

# Power Distribution Systems For The Beijing 2008 Olympic Games

M.J. Kornblit, P.E., Sr. Systems Engineer, GE Beijing 2008 Olympic Games Solutions

The design and construction of any significant commercial facility and its crucial utility systems is exacting and undergoes much scrutiny. Consider the added attention and requirements to which that structure may be subject if it were to act as a focal point for the pride of an emerging world power to be viewed and scrutinized by two thirds of the world's population. Interest in the phenomenon known as the Summer Olympic Games have grown such that TV viewership of the Beijing 2008 Olympic Games is expected at about 4 billion and actual visitors to the Beijing venues alone will likely exceed 2 million. Over 37 major arenas have been newly constructed simultaneously for these competition events, eleven existing sporting structures were extensively renovated and countless new ancillary facilities have strategically mushroomed up for housing and to best display the grandeur of this experience and its host country. Governmental expenditures is estimated at 40 billion U.S. dollars, not including the significant stakes taken by other interests including the IOC organization, the numerous international and national broadcaster organizations, advertisers, sponsors, owners and investors. To say that functionality, safety and reliability are important for these structures is an understatement.



Fig. 1 Beijing Olympic Green

To satisfy often-diverging interests, existing national and local codes are supplemented with guidance for every aspect of the structures' requirements provided by the IOC (International Olympic Committee), OBO (Olympic Broadcasting Organization), BOB (Beijing Olympic Broadcasting Co.) and others. Various guides are issued by these Olympic organizations including a 2600 page Venue Survey Report, and a 164 page Guidelines For Energy Infrastructure. The implementation of these guidelines becomes the responsibility of the national government appointed OCOG (Organizing Committee for the Olympic Games), BOCOG as it is known for the Beijing games. The effectiveness of the guideline implementation is evaluated on a regular basis with updates and clarifications issued as required.

The electrical power distribution system naturally plays a central role in the effective design of these facilities. It must not only be capable of supporting the mundane unglorified everyday needs of the building, but its quality and reliability is expected to be up to the task of facilitating the uninterrupted requirements for continuous sporting events to occur, while powering cutting edge technology such as high definition slo-mo for simultaneous sports gratification around the world. The need for a continuous flow of reliable electricity is evident in all aspects of the event: from the power necessary for continuous flicker-free sports lighting required to permit fair and uninterrupted athletic competition, to the precision electronic timing devices which will determine the outcome of the events within a fragment of a second, to the high definition cameras and broadcasting equipment which will allow the world to witness the events in real time, though they may be happening half a world away.

The need for reliable power is stressed by the International Olympic Organization from the earliest workshops and working meetings held to acquaint the host country's responsible organizations with the expectations. And these requirements are detailed in the written guides and guidelines provided to them. Basically, two categories are considered by the IOC: competition venues, areas where the sporting events take place, and their event related activities such as sports lighting, ceremonies and many others; and non-competition venues such as the Olympic village, sponsor hospitality village, and the IBC which is the most important venue of all since it serves as the nerve center for all broadcasting during the Olympic Games. The power quantity, quality and reliability for each venue and related activity segment is assessed and categorized as 'normal' (outages will not affect sporting events or broadcast), 'critical' (outages could negatively affect services on which either of these two depend), or 'imperative' (power interruptions could have a direct impact on the sporting event or broadcast). So, by definition, any activity, which, if disturbed, can negatively impact the sporting event or its broadcast, is classified as imperative. This includes such elements as field-of-play lighting, scoring and timing, telecommunications, ceremony sound (but not public address system), graphics and animation, athlete cooling fans.

Redundant power sources are recommended for all Olympic Games structures but necessary for the most crucial categories. Upon loss of normal power, the alternate source must be on-line within a short period of time: less than one second if provided as a second utility service, less than 20 seconds if served by back-up generation. Depending on the magnitude, sensitivity, and distribution of the crucial loads, the means of attaining redundancy can vary, and the detailed requirements for certain loads can be extensive. For example, a small stand-alone imperative load could be served from an appropriate utility outlet and UPS, or redundant UPS's. Field-of-play (FOP) lighting, on the other hand, is typically a very large imperative load and every aspect of its design, including the power supply, receives special attention. This is understandable since an interruption in proper lighting levels during competition can impact concentration of the athletes thereby negating the results, disrupts broadcast of the event, and since most FOP lighting relies on metal-halide technology even a minimal voltage disturbance can cause an extended outage. The power supply must therefore be fully redundant, backed up by generation, and the lighting divided into two equal groupings. During competition each group must be isolated from the other and fed from a separate source, each source capable of feeding the full load if necessary. It is also necessary to physically interlace the lamps between groups to minimize the

overall impact on the field if an outage does occur. A random interlacing of the three phases fed to the lamps is also required to reduce possible visual flicker, observable during certain conditions.

Various approaches are possible to resolve the more extensive requirements, and are implemented based on many considerations, but always following appropriate approvals. Some FOP lighting designs, such as the National Stadium (or Bird's Nest, shown to the right) do incorporate large UPS or similar systems to make certain the highest level of power quality is retained throughout the critical need period. And there are many such periods at this facility throughout the relative short life span of the Olympic Games since it also serves as the setting for the opening and closing ceremonies in addition to the sport competitions. Much of the FOP lighting and other systems in use for the Olympic Games are only needed during this period of time and are therefore temporarily appended to the main facility. These systems, and the temporary power used where needed must interface with the permanent power system (shown below for the National Stadium, figure 3) and facility in a flawless complimentary manner

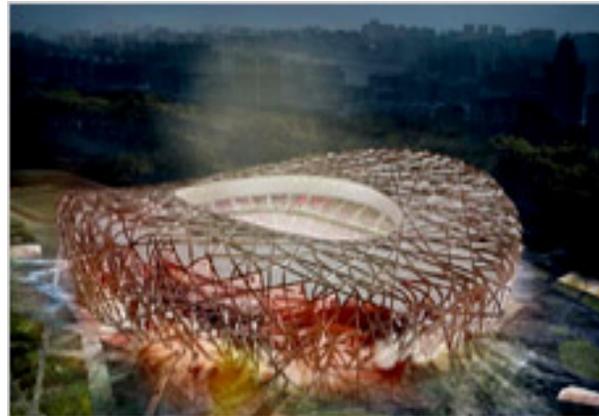


Fig. 2 National Stadium

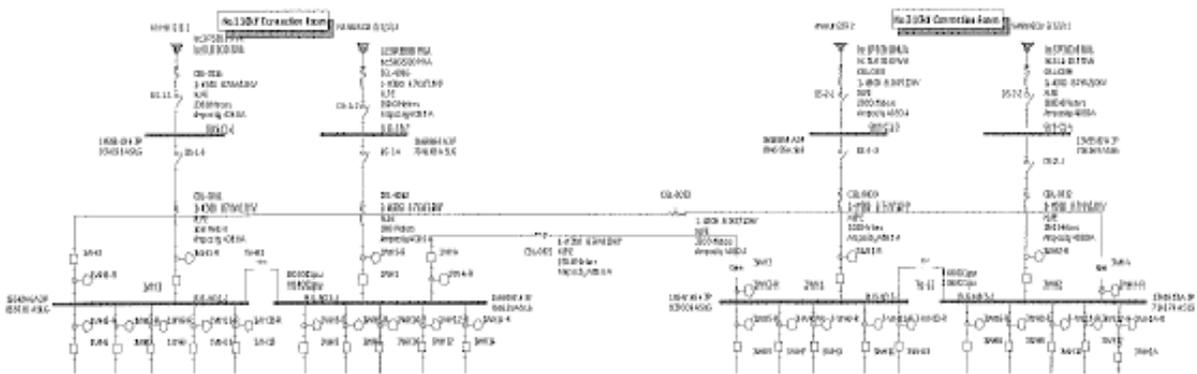


Fig. 3 National Stadium Electrical 1-Line Diagram

Each venue must incorporate an appropriately sized and equipped broadcasting compound. This compound is a separately fenced area designated to serve as the central command station and source for all broadcasting needs at that remote facility, including their power requirements within the venue location. All aspects of this compound are clearly detailed by BOB. Two sources of utility power are required to supply each compound, the sources coming from

geographically independent parts of the national power grid. The power is transformed at the compound, distributed at low voltage levels and supplemented through the use of temporary standby generators. The loads are classified as ‘domestic’ or ‘technical’, grouped as such and configured to receive backup generator power, though the generators are only activated and switched into service automatically for the technical loads, which are considered most essential. Any critical, sensitive loads which need uninterrupted high quality power are fed through UPS’s located downstream of the compound electrical system’s front end illustrated in figure 4 below.

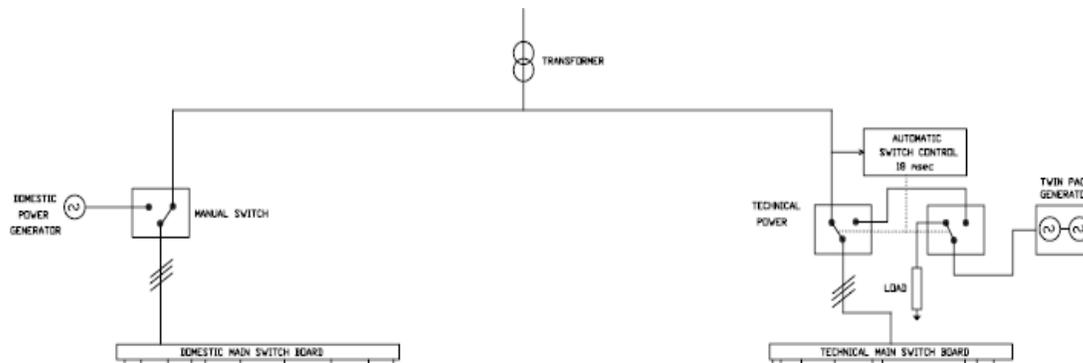


Fig. 4 Venue Compound Electrical 1-Line Diagram

The IBC (International Broadcast Center), located within the National Convention Center, represents the critical hub of all broadcast activities and is therefore considered the most crucial venue of the Beijing 2008 Olympic Games. Estimated at about 24MVA, it represents the largest single concentration of loads of any facility at the Olympic Games and the greatest expenditure to assure the highest level of power reliability and quality. Four separate utility feeds from at least two geographically independent power stations serve this facility at multiple switchgear locations. Power is distributed at 10kV to numerous multi-sourced low-voltage (LV) substations throughout the facility and configured such that each LV bus receives a normal utility source, a standby utility source and is interconnected to temporary standby generators, as illustrated in Figure 5 below. As shown, each pair of LV substations forms a single lineup unit and shares a common standby source. Each of the three 10kV feeds supplying any substation lineup unit must originate at an independent source bus to minimize the possibility of a common source bus outage. PLC based control help monitor all critical system parameters and provide the automated switching, tracking and communications necessary to properly manage such a sophisticated distribution system and critical application.

Though highly unusual in China, special approval was received to permit low voltage parallel operation under certain system conditions for many of the most crucial LV substations in the IBC. Because of the unprecedented nature of this requirement, final approval to proceed was slow in coming and not received until months after the installation of standard non-parallel gear. At that point, not only had the need for parallel operation captured widespread high-level attention, but it now had to be implemented in a fully functioning critical facility with minimal tolerance to disturbances of any kind. The plan on how to best proceed, selection of proper

components, design of the control logic and modification of the equipment received abundant attention during the entire upgrade and extended testing process prior to final approval and acceptance.

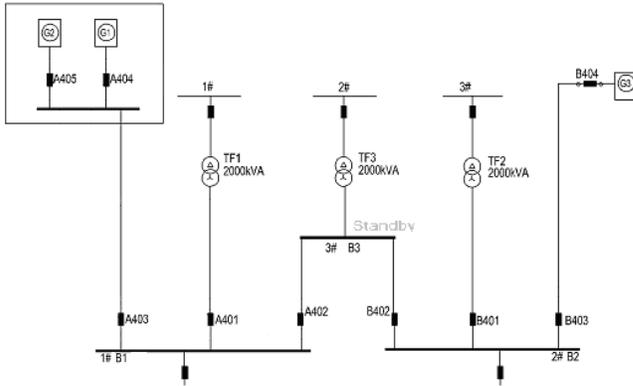


Fig. 5 Typical IBC LV Substation Electrical 1-Line



Fig. 6 One Line-Up of IBC Switchgear

As meticulous and elaborate as the plans and expenditures are for these events, many of the facilities and their power systems will undergo widespread modification following the Olympic Games. The National Convention Center, for example, will no longer have a need for a broadcasting center or any of its ancillary loads after these games, nor large sport competition venues. Major renovations will begin shortly after the Closing Ceremonies, which will transform the space into a convention center, hotels, office buildings and a shopping mall. The extensive initial power system, occupying numerous large vaults within the second level basement area, will be downsized and relocated to other floors in the facility. Such changes are not unique to this building, or the Beijing 2008 Olympic Games. Most structures will experience change of some extent, many significant. Proper planning and experienced selection of product and configuration can help to effectively apply and then reapply much of the most important elements in the system.

One such example can be demonstrated by a key project with the electric power bureau of Beijing. Responsible for providing power to every venue's broadcasting compound, and bulk power of varying types for the opening and closing ceremonies of the Beijing 2008 Olympic Games, much advance planning preceded the final designs of the equipment to be used. Specially configured and properly equipped containerized substations were designed for these applications (Fig. 7). The modules were suitable for use throughout the Beijing 2008 Olympic Games and for the many future project needs throughout the city that were to follow these unique events.



Fig. 7 Containerized Substations

The magnitude of today's ventures and accomplishments are truly breathtaking. The advances in technology that help bring these dreams to fruition depend on an infrastructure of power, control and communication that's as cutting edge and dependable as the results expected from the entire project. Selecting the proper products designed for, and with a proven track record of reliable operation, which incorporate the most appropriate user and application integration flexibility necessary, at competitive costs play an important part in helping to make these projects a success. In addition to the products, the culture to respond creatively to the many challenges ever present on any significant project is the difference between solving a problem and developing an overall solution.