Electricity Engineers' Association

Annual Power Engineering Exchange

APEX | 2016

MANAGING UNCERTAINTY AND RISK

AUCKLAND—6TH SEPTEMBER
UNIVERSITY OF AUCKLAND

Professional Development Programme

8.30am	**Registration, Arrival Tea & Coffee**

8.55am	**Welcome—Peter McClean—EEA Board member**
9.00am	**Tom Wollerman**—Transpower: Catenary Support System Development
9.25am	**Kelsey Keenan**—Meridian Energy: Te Āpiti Generator Investigation
9.50am	**Bary Babu**—Counties Power: Supporting Franklin District Growth
10.15am	**Harshal Patel**—Beca: Waterview Connection Tunnel - HV System Supply
10.40am	**Morning Tea**
11.00am	**Tiantian Xiao**—Hamer Limited: Thermal Performance of Low Voltage Network Switchgear
11.25am	**Terrence Ibasco**—Beca: An introduction to earth potential rise
11.50am	**Mitchell Beggs**—Meridian Energy: The crude reality of oil
12.15am	**Torry Hanson**—Mitton ElectroNet: Earthing Safety in Design
12.40pm	**Lunch**
1.15pm	**Marcel Van Mellaerts**—Northpower: Lungga power station expansion project
1.40pm	**Michael Hammerich**—Powerco: Mitigation of Arc Flash Hazards
2.05pm	**Daniel Pugh & Jarrod Wyatt**—Meridian Energy: Intake Screen Refurbishment across Meridian's Assets
2.30pm	**Jichao Chen**—AECOM: Impact of resistive grounding during bushing failure
2.55pm	**Afternoon Tea** ***CAST YOUR VOTE FOR THE BEST APEX PRESENTATION - PEOPLE'S CHOICE AWARD***
3.20pm	**Panel Discussion** Session facilitated by **Jasleen Kaur**—Beca ***Helping graduate engineers mature into capable industry professionals: challenges, experiences and ideas*** Panellists: **Rui Ding**—Beca; **Archana Devi**—Transpower; **Sol Friedman**—Wellington Electricity; **Robbie McIvor**—Transpower
4.20pm	**Presentations—Joint EEA/CIGRE Best APEX Presentation Award and People's Choice Award** **Closing Comments—Peter McClean—EEA Board member**
4.40pm	**Social Function**
6.00pm	**Close of APEX 2016 Summit**

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ABOUT THE PRESENTERS

8.30am **Registration, Arrival Tea & Coffee**

8.55am **Welcome from Peter McClean—EEA Board Member**

9.00am **Tom Wollerman—Transpower**

Tom Wollerman studied mechanical engineering at the University of Canterbury, graduating in 2014. Since graduating, he has been on Transpower's Graduate Programme and he recently spent 8 months working on the Bunnythorpe-Haywards re-conductoring project where the Catenary Support System has been developed and deployed.

Catenary Support System Development

As part of Transpower's Bunnythorpe to Haywards re-conductoring programme, Electrix, Beca, and Transpower have been developing an innovative type of crossing protection, the Catenary Support System (CSS). The CSS was primarily developed to address the risk associated with re-conductoring over suburban areas such as Waikanae, where numerous dwellings have been built under the transmission line since its construction, and as a tool in Transpower's arsenal for crossing roadways, railways, and other electrical assets.

The CSS uses a high strength Dyneema rope deployed above a conductor, across an entire span. Suspended from the rope are a series of lightweight nylon blocks, manufactured in Hamilton, that support the conductor in the event that the conductor breaks or loses tension.

Traditionally, crossings requiring protection have been mechanically protected by assemblies ranging from simple 'H' structures to extensive scaffold gantries. The assemblies are typically placed either side of the crossing and may have a net between them depending on the level of protection required.

The CSS can be used in place of traditional hurdles and has several distinct advantages. The CSS is deployed over an entire span in a matter of hours, eliminating the requirement for a separate hurdle for each crossing within the span. The CSS can also be deployed over motorways and railways without requiring their closure and even be deployed over live substations removing the uncertainty surrounding outages and closures.

9.25am **Kelsey Keenan—Meridian Energy**

Kelsey Keenan is a Graduate Electrical Engineer with Meridian Energy. She has been working for Meridian since 2014 on their hydro generation sites in the Waitaki Valley and Manapouri where she has worked in large scale project teams as well as managing work packages of her own. She has been in Strategic Engineering Team where the focus was on the long term direction of the plant and then more recently in the maintenance side with the Tactical Engineering Team. At the start of 2016 she rotated into the Wind Engineering Team where she has predominantly been investigating generator failures at Te Āpiti.

Te Āpiti Generator Investigation

Te Āpiti is a windfarm based in the lower North Island, it has been operating since 2004 and was the first windfarm that Meridian built. It has 55 NM72 turbines which each contain a 1.65MW induction generator connected via a gearbox to the main shaft. There have been occurrences of failed generators on the site since 2007 with a significant number having been replaced across the span of the farm.

Meridian have been investigating these failures to identify any contributing factors which could be addressed to help mitigate the risk of multiple failures. There are many different aspects to this including sorting through historical work records, trending the generator monitoring data pre-failure and testing our fleet to quantify the present condition of generators across the farm. This information can then be used to identify some changes to our processes to help identify issues early so we can manage repairs effectively or even prevent them from occurring. The following presentation will cover how we have approached this investigation, what we have found out, the testing we have been conducting and the recommendations made as a result of this work.

9.50am **Bary Babu—Counties Power**

Bary Babu is a Planning engineer, who has been with Counties Power for the past 5 years. Bary's role involves short to long term network planning, protection and control scheme development, and network augmentation projects. She has a B.E. (Hons) degree from Auckland University of Technology

Supporting Franklin District Growth

Counties Power has been providing reliable electricity supply to residential and industrial customers in the Franklin district for over 90 years. The strong growth in the Franklin district has led to the need to reinforce electricity supply in the Tuakau area. This was primarily driven by Watercare services upgrade and a new dairy processing plant development. The supply reinforcement considered a range of options. The optimal solution was to construct two new 110kV lines and establish a new 110/22kV zone substation. A Tuakau zone substation project was initiated in late 2013 for 2015 completion. Management of risk and uncertainty were critical aspects of this project. The key considerations were given to,

- Reliable forecast of future growth, and optimise asset rating and utilization
- Optimal site and line route selection, and securing easement agreements with individual property owners
- Quality assurance of new equipment and design
- Maintain secure and reliable supply to customers during construction.

10.15am **Harshal Patel—Beca**

Harshal Patel is a Power Systems Engineer at Beca, joining after the completion of his degree at AUT University in 2012. Since joining Beca, Harshal has undertaken a range of projects in the Generation, Distribution and Transmission sectors with experience in Primary, Secondary and Industrial designs.

Waterview Connection Tunnel

The Waterview Connection project, a NZ Government asset being delivered by the NZ Transport Agency and its contractors the Well-Connected Alliance, is the largest most complex infrastructure project to be undertaken in New Zealand, to date. Once completed the project will complete an alternative route around Auckland, unlocking the potential to become a truly world class city.

A tunnelling project of this scale requires a resilient HV system to supply power to major mechanical loads such as tunnel exhaust fans which control the emissions from vehicles in the tunnel, jet fans which are used to dissipate smoke during fire scenarios and large pumps to extract water collected at the lowest point in the tunnel to dedicated sumps. The failure of such services presents risks from an economic and health & safety standpoint.

The sudden closure of the tunnel due to loss of major services would result in a ripple effect of traffic congestions across Auckland's motorway networks with direct impact to the economy, build-up of emissions from non-flowing traffic and an inability to extinguish fires within the tunnel.

The HV system at the Waterview Connection consists of two 22 kV indoor substations located at the northern and southern end of the tunnel supplied from two different distribution zone substations with two 22 kV cables connecting the two substations together to form a redundant ring for security of supply.

This presentation will give an overview on the design of the HV network with a high level discussion on the protection philosophy and the technical challenges faced during construction.

10.40am **Morning Tea**

11.00am **Tiantian Xiao—Hamer**

Tiantian Xiao is a 3rd Professional Year Undergraduate Student at the Department of Electrical and Computer Engineering, University of Canterbury. She received an EEA scholarship in 2016.

Thermal Performance of Low Voltage Network Switchgear

Low Voltage (LV) network switchgear assets are often located in publically accessible places: on berms, in footpaths and driveways, for which public safety as well as operator safety is a paramount consideration.

The first step in providing assurance about the safety of LV network switchgear is to demonstrate that its design complies with the requirements set out in AS/NZS 3439. The objective of this standard, as set out in Part 1, is to define service conditions, construction requirements, technical characteristics and testing for LV switchgear and control gear assemblies. Part 5 includes particular requirements for assemblies for power distribution in public networks.

It is entirely practicable to demonstrate, through type testing, that LV network cabinets and enclosures are compliant with AS/NZS 3439; and this requirement is widely (though not universally) specified by New Zealand electricity network operators.

On the other hand, the thermal performance requirements set out in AS/NZS 3439 are not generally verified for assemblies for network applications, even though these include temperature limits which, if exceeded, could jeopardise the integrity of the asset and present a risk of harm to members of the public and damage to property. This reflects in part the practical challenges of testing each and every design of LV network switchgear: there are many variants of distribution frames, link pillars and service connection boxes, and indeed installations can be site specific.

This paper presents a multi-factor thermal model that was developed to provide a quantitative assessment of the temperature limits of practical configurations of LV network switchgear. The model takes into account engineering variables such as component and materials selection, dimensions, conductor sizing, inter-connections and fuse ratings.

The results of the model were compared with the results of a series of thermal performance tests conducted on a new range of underground LV network switchgear. This has been developed to provide an inherently safe option for the installation of distribution frames, link pillars and service connection boxes that avoids issues of public amenity and visual impact.

A brief discussion is included of the design features of the product range. These address known safety and operational issues associated with earlier generations of underground LV switchgear.

11.25am **Terrence Ibasco—Beca**

Terrence Ibasco completed his Bachelor of Electrical and Electronic Engineering from The University of Auckland in 2012. He has been working as a Power Systems Engineer at Beca focusing on Primary Substation design. Other work include arc flash assessment for local and overseas clients, and EPR studies for major clients such as Transpower.

An Introduction to Earth Potential Rise

One of the first principles taught in Electrical Engineering is that ‘ground’ or ‘earth’ should always be at zero voltage. Locations in the Power System which should not induce a potential difference must be referenced and connected to this common point. Earthing of substation equipment, support structures and towers is achieved via connection to the underground earth grid using copper conductor. Ideally, a well-designed earthing system ensures that the full fault current will flow safely back into the ground.

However, in reality, everything has an impedance and when current flows through a resistive element including soil, voltage is produced thus raising the local earth potential. This phenomenon is called the Earth Potential Rise (EPR). EPR gives rise to touch, step and transferred voltages. Touch voltage is the potential difference between the hands and the feet while step voltage is between two feet. Transferred voltages refer to the voltage transmitted along nearby metallic fences or underground services like gas/water pipes and communications cables.

These hazards can be lethal if not dealt with. Mitigation measures include asphalt layering, additional buried copper and installation of isolation in fences to name a few. Awareness of EPR is the first step in ensuring the reliability of the Power System and safety of electricity workers, the public and connected customers.

11.50am **Mitchell Beggs—Meridian Energy**

Mitchell Beggs completed his BE (Hons) in Mechanical Engineering at the University of Canterbury in 2014. Following a summer placement with Meridian Energy in 2013/14 he secured a graduate mechanical engineering position starting in February 2015. Currently part of the Tactical Engineering Team located in Twizel, Mitchell is involved in projects across all of Meridian's hydro assets in the Mid Waitaki, Upper Waitaki and Manapouri sites.

The Crude reality of Oil

Oil is very important in ensuring reliable operation of generating equipment. It is a major component of shaft bearings, governor systems, and transformers. Oil is used in this equipment for lubrication, wear reduction, cooling, and as an insulator. A condition monitoring programme looks at the oil particle count, element content, and water content. The results allow Meridian to assess the current condition of the oil, as well as see if any equipment is wearing excessively, and assess its risk of failure. The results of the condition monitoring have indicated that much of Meridian's oil is at end of life and an oil replacement programme has been initiated to address this. The oil replacements have provided a unique opportunity to look inside oil pipework, tanks, and servos to assess the condition of our plant.

The following presentation describes Meridian's oil condition monitoring programme, analysis of condition monitoring results, and resulting actions from the analysis. Also included is a case study of Manapouri's main unit transformer failure, and whether an oil condition monitoring programme could have predicted the failure earlier.

12.15am **Torry Hanson—Mitton ElectroNet**

Torry Hanson has two years' experience in the power industry, and has already been involved in a diverse range of projects. During his last year of study, Torry worked for Mighty River Power within the geothermal division working on asset management studies for several of the geothermal power stations within the central North Island, NZ. Since completing his degree with the University of Canterbury in 2014, Torry secured a full time job at Mitton ElectroNet as Graduate Engineer within the Earthing Team.

Within the earthing team Torry has been utilising his problem solving skills working on earthing related projects, namely: soil resistivity analysis, earth system modelling/design right through to on-site earth system testing. Additionally, Torry has been responsible for modelling various HV cable arrangements under steady state and transient conditions. Aside for technical related aspects, Torry has been honing his project management skills by managing projects for key clients.

Earthing Safety in Design

Safety in Design has become an intrinsic process for engineers today, to ensure that their designs achieve safe outcomes for personnel working onsite. This concept is relevant and has direct implications while assessing the earthing safety of a substation. When new equipment is installed or maintenance is carried out at a substation that has been determined hazardous in terms of touch, step or transfer potentials, there are certain factors that contractors should be aware of, and necessary precautions to take to eliminate uncertainty and reduce risk. Gardiner (K) Zone Substation is a United Energy asset located in Melbourne, Victoria. In 2015, the site was tested by Mitton Electronet (MEL) and multiple hazards were identified within and around the site. Earlier this year (2016), a harmonic filter and its associated switchgear were installed within the same substation and the contractor completing the installation engaged MEL to model the site, and provide recommendations to ensure their personnel would be safe during the installation phase. The site was re-tested in July this year to determine whether the site had been made safe post-installation. This type of analysis is covered extensively in Australia, and should be considered for future work within New Zealand.

12.40pm **Lunch**

1.15pm **Marcel Van Mellaerts—Northpower**

Marcel Van Melllaerts started working for Northpower in 2011 as a trainee electrical engineer. In his current position as a Design & Commissioning Engineer, Marcel is responsible for earth grid design and modelling, off-shore generation and substation projects, and the development of electrical conceptual and detail design drawings. He also has experience in power system modelling and analysis, protection schemes, project management and training.

Lungga Power Station Expansion Project

Risk and uncertainty may be prevalent when integrating new equipment into an existing network. If not managed effectively personnel and equipment safety can be compromised. In Honiara, Solomon Islands, Northpower was the Electrical contractor responsible for designing, procuring, building and commissioning the electrical balance of plant for the Lungga 10MW Diesel Power Station. From conceptual design and pricing through to commissioning and hand-over, uncertainty and risk has been managed effectively to achieve a solution for all stakeholders involved.

- Some of the key uncertainties and risks that were managed closely include:
- Contract structure – Based on a FIDIC Contract
- Stakeholder management
- Safety by design
- Meeting the employer's requirements
- Integrating into the existing network
- Commissioning activities
- Unexploded Ordinance and working in the local environment

The Lungga power station expansion project was extremely demanding for all personnel involved principally due to delays leading to an extremely condensed time frame for the delivery of Northpower's component of the works. Uncertainty was present from the project outset and required the active management of a number of extraordinary risks in order to build Honiara's largest power station.

1.40pm **Michael Hammerich—Powerco**

Michael Hammerich completed his studies at the University of Canterbury in 2014 before starting as a Graduate Electrical Engineer with Powerco. He has been in Powerco's Graduate Programme since January 2015, where he has been rotated through the Technical Services, Planning and Design teams. These different departments have given him experience in various aspects of distribution engineering such as, writing company policy, planning renewal projects, and the design of the overhead network and substations. Once finishing his time with the Design team he will move into the Protection Team and then into Service Delivery to complete the Graduate Programme.

Mitigation of Arc Flash Hazards

Arc flash is a health and safety risk that any public or personnel is exposed to when coming within close proximity to live equipment. Arc flash occurs when an uncontrolled current arc of significant magnitude is initiated – either through equipment failing catastrophically, or breakdown of insulation systems. This arcing releases a large amount of explosive energy in the form light, sound and heat. Nearby public or personnel can be inflicted with burns and bruising from the blast, sometimes so severe that they result in death. Powerco has recently completed a project to quantify the energies that could be released in the event of a flashover within any one of their 115 zone substation 11kV switchboards. The investigation identified 27 sites exceeding the heat protection limitations of their standard category 2 PPE. The magnitude of arc flash energy that personnel are exposed to is influenced by the fault current, distance from the arc and the protection duration at the point of the arcing. This information in conjunction with risk management techniques were used to change Powerco's operational procedures and implement various mitigation measures. Through these actions Powerco has managed reduce this number of substations with excessive energies to four, creating a safer network for staff and contractors.

2.05pm **Daniel Pugh & Jarrod Wyatt—Meridian Energy**

Daniel Pugh is in his second year of Meridian's Graduate Programme as a Mechanical Engineer. He completed his first year of the programme in Twizel working among the Tactical Engineering team on various projects around Meridian's hydro assets. His current rotation sees him working at West Wind as part of the Wind Engineering team.

Jarrod Wyatt is a recent graduate from the University of Canterbury and now works as a Graduate Mechanical Engineer for Meridian Energy. He is currently based in Twizel as part of the Tactical Engineering Team where he is involved in a number of different projects around Meridian's hydro sites.

Intake Screen Refurbishment across Meridian's Assets

Like many asset owners, Meridian is faced with aging equipment and plant. Unlike much of the equipment in a power station which is constantly maintained and refurbished intake screens are often a forgotten gem, despite their importance as a protective barrier for the rest of the plant. Intake screens form the first and last barrier to prevent foreign objects from entering the penstocks and subsequently, the generating plant.

Until recently there has been much uncertainty as to the condition of intake screens beneath the water's surface. In recent years many of Meridian's intake screens were found to have suffered varying levels of corrosion, with all screens requiring some form of refurbishment or replacement. The corrosion present on the screens reduces their structural strength and will only worsen if no remedial work is carried out.

The following presentation covers the assessment undertaken to ascertain the condition of Meridian's intake screens, including determining how much corrosion is acceptable before the screens are unfit for further service. It will also discuss the best protective coating systems to lengthen the life of the screens and prevent the risk of failure between refurbishments.

2.30pm **Jichao Chen—AECOM**

Jichao Chen completed his Master of Engineering (Electrical and Electronic) with First Class Honours at The University of Auckland in 2014. He has worked with AECOM Auckland Transmission and Distribution team since March 2015 as an electrical engineer. Jichao has been involved in numbers of projects in Australia and New Zealand, including detailed protection system design, cable and earthing system design.

Impact of Resistive Grounding during Bushing Failure

In July last year, a transformer in Horizon Energy's Kope substation suffered a significant failure on one of its bushings. It caused a few feeders tripping. AECOM was engaged to investigate the event. There were some welcome and unwelcome attributes of changing from solid grounding to low resistance grounding. This presentation will talk about what happened, what was found and the lessons learnt from the event.

2.55pm **Afternoon Tea—Cast your vote for the Best Presentation - People's Choice Award**

3.20pm **Panel Discussion, facilitated by Jasleen Kaur—Beca**

Jasleen Kaur is a Graduate Power Systems Engineer at Beca. She has been working with the team since November 2014 when she started as an intern. She moved to Auckland from India in 2012. As a university student, she spent a lot of time being involved with groups like IEEE (Institute of Electrical and Electronics Engineers) as the Chair of the Student Branch at the University of Auckland, and the Women in Engineering Network (WEN). She is currently the Chair of the IEEE Young Professionals Committee for the NZ North Region. The committee aims at providing a platform for the young professionals in the industry to come together and share ideas for a brighter and smarter future.

Helping graduate engineers mature into capable industry professionals: challenges, experiences and ideas

Panellists: **Rui Ding—Beca**, **Archana Devi—Transpower**, **Sol Friedman—Wellington Electricity**, **Robbie McIvor—Transpower**

New Zealand's electricity supply industry can be broadly divided into six sectors: generation, transmission, distribution, retail, consumption, and regulation. Engineers with the right knowledge and experience are needed in every one of these sectors if New Zealand is to maintain a robust, sustainable and agile network.

Students may perceive that little is done to familiarise them with the types of roles available in the industry, or with the type of training, experience and personal traits they will need in order to thrive there. Graduate engineers may also seek rotation programmes that will expose them to various sectors of the industry, give them a broad technical knowledge and professional skills, and enable them to decide which sector they would be most motivated in working in.

On the other hand, some could argue that training solutions and rotation opportunities are already in place. Job mobility within New Zealand and overseas may however create disincentives for recruiters to further invest in graduate training.

This panel discussion will aim at highlighting a range of views, from both the panel participants and the audience, on challenges (current or anticipated) faced by graduates and the industry. It will touch upon experiences in New Zealand and overseas, and examples of training method adopted overseas. It will also talk about some of the measures already in place in some parts of New Zealand and see how those could be rolled over across the industry.

4.20pm **Awards Results—Joint EEA / CIGRE Best APEX Presentation Award and People's Choice Award**

4.40pm **Social Function**

6.00pm **Close of APEX 2016**

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