THE UNIVERSITY OF MELBOURNE

Graduate-Level Short Course: *Dynamics of low-carbon power systems*

Power and Energy Systems Group,
Department of Electrical and
Electronic Engineering

Melbourne Energy Institute

Course Information

14-18 November 2022

About the short course

The short course on *Dynamics of low-carbon power systems* covers fundamental and advanced modelling of power system dynamics in grids dominated by renewable energy sources (RES), distributed energy resources (DER), and inverter-based resources (IBR).

The short course on ***Dynamics of low-carbon power systems*** is a five-day graduate-level course delivered as part of the strategic collaboration between the **University of Melbourne**, Australia, and the **University of Manchester**, UK, and hosted by the Melbourne Energy Institute at the University of Melbourne. It covers fundamental and advanced modelling of the dynamics of power systems with increasingly deeper penetration of renewable energy sources (RES) and distributed energy resources (DER), most of which are inverter-based resources (IBR) that are asynchronously connected to the grid via power electronic interfaces.

The course will be primarily delivered by **Prof Jovica Milanović** from the University of Manchester, who is also currently visiting professor in the Department of Electrical and Electronic Engineering at the University of Melbourne. Other lecturers include:
Dr Mehdi Ghazavi Dozein, University of Melbourne;
Dr Ahvand Jalali, Australian Energy Market Operator;
Mr Russell Frost, Australian Energy Market Operator;
Mr Farhad Billimoria, University of Oxford;
Mr Christiaan Zuur, Australian Clean Energy Council;
and **Prof Pierluigi Mancarella**, University of Melbourne and University of Manchester.

Topics that will be discussed include: fundamentals of power system dynamics and stability; impact of power electronics-interfaced renewable energy sources and distributed energy resources on system operation, stability and control; role of new technologies such as battery energy storage systems and hydrogen electrolysers; and economic, regulatory, and policy aspects of essential system services. The course will also include industry presentations about the challenges of operating low-carbon grids, with real examples from Australia and some of the deepest penetration of RES, DER and IBR in the world.

COURSE DELIVERY

This course is provided free of charge and will be delivered fully online from **Monday 14th to Friday 18th of November 2022**, from 8:30 am to 1:00 pm, Australian Eastern Daylight Time (AEDT).
Live lectures will also be recorded so that they can be accessed by individuals in different time zones. All live and recorded lectures and the corresponding material will be accessible via the University of Melbourne's Learning Management System, *Canvas*.

TIMES (MELBOURNE TIME, AEDT)	
3 or 4 lecture blocks per day (45 min to 1 hour of lecture time, including Q&A, separated by 15-min breaks)	
Block 1:	8:30am-9:30am
15-minute break	
Block 2:	9:45am-10:45am
15-minute break	
Block 3:	11:00am-12:00pm
15-minute break	
Block 4:	12:15pm-1:00pm

EXPRESSIONS OF INTEREST

To register your interest, click *APPLY NOW* and complete the form.

Apply now ›

CONTACT

For further information, please contact the Melbourne Energy Institute >> mei-info@unimelb.edu.au

Monday 14th November: Fundamentals of power system dynamics and component modelling

Professor Jovica Milanović

Block 1. Power system stability
Power system stability terms and definitions
What is power system stability and why is it important?
Classification of power system stability studies
Block 2. Modelling of synchronous machines and associated controls
Modelling of synchronous machines
Modelling of excitation systems
Modelling of turbines and governors
Block 3. Modelling of power system components for stability studies
Modelling of transformers
Modelling of transmission lines & cables
Modelling of power system loads

Tuesday 15th November: Low-carbon power system stability

Professor Jovica Milanović

Block 1. Power system stability studies
Small disturbance stability of power systems
Large disturbance (transient) stability of power systems
Frequency stability
Voltage stability
Block 2. Changing nature of power/energy systems and associated challenges
Drivers for change of design and operation of electrical power systems
Operational challenges of net-zero power systems
Approaches to address some of the challenges
Block 3. Dynamic behaviour of systems with converter interfaced generation
Characteristics on converter interfaced generation
Definition and classification of power system stability
Rotor angle, voltage stability and frequency stability
Resonance and converter driven stability

Professor Jovica Milanović

The University of Manchester

Visiting Professor, *the University of Melbourne*

Jovica V. Milanović is a Professor of Electrical Power Engineering at the University of Manchester, UK, and has been a visiting professor at several universities around the world. He has given over 30 keynote speeches at conferences and presented over 150 courses, tutorials and lectures to industry and academia around the world. Professor Milanović is Foreign member of the Serbian Academy of Engineering Sciences, FIET, FIEEE, member of the IEEE Fellows Committee and Editor-in-Chief of IEEE Transactions on Power Systems. He was a member of the IEEE PES Governing Board for six years, vice-chair of IEEE PES Fellows Evaluation Committee and Chair of the IEEE Herman Halperin Transmission and Distribution Award Committee.

Wednesday 16th November: Modelling of new technologies

Professor Jovica Milanović, Dr Mehdi Ghazavi Dozein

Block 1. Modelling and impact of DG on system dynamics
Approach to modelling of distributed RES
The impact of RES on system dynamics
Examples of probabilistic modelling of RES
Examples of probabilistic stability studies
Block 2. Demand profiling and load modelling for stability studies
Efficient demand side management
Demand profiling
Automated load model development
Required accuracy of load models
Block 3. Modelling of battery energy storage systems
Fundamentals
Dynamic support services
Real-life examples
Block 4. Modelling of hydrogen electrolysers
Fundamentals
Dynamic support services
Real-life examples

Thursday 17th November: Australian real-life experiences in operating low-carbon grids

Dr Ahvand Jalali, Mr Russell Frost

Block 1. RMS vs EMT simulation of IBR-rich grids
Need for power system modelling and simulation
Difference between RMS- and EMT-type simulations
The need for EMT-type simulations in high-IBR grids
Block 2. Real-life examples of EMT studies and validation
AEMO's EMT journey and examples of EMT model validation
Real-life applications of EMT-type models
Block 3. Frequency control and stability in low-carbon grids
Introduction to the South-West Interconnected System
Frequency control methods overview
Frequency response from machines and equipment
Distributed PV disconnection during disturbance event
Block 4. Real-time frequency stability tool
Single mass model for frequency stability studies
Equipment modelling and validation from real events
Software tool creation and demonstration

Dr Mehdi Ghazavi Dozein, Associate Lecturer in Power Systems, *University of Melbourne*

Dr Ahvand Jalali, Senior Power System Engineer, *Australian Energy Market Operator (AEMO)*

Mr Russell Frost, Senior Power Systems Engineer, *Australian Energy Market Operator (AEMO)*

Friday 18th November: Techno-economic, policy and regulatory aspects of essential system services in a low-carbon grids

Professor Pierluigi Mancarella, Mr Farhad Billimoria, Mr Christiaan Zuur

Block 1. From physics to economics: techno-economic aspects of essential system services in low-carbon grids	
	Low-carbon grids: the "new physics" and system security
	Essential system services in low-carbon grids
	Grid fragility and the merging of security and resilience
	What role for markets, regulation, and energy policy?
Block 2. Power system fragility and risk allocation in transitioning electricity markets	
	Power system risk and fragility from coupling of emergent and legacy resources
	Pathways for economic characterization, and why it matters
	The role of risk allocation and hedging for essential system services
	The insurability of power system risks
Block 3. Policy and regulation for essential system services	
	A short history of system stability in Australia
	Frequency stability
	System strength
	What's next? Operation and planning aspects
	Emerging thinking on harmonic solutions from network service providers

Professor Pierluigi Mancarella
Chair Of Electrical Power Systems,
The University of Melbourne
Professor of Smart Energy Systems
The University of Manchester

Mr Farhad Billimoria
Energy market design
University of Oxford and Australian Energy Market Operator

Mr Christiaan Zuur
Director, Energy Transformation
Clean Energy Council

For further information about our activities:
Power and Energy Systems Group: electrical.eng.unimelb.edu.au/power-energy
Master in Low-carbon Power Systems (Electrical and Electronic Engineering): electrical.eng.unimelb.edu.au/study/low-carbon-power-systems-specialisation

Contact us
Melbourne Energy Institute
The University of Melbourne
Level 1, Melbourne Connect
700 Swanston Street
The University of Melbourne
Parkville, VIC 3010
mei-info@unimelb.edu.au

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