓和酒店各自的空中大堂换乘本区电梯。服务式公寓和酒

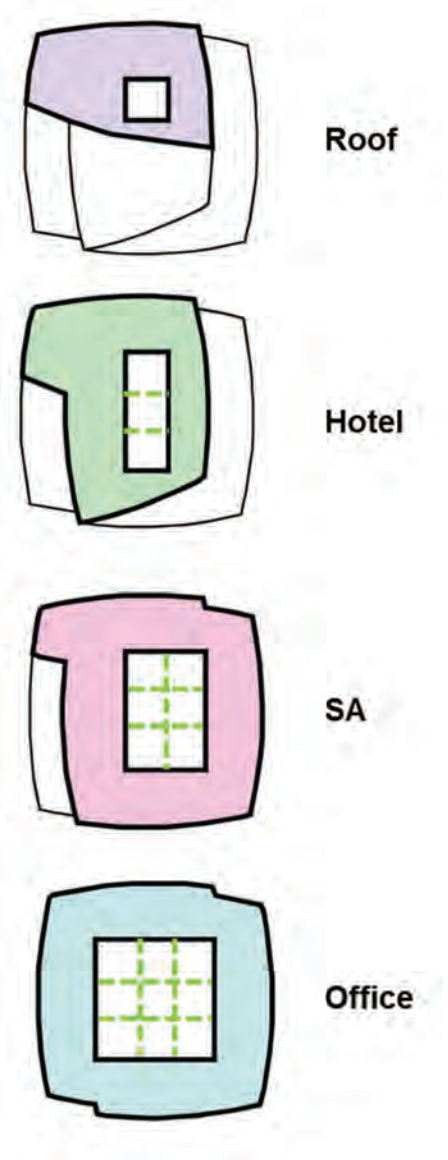

Figure 7. Guangzhou CTF Centre – core changes from low to high levels (Source: WSP|PB)
图7. 广州周大福中心 – 由低层至高层的核心筒变化（来源：科进|柏诚）

The challenge imposed on the WSP | Parsons Brinckerhoff design team was to completely alter their VTS and MEP system to integrate into a stepped/trimmed core (Figure 7). From the figure, it can be observed that the core of the office zone is the greatest, then one bank of lift shafts is withdrawn at the serviced apartment zone and hotel zone respectively, leaving only one lift shaft to the roof at the end. The GZCTF stepped- or trimmed-cored scheme has the advantages of optimizing the floor plate size, maximizing the usable floor efficiency and constructability, whilst reducing the core sizes from the MEP and VTS design perspective.

MEP and VTS design features of the GZCTF are described in the following section:

- District chilled water is supplied to offices and podium areas since a District Cooling System is available in the district where GZCTF is located. A secondary water-cooled central chiller plant is also designed in the basement as back-up facilities for office and podium retail floors. A remarkable achievement was the minimization of hydraulic pressure break with high energy efficiency and reliability. This is done by assigning a total of three separate chiller plants to the offices/podiums, serviced apartments, and hotels (Figure 8). The challenging part was to optimally locate the energy centers for enhancing system reliability, energy efficiency, and to coordinate with architects and structural engineers.
- A Variable Air Volume (VAV) system will be used for offices while a Fan Coil Unit (FCU) system will be installed in serviced apartments and hotel. To enhance environmental quality, the design has been aimed to achieve the following Green awards: LEED® Gold for offices, retail and hotels; and PRC Green Stars. One of the methods of attaining the aforementioned awards was to include relevant green engineering provisions, such as high performance building envelope, heat recovery chillers, air-side free-cooling (office and ballroom), CO2 fresh air control, water-saving valves, energy efficient lightings, air-conditioning condensate collection and reuse, and wastewater treatment and reuse, etc. (Lam 2013).

店区各有4台穿梭电梯。服务式公寓的住户能于其空中大堂换乘共11台的本区电梯至各层。而酒店住客则能于其空中大堂换乘共4台的本区电梯至酒店层或共3台的穿梭电梯至到达顶层的餐厅。

科进|柏诚设计团队所遇到的挑战是需要彻底改变原设计的垂直运输系统及机电设计并集成为一个阶梯形的核心筒（图7）。由图可见，办公区的核心筒是面积最大的。在服务式公寓区和酒店区，分别有一组的电梯井被取消，最后只留下一个电梯井通到屋顶。广州周大福中心的阶梯形式核心筒有许多优点，例如：优化楼面板大小，最大程度地提升楼层得房率和可施工性，并同时减少了机电和垂直运输系统所占用的核心筒面积。

广州周大福中心机电系统和垂直运输系统设计特点：

- 因周大福中心所在位置可提供区域制冷系统，办公区域和裙楼均采用区域供冷却水。二级水冷式制冷机房位于大楼地下层，为办公和地库裙楼区域提供后备冷冻系统。三个不同的能源中心分别为办公区域、服务式公寓和酒店供冷（图8），大大提升能源效益和系统可靠性，同时减低冷却水系统的压力间断。此设计的挑战在于如何与建筑师和结构工程师配合，优化能源中心布置，以此增强系统可靠性和能源效益。
- 变风量（VAV）系统将用于办公区域，风机盘管（FCU）系统则用于服务式公寓和酒店区域。为增强环境质量，设计旨在取得绿色奖项LEED®金级认证和中国绿色星级认证，其中的

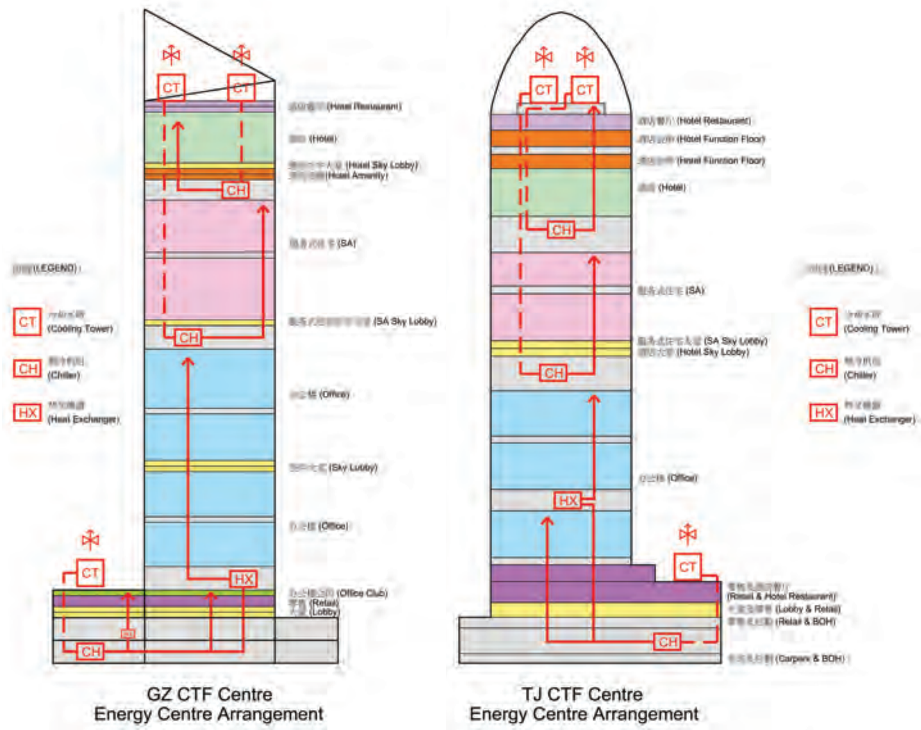

Figure 8. Guangzhou CTF Centre & Tianjin CTF Centre – energy center arrangements (Source: WSP|PB)
图8. 广州周大福中心及天津周大福中心 – 能源中心布置（来源：科进|柏诚）

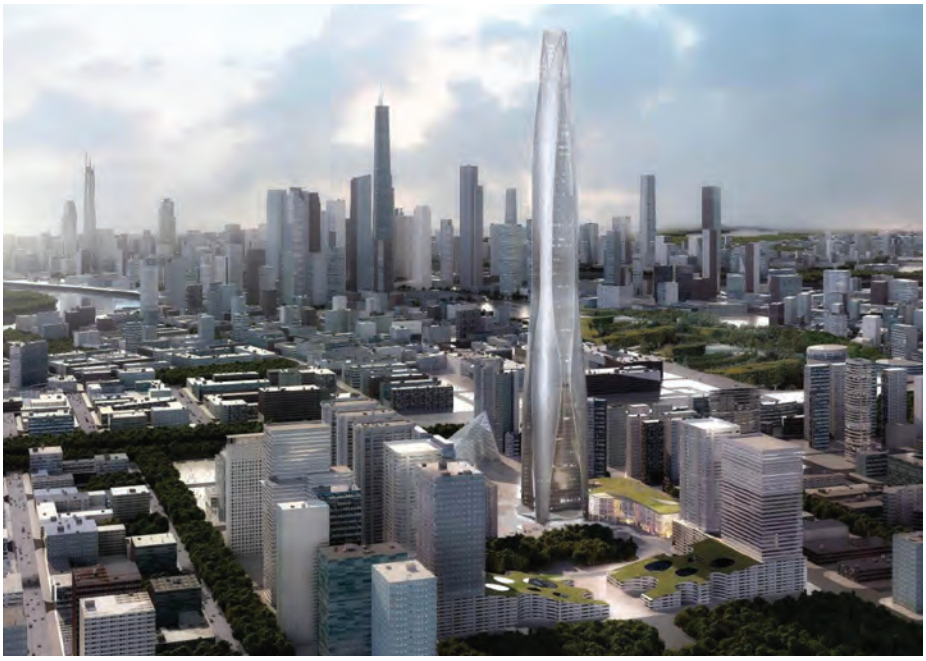

Figure 9. Tianjin CTF Centre (530m) (Source: SOM)
图9. 天津周大福中心（530米）（来源：SOM）

Figure 10. Tianjin CTF Centre (530m) (Source: SOM)
图10. 天津周大福中心（530米）（来源：SOM）

Figure 11. Tianjin CTF Centre – site photo taken in April 2016 (Source: WSP|PB)
图11. 天津周大福中心（530米）– 2016年4月施工照片（来源：科进|柏诚）

Figure 12. Tianjin CTF Centre (530m) – site photo taken in May 2016 (Source: WSP|PB)
图12. 天津周大福中心（530米）– 2016年5月施工照片（来源：科进|柏诚）

- The hotel shuttle elevators that serve the roof restaurant area allow the hotel guests to take the express elevators to reach the top restaurant floor at the hotel sky lobby. Overall, the smaller core of the building at the top hotel zone will have the merits of higher usable floor efficiency with much less wind load impact on the structure, and therefore reduced capital cost in construction.
- The two fastest elevators in the world with speed of 20m/s are installed in GZCTF and serve as the shuttle elevator between hotel sky lobby and main lobby at G/F. The speed of these shuttle elevators doubles the speed of the elevator going to the observation deck of the Burj Khalifa in Dubai.
- The entire building has just got building permit approval and will be in operation by the third quarter of 2016.

Tianjin CTF (Chow Tai Fook) Centre

Tianjin is one of the five national central cities of China. Tianjin CTF Financial Centre (TJCTF) is situated in Binhai, an Economic Development Area in Tianjin where more than half of the Fortune 500 companies are based. TJCTF, which is a 530m high supertall building with a total GFA of 350,000 m2 comprising Grade-A office, retail podium with parking, 5-star hotel and serviced apartments programming, is a very slender tower, and the whole building shrinks like a bowling pin. The reduction in floor area at higher zones helps reduce a lot of wind load imposed on the whole building and hence optimizes considerable structural cost savings (Figures 9 &10). The building is under construction now (Figures 11 & 12).

The VTS system divides the whole building into three functional zones: office, serviced apartment and hotel. Dedicated sky lift

一项方法是在设计中涵盖绿色工程设备，例如高效建筑围护结构、热回收制冷机组、空气侧免费供冷（办公区域和宴会厅）、二氧化碳及空气新风流量控制、节水阀、节能灯具、空调冷凝水收集和再利用、废水处理和再利用等（Herbert，2013）。

- 乘客可在酒店空中大堂换乘直达电梯，直接到达酒店顶层餐厅。总体来说，建筑核心筒面积的减少可提升楼层得房率，并降低风力对于建筑结构的影响，因而进一步减少了建筑成本。
- 广州周大福中心安装了两部全世界最快的电梯，最高时速可达20m/s。这两部电梯用于往返酒店空中大堂及地面大堂的穿梭电梯。这两部穿梭电梯的时速是迪拜哈利法塔观光层穿梭电梯的两倍。
- 广州周大福中心已获得建筑许可证，并将于2016年第三季度开业。

天津周大福中心

天津是中国五个国家中心城市之一。天津周大福中心位于天津滨海新区，是天津的经济开发区，超过半数的世界财富500强公司在此投资。天津周大福中心高530米，建筑面积350,000平方米，包括甲级写字楼，商业零售及地下车库，五星级酒店及会所和服务式公寓。本项目为细长型大楼，整体向上收缩，建筑外形如保龄球瓶状。因高区建筑面积减小，降低建筑风阻，从而大幅降低建筑结构造价（图9、10）。该建筑现正进行施工阶段（图11、12）。

lobbies are provided for serviced apartment and hotel areas.

For the office zone, programming is further divided into 4 smaller zones. All these zones are served by 22 single-deck local elevators in total, 3 serving zone 1, 4 serving zone 2, 8 serving zone 3, and 7 serving zone 4.

Occupants of serviced apartments can take the 4 single-deck shuttle elevators to the serviced apartment lift lobby and reach apartment floors by the 6 single-deck local elevators. Meanwhile, hotel occupants can travel to the hotel sky lobby by 4 single-deck shuttle elevators from ground floor and transfer to 6 single-deck local elevators to arrive at their destination hotel floor.

In the previous core design scheme, the shape and area of the core was more or less the same across the whole building. In order to achieve higher usable floor area, the core design has shrunk together with the floor area, and thus a minimized core is resulted at higher zones. The reduction in floor and core area has created major challenges in designing the VTS and MEP systems.

One of the key difficulties is that the higher zone of TJCTF will have a smaller floor area. These high zone floors will serve as hotel accommodations rather than offices, which imposes challenges on the VTS design in view of fitting the lift lobby of the hotel into the thinnest core in the building and meeting VT requirements simultaneously. Traditionally, the lift lobby serving a particular element (e.g., hotel/ serviced apartment) in a building will be located right below that element. However, this strategy is not feasible in TJCTF because of its bowling-pin-shaped building structure. The core area at the hotel zone is insufficient for its sky lobby to be located right below the hotel zone. The solution is to locate the hotel at the top, but with the hotel sky lobby below the serviced apartments, keeping the core as compact as possible. Therefore, the core is designed like a small square tube inside a large square tube. The inner part of the core contains all the building services, local elevator shafts and the fire escape stairs and runs the full height of the building. The outer part of the core contains the shuttle elevator. In other words, the big core is terminated at the hotel sky lobby while a tiny core remains throughout the hotel floors.

For the VTS for office zones, challenges may be faced in view of jam-packed situations at lift lobby during peak hours. Similar to GZCTF, there are in total 4 zones of offices, a large amount of office occupants would be expected when the office floors are rented out. Nevertheless, the core area in TJCTF is limited and therefore the number of elevators serving the office floors is limited and jam-packed situations may be a result. A Destination Control System (DCS) is adopted to optimize the VTS capacity during up-peaks. Elevator passengers will be assigned to a designated elevator by the security entry gate when they pass through it to enter lift lobby. It can help to improve the situation in a way that fewer stops can be made by the elevators if people going to the same floor are assigned to the same elevator, and thus less travelling time can be achieved. The DCS can also enhance the security level in the TJCTF since the available floors that can be reached by elevator passengers is limited. Time can be saved for the registration of destination and the queues can then be avoided.

Apart from the challenges to VTS design mentioned, the description below summarizes the challenges to MEP design and the corresponding solutions:

- Similar to the design adopted in the GZCTF, three individual chiller plants are assigned for the office and retail podium, serviced apartment, and hotel and clubhouse areas (see Figure 8). As mentioned in the previous section, the aim of this design is to minimize the hydraulic pressure break to enhance system efficiency and reliability.
- Heating and Anti-Frosting – Tianjin encounters extremely cold weather during winter. There is insufficient available heat provision from the city's heat supply and some MEP equipment is exposed to the cold environment. Therefore, a challenge is imposed on the MEP design in the heating and anti-frosting aspect. To tackle the problem, the owner's independent boiler room for heating supply is adopted. A Variable Air Volume (VAV) box with heating coils and a radiator is adopted in the office area whilst a four-pipe Fan Coil Unit and under-floor heating system are provided for serviced apartment and hotel areas. To avoid frosting of the MEP equipment installed outdoors like Air Handling Units (AHUs), double casing with insulation, electrical heater and other anti-frosting means are equipped. An anti-frosting alarm system is equipped with the coils in the AHUs as means to control or monitor the frosting situation.

The Tower is targeting a LEED Gold rating for retail, office, hotel and serviced apartment programming.

大楼的垂直运输系统将整座大楼分为3个功能区：办公区、服务式公寓及酒店。服务式公寓及酒店各有其专用的空中大堂。

办公区再被细分为4个区域，所有区域由共22台单轿厢本区电梯服务，其电梯分配为3台本区电梯服务区域1、4台服务区域2、8台服务区域3而7台服务区域4。

服务式公寓的住户能于地面层大堂搭乘共4台的单轿厢穿梭电梯至服务式公寓空中大堂，再换乘共6台的单轿厢本区电梯至公寓层。同时，酒店住客能搭乘共4台的单轿厢穿梭电梯至酒店空中大堂再换乘共6台的单轿厢本区电梯至目的楼层。

在早期核心筒设计方案中，全栋楼中的核心筒形状及面积几乎相同。为取得更高的楼层得房率，核心筒随着楼层面积减小而收缩，因此高区只有较小的核心筒。楼层面积与核心筒面积的减少为机电和垂直运输系统设计带来重大挑战。

该项目主要设计难点之一是高区面积较小。高区为酒店客房区域，主要设计挑战为如何在最小的核心筒内设计垂直运输系统与酒店电梯大堂并同时满足垂直运输要求。一般来说，服务特定功能区（如酒店，服务式公寓）的电梯大堂会位于该功能区下方，但这种设计并不能应用于天津周大福中心。由于其类似于保龄球瓶的建筑外形，若酒店空中大堂位于酒店区域下方，则该层核心筒面积不能够满足设计需要。解决方案是酒店区域仍位于建筑顶部，但酒店空中大堂则位于服务式公寓下方，使核心筒于酒店区尽可能保持小巧紧凑。因此，核心筒设计类似于小方形管外面套了大方形管。核心筒的里面部分包含了所有楼宇设备管线。本区电梯井道和防火楼梯并贯通整座大楼，而核心筒的外面部分为穿梭电梯。换句话说，酒店空中大堂下面为大核心筒，酒店空中大堂直到酒店区域楼层为小核心筒。

办公区域的垂直运输系统设计面临的挑战主要是上下班高峰期电梯大堂密集的人流。与广州周大福中心类似，办公区域分为四个区，当办公楼层出租以后，可以预计将会有大量的人流进出。由于天津周大福的核心筒面积限制了服务办公楼层电梯数量，可能会造成人流拥挤的情况。因此于上行高峰时段将采用电梯目的选层系统（DCS）以优化垂直运输系统运载能力。电梯乘客将会在通过入口闸机时被分配至指定的电梯。如果去同一楼层的乘客搭乘同一部电梯，将会减少电梯停层次数并减少运输时间。电梯目的选层系统（DCS）亦可通过限制电梯乘客可以到达的楼层，提高大楼的安全性。通过电梯目的选层系统亦可以减少乘客选楼的时间，避免出现人流拥挤和排队的现象。

除了以上垂直运输系统设计遇到的挑战，下文概括了机电系统设计遇到的挑战及相

A New Megatall Tower In Wuhan

Being the capital of Hubei Province, Wuhan is one of the largest cities with a major transportation hub in central China. A new megatall tower will be situated in the newest CBD in the Hankou area of Wuhan. Upon its completion, it would be one of the tallest buildings in the city with a height of over 600m. This development is designed to be defined as the symbol of the blossoming image of the city. This megatall Grade-A office tower will be divided into 8 zones with 3 sky lobbies. A very efficient VTS with a combination of high speed double-deck shuttles and single-deck local elevators will be adopted. This will excellently integrate with the core design to achieve the highest floor efficiency. Since there will be a tremendous amount of occupants expected in the megatall office tower, challenges will be imposed on the overall efficiency of the VTS. As a result, during the concept design stage, a detailed assessment and analysis will be undergone to evaluate and figure out cost effective solutions on VTS to suit the project's needs.

The development is currently in the concept design stage, and one of the design goals of the development is to achieve LEED® Gold standards. In energy and sustainability aspects, highly efficient energy centers will be adopted and placed on the basement floors and other selected floors in the tower. The strategy of this arrangement is to locate the energy centers close to load centers to ensure cost-effective distribution of MEP services such as electricity, cooling and heating, and plumbing and drainage within the building. This can also help reduce the number of heat exchanger to be installed in the development since fewer hydraulic pressure breaks are needed. As a result, MEP plants with higher efficiency and reliability can be obtained.

Apart from the features mentioned above, more green and sustainable features as discussed below will be considered for adoption in the development:

- Photovoltaic (PV) panels
- Solar heating
- Geothermal energy
- Greywater recycling
- Stormwater harvesting

Since the development is under concept design, architectural rendering and design data would not be available at this stage.

应解决办法：

- 与广州周大福中心类似，三个不同的能源中心分别为办公及商业零售区域、服务式公寓和酒店供冷（图8）。正如前面提到，该设计的目的是减少冷却水系统的压力间断并提升能源效益和系统可靠性。
- 供暖及防冻 – 由于天津冬季气温极低，城市热力供应不足并且部分机电设备将处于寒冷的室外环境中，因此机电系统设计在供暖及防冻方面面临挑战。为了解决该问题，项目将自设锅炉供冬季采暖。办公区域使用连采热盘管的变风量末端装置及散热器，而服务式公寓和酒店采用四管制风机盘管系统和地暖系统。为防止安装在室外的机电设备，如空气处理机组，结霜，采用了含隔热材料的双层外壳，电加热装置和其他防冻方法。此外通过在空气处理机组内的盘管上安装防结冰警报系统，能控制和监控盘管结冰状况。
- 该项目的商业零售、办公、酒店和服务式公寓都旨在取得绿色奖项LEED®金级认证。

武汉新建超高层项目

作为湖北省的省会，武汉是中国中部地区最大、最主要的交通枢纽城市之一。在武汉市汉口区新规划的中央商务区，将建一座新的超高层建筑。该项目完成后的建筑高度将超过600米，是武汉市最高的建筑之一。该发展项目被定义为武汉繁荣发展的标志。这座超高层甲级写字楼将分为8个区和3个空中大堂。高效的垂直运输系统将采用高速双轿厢穿梭电梯与单轿厢本区电梯相结合的方式。垂直运输系统设计将与核心筒的设计形成良好配合，从而取得最高的楼层得房率。由于此超高层建筑将会有数量庞大的使用者，垂直运输系统的总体效率将会面临挑战。因此在概念设计阶段，需通过详细的评估和分析，找出能够满足项目需求且最经济的垂直运输系统解决方案。

本发展项目目前正处于概念设计阶段，其设计目标之一是获得LEED®金级认证。在能源及可持续发展方面，高效的能源中心将置于地下层和塔楼中的特定楼层。这种做法是为了让能源中心靠近负荷中心，以便能够高效地布置各类机电管线，如电气、供冷、供热和给排水。除此之外，由于水系统压力间断分段减少，该设计还能减少项目中热交换器的安装数量。因此，机电系统将具有更高的效率和可靠性。

除上述要点外，以下绿色可持续措施也将考虑应用在项目中：

- 太阳能光伏板
- 太阳能采暖
- 地热能
- 中水回收利用
- 雨水收集

由于该项目正处于概念设计阶段，暂未能提供建筑图和设计数据。

结论

建设超高层建筑是世界可持续建筑发展的趋势。大部分超高层建筑均超过100层并为不同种类的使用者服务。不同使用者的需求为机电和垂直运输系统带来挑战。除了使用者的需求外，独特的建筑结构和外形也为机电和垂直运输系统设计增加了困难。

当超高层建筑和综合型发展大楼逐渐成为社会的必需品时，建造这些楼宇所需要的专业技能和革新技术也日趋重要。为适应快速变化的环境，建筑结构和设计也随着时代进步而改变。从大量的机电及垂直运输系统设计经验中可以总结以下几项要点（Vincent & Herbert, 2014）：

- 每一幢建筑都是独特的，没有万能的设计方案。
- 发展商、物业管理、建筑师、结构工程师、机电工程师及垂直运输系统工程师之间应有一个达到各专业充分协调的一体化设计。
- 平衡功能需求和楼层得房率。
- 机电系统设计方面的重要考虑因素包括：
  - 区域环境
  - 系统可靠性
  - 绿色及能源效益
  - 高端科技
  - 成本效益
  - 可持续发展
  - 未来变化的灵活性（运营及维护）
  - 用户便利性（运营及维护）
- 垂直运输系统设计应与以下方面形成和谐的互动：
  - 国际品牌和标准
  - 建筑
  - 机电
  - 结构
  - 成本
  - 运行

Conclusion

The construction of megatall and near-megatall buildings is a trending sustainable development all over the world; the majority of them have more than 100 stories and serve a large variety of user groups. The needs of the various user groups cause challenges to MEP & VTS design. Apart from the occupants' needs, the unique structure and shape of the building put burdens on MEP & VTS design as well.

In addition, as supertall and megatall mixed-use buildings become more of a necessity than just a mere luxury, the demand for expertise and innovation in the construction of these landmark towers will be greatly increased. It is essential for the structures and designs to change over time to adapt to the rapid-changing environment. The following key considerations/challenges from the MEP & VTS design and operation viewpoints are concluded from the extensive collection of experiences in the design and construction of tall buildings (Tse and Lam 2014):

- Every building is unique; there is unlikely a "one-size-fits-all" design approach.
- There should be a well-integrated design with full coordination between owner, operator, architects, structural engineer, MEP and VTS designers.
- The functional requirements and floor efficiency should be well-balanced.
- Important factors from an MEP system design stand point:
  - Regional environment
  - System reliability
  - Green and energy efficiency
  - High-tech and state-of-the-art
  - Cost effectiveness
  - Sustainability
  - Flexibility for future changes (operations & maintenance)
  - User-friendliness (operations & maintenance)
- VTS designs should be interactive and harmonized with the following:
  - International Brand and Standard
  - Architecture
  - MEP
  - Structure
  - Costs
  - Operations

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