Microgrid Energy Management System
- A short course jointly organized by Power Engineering Division, School of Electrical and Electronic Engineering, NTU and IEEE Singapore Section -
(Last updated on Aug 18, 2010)

Introduction

The electric power industry is rapidly moving towards information rich microgrids. In the next 5 to 10 years, distribution power grids around the globe will be transformed through innovations driven by the availability of information and communication infrastructure. The two-way data communications across the grid allows real-time monitoring and control of the grid performance. The design and deployment of such an advanced and reliable information and communication infrastructure is certainly a challenge but it is a fundamental requirement for making today's grid “smarter”.

Distributed generation (DG) technologies such as wind power generation, photovoltaics, fuel cells and micro-turbines are expected to play a significant role in future electricity supply and low carbon economy. However, the increase of DG penetration depth in the power system will bring a new challenge for operating the power system safely and efficiently. This challenge can be partially addressed by a microgrid which is a cluster of DGs and loads interconnected to the distribution network. The microgrid technologies will allow the grid to better adapt to the dynamics of DGs, permitting them to provide their full benefits. Because the intermittent output power of renewable DGs such as solar and wind power, energy storage is required in the microgrid. With the four-quadrant operating capacity of the energy storage, the microgrid can easily control the bidirectional power flow and maintain system instantaneous power balance. The energy storage systems in the microgrid can be batteries, flywheels, super-conducting magnetic energy storage (SMES) or supercapacitors.

This course presents the research and development work of the A*STAR funded Microgrid Energy Management System (MEMS) project at NTU. It comprises Scheduling and Forecasting functions, Network Applications functions and its associated energy sources which may include micro-turbines, traditional generators and renewable energy sources, power converters, sensing and communication devices. It focuses on the design of software algorithms and control schemes that can be used for minimizing the schedule cost or maximizing the revenue of MEMS. More importantly, the proposed MEMS could ensure the secure operation of energy distribution systems. While courses related to MEMS have been conducted in both the United States and Europe, this course is unique as it showcases the laboratory prototypes for testing new devices, control schemes and market policies/standards/rules related to future development of microgrids in Singapore and the region. Some results of MEMS will be presented. The proposed system helps not only in bringing down electricity bills but also helps in reducing the CO₂ emission. The exploitation of the proposed MEMS for a community, district, shipyard, or port in Singapore is tremendous.

Details of the A*STAR funded MEMS project are available at http://eeeweba.ntu.edu.sg/IEDS.

Course Objectives

With the increase in energy consumption and the depletion of fossil fuels, the electricity prices of conventional generating sources have increased steadily. The increased CO₂ emissions have influenced the global climate change. In light of these changes, the environment and energy experts have reached a consensus to move towards renewable and alternative sources and to use energy resources more efficiently. In this context, microgrids and/or smart grids which provide intelligence for monitoring and control of distribution systems can play a significant role as a platform for incorporation of renewable and alternative energy sources.
With the introduction of competition and market operations in Singapore, energy efficiency could further be improved through active demand side participation. As a nation without natural resources, it is important for Singapore to invest in clean energy sources, microgrids and innovation to enhance the efficiency of its supply system and to better position Singapore for its energy needs.

This course aims at covering how technology enhances the efficiency of the energy supply system. It discusses the basic concepts of the proposed Microgrid Energy Management System, renewable energy sources, power converters, their interface through sensing and communication technology. In addition the status of the Singapore energy distribution system, electricity market and the Intelligent Energy System project initiated by Energy Market Authority (EMA) will be briefly discussed. Towards the end of the course, research works conducted at NTU will also be reported. Specifically, the setup and benefits of MEMS at NTU will be discussed and a real-time demonstration of MEMS built by the team will be conducted. Figure 1 shows the laboratory prototype of MEMS at NTU.
Course Outline

Overview and Introduction
- Global energy needs
- Renewable energy technologies: opportunities and barriers
- Distributed generation versus centralized generation
- Microgrids: benefits and challenges

Microgrid Energy Management System (MEMS)
- Proposed MEMS
  - forecast and scheduling functions
  - network applications functions
- Future development of MEMS
  - advanced metering infrastructure
  - demand side management
  - demand response management
  - electric vehicles
  - shore power

Advanced Sensing and Communication Technologies
- Smart power sensors
- Wireless communication technologies (Wi-Fi, RF, GPRS, 3G and WiMAX)

Converter Design, Operation and Control for Microgrids
- DC/DC converters: boost converters, voltage-lift converters and super-lift converters
- DC/AC inverters: pulse-width-modulated (PWM) voltage source inverters
- Fundamentals, operation principles and control of clean and renewable energy sources such as photovoltaic, wind, fuel cells and micro-turbines.
- Synchronization and maximum power point tracking
- Necessity of energy storage within the microgrid
- Types and control of energy storage

Demonstration of MEMS
- Components of microgrid setup at Laboratory for Clean Energy Research (LaCER)
- Operation and control of MEMS

The details of the finalized course schedule will be available at http://eeeweba.ntu.edu.sg/IEDS a couple weeks before the scheduled course date.
Instructors

H. B. GOOI received his PhD degree from Ohio State University in 1983. From 1983 to 1985 he was an Assistant Professor in the EE Department at Lafayette College. From 1985 to 1991, he was a Senior Engineer with Empros (now Siemens), USA where he was responsible for the design and testing of energy management system (EMS) projects. In 1991, he joined the School of EEE, NTU as a Senior Lecturer. Since 1999, he has been an Associate Professor. In September 2008, he was appointed Deputy Head of Power Engineering Division. He is a registered professional engineer in USA and Singapore and a Program Manager of A*STAR Intelligent Energy Distribution System, NTU. He taught EMS courses for dispatchers and managers at Power System Control Centre in Singapore, Indonesia and Malaysia. He participates in the EMA-NTU Intelligent Energy System Pilot Project launched by EMA.

P. L. So received his BEng degree (first class honours) in Electrical Engineering from the University of Warwick in 1993, and his PhD degree in Electrical Power Systems from Imperial College, University of London in 1997. He worked as a Protection Engineer in China Light & Power, Hong Kong for 11 years before joining NTU in 1997. Currently he is an Associate Professor in EEE, NTU. He has over 12 years of research experience in power system stability and control, active power filters, and power line communications. His current research works focus on intelligent energy distribution, energy management, microgrids, and smart grids. He is a Co-PI for A*STAR Microgrid Energy Management System (MEMS). He is also one of the key team members of the EMA-NTU Intelligent Energy System (IES) Pilot Project launched in November 2009 by EMA.

F. L. Luo (M’84, SM’95) received his B. Sc. Degree, First Class with Honours from Sichuan University, Chengdu, Sichuan, China and his Ph. D. in Electrical Engineering and Computer Science (EE & CS) from Cambridge University, England, UK in 1986. He is an Associate Professor in NTU, and has published 10 teaching text books and more than 280 technical papers in IEEE Transactions, IEE/IET Proceedings and other journals, and various International Conferences. His present research interest is in the Power Electronics and Motor Drives, AC/DC, AC/AC & DC/DC Converters and DC/AC Inverters, Digital Power Electronics, microgrid management and renewable energy systems. He is currently the Associate Editor of the IEEE Transactions on Power Electronics and Industrial Electronics.

D. Mahinda Vilathgamuwa received the B.Sc. and Ph.D. degrees in electrical engineering from the University of Moratuwa, Moratuwa, Sri Lanka, and Cambridge University, Cambridge, U.K., in 1985 and 1993, respectively. In 1993, he joined the School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore, as a Lecturer, where he is currently an Associate Professor. His current research interests include power electronic converters, electrical drives, and power quality. Dr Vilathgamuwa is the Vice Chairman of IEEE Section, Singapore.
Who Should Attend?

This course is useful to engineers and managers working in clean energy, renewable energy, converter design and operation of microgrids, smart grids and intelligent energy systems. It is beneficial to anyone who wishes to know more about the development of microgrids and smart grids in Singapore. The course will be structured towards experience sharing and knowledge transfer.

### Course Information

| Date: | August 27, 2010 (Friday) |
| Time: | 8:30 am to 5:45 pm |
| Lecture Venue: | Executive Seminar Room (ESR) #02-19/A, Level 2, Wee Kim Wee School of Communication and Information (WKWSCI), NTU |
| Demo Venue: | Laboratory for Clean Energy Research (S2-B7c-05), School of EEE, NTU |
| Fee (nett amount): | S$500 or on site S$550 (subject to space availability) |
| S$450 for early bird registration by August 2, 2010 or $400 for group registration (3 or more from the same organization registered at the same time by August 26, 2010) |

Fees include refreshments, lunch and course notes. Payment is to be made payable to IEEE Singapore Section via a Singapore cheque or bank draft in Singapore dollars. Overseas participants are asked to contact Mrs Jasmine Leong for details of TT transfer at:

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Blk 121 Paya Lebar Way
#03-2801
Singapore 381121
Tel: (65) 6743 2523
Fax: (65) 6746 1095
Email: sec.singapore@ieee.org
### Participant's Details

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### Organization's Details

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