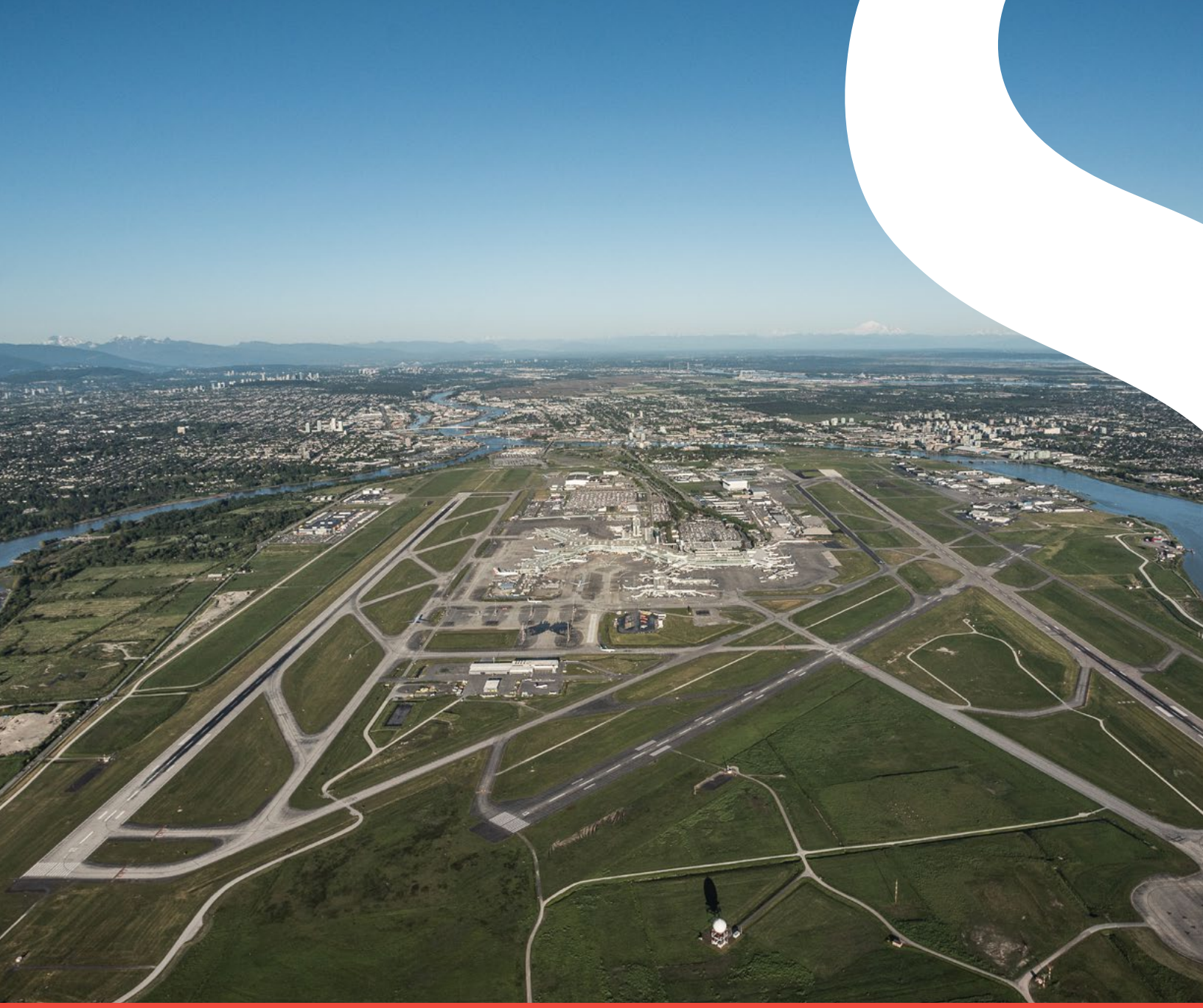

YVR Flywheel Energy Storage and Airfield Critical Power System

Canadian Consulting Engineering Awards
Natural Resources, Mining, Industry and Energy

EXECUTIVE SUMMARY

WSP was the prime consultant for the design and construction of a new critical back-up power system using innovative flywheel energy-storage technology for Vancouver International Airport's (YVR's) north airfield lighting system. The existing system was aged, had a 30 second blackout period at start-up during power outage events, was unreliable, and was expensive to operate and maintain.

Project objectives were:

- Provide a highly reliable safe system that provides continuous power under all conditions to the north airfield lighting system
- The solution must be environmentally sustainable
- Lighting system electrical-noise (harmonics) to upstream systems is minimized
- The system is easy to operate and maintain

The new system met all project objectives, using technology never used before at a commercial airport, but proven in other mission-critical applications. It includes a flywheel energy storage uninterruptible power supply (UPS) system, coupled with intelligent switchgear and high-efficiency generators. The project was designed and constructed around existing infrastructure to avoid any interruption to operations of the existing system during construction.

Significant planning and coordination ensured successful commissioning and switch-over to the new system without impact to airport operations.

Project Site Location at Vancouver International Airport

The YVR Flywheel Energy Storage and Airfield Critical Power System was recently awarded the 'Award of Excellence' at the 2018 ACEC-BC Awards for Engineering Excellence (Energy & Industry category)

Project achievements include:

- Elimination of runway lighting blackouts
- 78% (68,000L) annual reduction in system fuel consumption
- 90% (6.45 tonnes) reduction in system greenhouse gas emissions
- 100% elimination of lighting system electrical noise to upstream systems
- 73% operation and maintenance cost reduction.

The result is a highly reliable and efficient system exceeding project objectives.

The project recently received the 'Award of Excellence' in the Energy & Industry category at the 2018 ACEC-BC Awards for Engineering Excellence.

Project Site Area containing Flywheel UPS System, Generators, and Switchgear

PROJECT OBJECTIVES, SOLUTIONS AND ACHIEVEMENTS

BACKGROUND

Located on Sea Island in Richmond, British Columbia, Vancouver International Airport (YVR) is the second busiest airport in Canada, handling over 22 million passengers and over 280,000 flights a year. Fifty-five airlines serve YVR, connecting people and businesses to 125 non-stop destinations in Canada, the US, and around the world via chartered and regularly scheduled flights.

YVR has two main parallel runways, the north runway and the south runway, each oriented in an east-west direction, as well as a third cross-wind runway. Keeping runways operational during all conditions is essential to the safety and operation of YVR, and sophisticated lighting and safety systems are key elements in allowing airplanes to take-off and land in all weather conditions. Low visibility conditions, which occur during nighttime, rain, snow, sleet, and fog events, cause significant risk to airports during take-offs and landings, since pilots and airport control tower operators cannot visually see the runways or nearby air traffic – and the lighting and safety systems play a critical role in successfully mitigating these conditions.

The electrical system operating the lighting and safety systems is therefore paramount to the safety and success of YVR as a global airport leader. No interruption can be tolerated and a reliable back-up power system that provides a continuous supply during power outages is essential. While YVR's lighting system has been updated to new energy efficient LED-style lights, the existing electrical back-up power system was aged and increasingly unreliable. A new modern solution was required to replace it.

PROJECT OBJECTIVES

The objectives of the project are as follows:

- Provide a highly reliable safe system that provides continuous power under all conditions to the north airfield lighting system.
- Provide a solution which, in addition to the above, is environmentally sustainable and reduces YVR's carbon footprint in line with the airport's stringent sustainability requirements.
- Significantly reduce or eliminate electrical noise (harmonics) generated by the lighting system which currently causes disturbances in the electrical system, potentially disrupting other electronic equipment.
- Ensure that the implemented solution is easy to operate and maintain with no interruption to the availability of the north runway and airfield.

SOLUTIONS

Replacing essential electrical systems at critical facilities, such as airports, is a complex undertaking. The solution requires significant technical knowledge and coordination to successfully execute with minimal interruption to existing airport operations and zero impact to the public. WSP evaluated a range of design options and technologies with YVR to determine the most suitable design to meet the project objectives. Continuous collaboration between WSP, YVR, airline carriers, and other stakeholders was key to the successful execution of the project.

Keeping the airfield lights operating and online can be challenging. When airfield lighting systems are required during low visibility conditions, such as storms and extreme weather conditions, the BC Hydro utility supply may also be disrupted by weather events. Using conventional back-up power systems, when a utility power outage occurs, the airfield lighting power source automatically switches to standby diesel generators, but takes about 30 seconds to switch over. During this 30 second "blackout period" the airfield lights are off – which could occur during a critical take-off or landing stage. The previous solution to this problem was to pre-emptively turn on the generators and use them to run the airfield lighting system for the complete duration of a low visibility event, regardless of whether the utility power was available or not. While this solution effectively eliminated the 30 second blackout period, it was highly inefficient and expensive, as the diesel generators were constantly running and operated for extended periods of time regardless of whether they were needed or not.

Flywheel Canisters

WSP selected and designed a flywheel energy storage and power generation system to solve these problems. This system consists of two 600 kW redundant high-efficiency diesel generators, an intelligent power switchgear distribution system, and a 625 kVA flywheel uninterruptable power supply (UPS) system. These three primary system components were designed to be installed in the same area as the existing power distribution system and were constructed around the existing equipment, eliminating impact to the existing system and allowing it to remain fully operational during the construction of the new system. This configuration was challenging, as the original area was not designed to house more than the generators and simple electrical switches, but the team developed creative designs that were successfully implemented without any disruption.

The innovative solution of using a Flywheel UPS system to provide large-scale uninterrupted power during a power outage while the backup generators start up was key, as it allowed significant flexibility in how the generators are operated. This type of system is the first commercial installation at an airport anywhere in the world, and as such, significant research and design development was invested to ensure the solution would be not only economically and technically viable, but is also robust, safe and reliable from an operation and maintenance perspective.

The Flywheel UPS system and the two generators interface with the intelligent switchgear system, which automatically monitors and switches power from the BC Hydro utility to the generators as required. Both generators are capable of each providing full backup power to the airfield lighting system, and the system is designed to automatically run one generator and switch to the second one in the event of a failure of the first generator. WSP developed advanced control algorithms to allow fast transfer between the two generators. This intelligent system eliminates the need to continuously run the generators during low visibility conditions, as the system only starts the generators when the BC Hydro utility supply fails. This was made possible because the UPS system provides uninterrupted emergency power to the lights during the 30 second blackout period while the generators start, bridging the gap for confidently seamless operation.

900 kVA Flywheel Energy Storage System

In addition to providing a reliable power system for uninterrupted power to the lighting system, the design of the UPS also completely isolates the airfield power system harmonics from the rest of the airport electrical distribution system, where these harmonics were causing disturbances. The solution integrated harmonic mitigation into the fundamental design, without the need for installing costly external harmonic mitigation equipment, which is currently being used in other areas of the airport.

The result is a highly efficient and reliable system that intelligently reacts to a utility power failure, only running the generators when required during a utility power outage, which can start and transfer to generators without any interruption to the airfield lighting. A safer system for a safer airport.

ACHIEVEMENTS

The key achievements of the YVR Flywheel Energy Storage project are:

- Significant improvement in airfield lighting system's reliability and availability.
- Immediate and significant reduction of the carbon footprint due to emissions.
- Implementation of a new highly reliable and redundant airfield lighting power supply system which far exceeds the capabilities of the existing system.
- Application of specialized flywheel technology for the first time in a commercial airport anywhere in the world, allowing for reduced environmental impact, and reduced operation and maintenance costs.
- Design expectations and objectives for an efficient and intelligent airfield lighting power supply system were met and exceeded.

Flywheel UPS System

Generator and Switchgear Room

TECHNICAL EXCELLENCE AND INNOVATION

FLYWHEEL UPS ENERGY STORAGE

A flywheel energy storage system was implemented with a UPS system to provide reliable and continuous power to the airfield lighting. Flywheels are extremely energy dense, and have significantly reduced environmental, operational, and maintenance impacts when compared to batteries, which are used with conventional systems. The use of flywheel energy storage is the first application of the technology in any commercial airport in the world

INTELLIGENT SWITCHGEAR

The backbone of the new airfield lighting power distribution is the intelligent switchgear. The switchgear was designed to be fully automated and intelligent, with the ability to select and synchronize power to the airfield lighting from either the BC Hydro utility power source, or from one or both generators. Additionally, the switchgear monitors all the power and energy consumption and starts and stops the generators as required to maximize the efficiency of the system.

AIR SOURCE HEAT PUMPS

All diesel generators need to have the engine jacket water heated while the generator is not in use. Traditionally, this involves large electric heating units which run continuously all year. Instead of electric heaters, WSP designed air source heat pumps which take heat out of the ambient air and compress it to high temperatures, which is then run through a heat exchanger loop with the generator engine jacket water.

SEAMLESS SWITCHOVER AND COMMISSIONING

The new airfield lighting system was required to be constructed, tested, commissioned and switched into service with minimal interruption to the airfield lighting. The new system was designed around the previous system, utilizing existing space without impacting operation of the system. A complex switchover and commission plan was developed and executed to switch the new system into service while simultaneously disconnecting and removing the existing system from service, without disruption to the north airfield lighting system.

Intelligent Switchgear

High Efficiency Generators

ENVIRONMENTAL, ECONOMIC AND SOCIAL SUSTAINABILITY AND AESTHETIC ASPECTS

ENVIRONMENTAL SUSTAINABILITY

The following features of the project enhance long term environmental sustainability and protection:

- Significantly reduced greenhouse gas emissions from diesel generators, as the new system is more efficient and only requires the generators to run approximately one tenth of the amount of time that was required by the original system. The new system reduces greenhouse gas emissions by approximately 6.45 tonnes annually, resulting in a 90% reduction in total emissions over the previous system.
- Use of the flywheel energy storage eliminates the disposal of large quantities of hazardous batteries, which would typically be required every five to seven years in conventional battery-based systems.
- Use of air source heat pumps to provide the necessary generator jacket water heating, through use of heat from the ambient air instead of large electrical heaters, resulting in an average reduction in energy consumption of 46,650 kWh per year.

ECONOMIC SUSTAINABILITY

Financial benefits from the project are realized through reduced operation and maintenance costs due to intelligently-operated power systems and new modern generators. It is estimated that annual operation and maintenance costs will be reduced by an average of 73%. A large portion of this cost reduction is due to the significantly reduced runtime of the generators because of the flywheel UPS system. Fuel savings alone are reduced by an average of 68,000 L per year, resulting in a 78% lower annual fuel consumption rate compared to the existing system.

SOCIAL SUSTAINABILITY

The primary objective of a power distribution system for an airfield lighting system is safety and reliability. The focus of this project was to significantly increase the reliability of the system to minimize delays and maximize safety for the 22 million travellers at YVR, a major international airline hub. The new system ensures that the north airfield lighting reliability is significantly increased, and that delays commonly associated with weather events will be dramatically reduced.

AESTHETIC ASPECTS

Although function often takes precedence over aesthetics in engineering, the physical appearance of a project usually garners the most attention. Given the significant public visibility of airports, the project has been designed to be integrated into the existing terminal building while eliminating visual impact from both the terminal and runways. There were specific considerations implemented for aesthetics, including hiding exhaust discharges and using architectural louvres that seamlessly blend in with the existing terminal building. Additionally, WSP implemented high noise reduction sound attenuation measures to mask the sound of the running generators from the public. The installation preserved the high-quality aesthetics of the YVR airport terminal, while also providing full functionality of the system and an effective and safe environment for the operators.

wsp