A 2-Day Professional Development Seminar on

Integrating Renewable Energy Systems into Power Grids

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Overview

The integration of new Renewable Energy Systems (RES) into existing AC electric power grids can present many and varied challenges to project developers, system planners and equipment manufacturers. This seminar will give practical insights into the issues that could be faced and the considerations that should be made by all project participants. The seminar will focus on those renewable energy resources (wind, solar) where the use of modern power electronic converters has become critical for their successful integration. Case studies describing the integration of several recent Renewal Energy projects will be highlighted.

Seminar Outcomes

This seminar will broaden participants' practical knowledge and understanding in relation to:

- **Basic power system operation including frequency and voltage control concepts.**
- **The generation technologies that form part of a typical RES development.**
- **The application of modern power electronic converters.**
- **How power electronics can assist with the integration of large scale RES into existing power systems.**
- **Issues confronting the power industry around the world due to large scale RES developments.**
- **What can RES do to minimise their impacts both at the connection point and more widely?**
- **How RES developments and their limitations can have network impacts "beyond the farm gate".**
- **Issues related to modelling and data provision, including National Electricity Rules (NER) requirements.**

Seminar Leaders' Profiles

Dr. Mark Davies, ***B.Sc.(Comm), PhD, MIEAust***, is the System Performance Team Leader for Transend Networks Pty Ltd. He received his B.Sc.(Electrical/Electronic) and Ph.D. (Converter Control Systems) degrees from Staffordshire University (UK) and has over 25 years' experience in electric power systems starting with GEC in 1981. He worked on the UK's first power electronic converters for AC grid applications and since the mid 1990's, has focused his research interests on high power Voltage-Sourced Converters (VSC) for reactive power control and HVDC transmission. Since the early 2000's, the application of such technology has grown significantly in line with the worldwide increases in renewable energy developments. Mark joined Transend in 2011 after an extended period of employment with Siemens AG as a consulting engineer.

Andrew Halley, ***B.E(Hons), GAICD, MIEAust, MIEEE,*** is the Principal Operations Engineer for Transend Networks Pty Ltd. He received his B.Eng (Electrical) degree from the University of Tasmania in 1997 and commenced work with Hydro Tasmania Consulting (now Entura) as a graduate engineer in Power System Department (PSD) in 1998. Andrew joined Transend in late 2006 as a Senior System Performance Engineer and became Principal Operations Engineer in 2011. His role now includes technical assessment of all new network connections (load and generation), real time operations support including commissioning oversight, and investigation of issues affecting the future direction of the Tasmanian power system, including the impacts of significant renewable energy developments. Andrew is a member of the Plant Modelling Reference Group (PMRG) convened by the Australian Energy Market Operator (AEMO) as well as CIGRE Australian Panel C4.

Transend Networks Pty Ltd (Transend) is the Transmission Network Service Provider (TNSP) for the Tasmanian region of the National Electricity Market (NEM).

Who Should Attend?

This seminar is aimed at engineers, technicians and managers who are interested in or need to broaden their understanding of the issues involved with Renewable Energy Systems. A step by step approach to knowledge build-up will be taken but tertiary education in electrical engineering (or similar science based disciplines) is recommended. After this two-day seminar the participants will become more conversant in the topic of Renewable Energy Systems and better equipped to plan, build and manage more future projects!

CPD Recognition

This technical seminar is designed to meet the Continuing Professional Development (CPD) needs of participants. A Certificate of Attendance will be awarded at the end of the program. This serves as evidence of your personal and professional commitment to building your career.

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Seminar Contents

DAY 1 - Dr Mark Davies

Introductory Sessions

1. **Overview of Renewable Energy Systems**
   All renewable energy systems still integrate with existing electricity grids as either synchronous or non-synchronous generators. It is important to understand the differences and commonalities between the various renewable technologies so that their potential impacts can be identified.

2. **Synchronous power systems**
   Participants will gain an understanding of how AC power systems function. The concepts of "synchronous" and "non-synchronous" generation will be explored in more detail including the role power electronic converters play. Examples from wind and solar generating systems will be provided.

3. **MW and MVAr control**
   It is important to understand the impacts of MW and MVAr flow in AC grids and how both can be controlled. The two axis (d,q) equations and concepts of symmetrical components will be reviewed given their application in many control algorithms used by power electronic converters.

Technology Sessions

4. **Asynchronous generators**
   Induction machines were amongst the first type to be used as Wind Turbine Generators (WTGs). The main attributes of these and other asynchronous generators will be described including solar. A running simulation model will be provided and used to explain operation in more detail.

5. **Commercially available WTG types**
   The three most common types (1/2, 3 & 4) of WTGs will be described and their relative advantages and disadvantages will be reviewed in the context of network integration issues.

6. **PWM converters**
   This type of converter is dominant in the field of renewable energy including small scale solar systems. Various types will be described along with their operating characteristics, including how their phase locked loops (PLLs) can impact on fault performance.

7. **Use of VSC HVDC for RES integration**
   The basic concepts of this form of HVDC will be introduced. The two variants will be described and the relative advantages and disadvantages will be examined. How the controllability of VSC HVDC can help facilitate the connection of RES will be discussed including frequency control, voltage control and potential contributions to system damping performance.

8. **Harmonics and resonance**
   The use of converter technologies can bring about power quality issues. The causes and effects of harmonics will be described and mitigation methods examined. The issues associated with shunt capacitors common in RES developments will also be examined including appropriate discharge methods.

DAY 2 - Andrew Halley

Introductory Session

1. **Experiences with RES to date**
   Even very large power systems are beginning to feel the impacts of renewable energy developments in their various forms. This opening session will review a number of overseas experiences and consider how these relate to Australia – now and in the future. A number of significant grid integration issues will be introduced.

Technology Sessions

2. **The issue of Fault-Ride-Through (FRT)**
   A term applied, often loosely. What are the basic issues behind FRT and how does fault location, fault type and clearance time affect the outcome. What are the mechanisms that might contribute to an unsuccessful FRT event?

3. **Impacts of RES on frequency control**
   The concept of transient energy loss will be explored and its impacts on system frequency control explained including increased rates of frequency change (df/dt). Impacts on Frequency Control Ancillary Services (FCAS) and the design of under and over frequency protection schemes will be considered. What should be the future expectations?

4. **Impacts of RES on system stability**
   It is becoming evident that different types of RES can impact power system stability due to their fault response characteristics and inherent "decoupling" through power electronic converters and their controls. Potential influences on transient and voltage stability, as well as system damping will be reviewed.

5. **Practical implementation of reactive power control schemes**
   Coordinated reactive power control, typically involving multiple items of plant in large scale RES developments, can be more difficult than initially appreciated. A range of typical control strategies (Q, p.f, voltage control) will be reviewed along with their advantages and disadvantages. The concept of "droop control" will be developed.

6. **Protection issues to be aware of**
   While accounting for synchronous machines in fault level studies (both on and offline calculations) is relatively straightforward, what are we doing with RES? What data is available to investigate such issues? What other network protection issues need to be considered, e.g. for anti-islanding?

7. **Modelling requirements**
   The complexity of RES technologies and their potential impacts on system operation demand that quality modelling information be made available to support new connections, especially at transmission voltage levels. The National Electricity Rule (NER) requirements will be reviewed along with work being undertaken by CIGRE to account for embedded generation in distribution networks.

8. **The Tasmanian RES story so far…**
   Many of the technical issues covered above will be brought into context with a general discussion on how the Tasmanian power system is being affected by large scale renewable energy developments and the types of issues that Transend, in conjunction with AEMO, are presently grappling with.