THE UNIVERSITY OF MELBOURNE

Power and Energy Systems Group

Melbourne Energy Institute

PhD-Level Short Course:
Advanced Modelling of DER-Rich Active Distribution Networks

19th – 23rd July 2021

Course Information

About the short course

The short course on Advanced Modelling of DER-Rich Active Distribution Networks covers fundamental and advanced modelling of active distribution networks with deep penetration of distributed energy resources (DER).

The short course on *Advanced Modelling of DER-Rich Active Distribution Networks* is a 5-day PhD-level course delivered by the Power and Energy Systems Group and the Melbourne Energy Institute at The University of Melbourne. It covers fundamental and advanced modelling of active distribution networks with deep penetration of distributed energy resources (DER).

Topics that will be discussed include power flow and optimal power flow algorithms suitable for diverse applications of active distribution networks with DER, consideration for uncertainty arising from renewables, provision of flexibility and grid services from DER, distributed multi-energy systems and community energy systems, and fundamentals of distributed energy markets.

COURSE DELIVERY

This course is provided free of charge and will be delivered fully online from Monday 19th to Friday 23rd of July 2021.

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 Learning Management System "Canvas".

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

DATES AND INSTRUCTORS	
Monday 19th July	Prof. Steven Low
Tuesday 20th July	Prof. Steven Low
Wednesday 21st July	Prof. Nando Ochoa
Thursday 22nd July	Dr. Maria Vrakopoulou
Friday 23rd July	Prof. Pierluigi Mancarella

TIMES (MELBOURNE TIME, AEST)	
4 lecture blocks (approximately 55 min of lecture time including Q&A and small break)	
Block 1:	8:30am-9:30am
Block 2:	9:30am-10:30am
30 minute break	
Block 3:	11:00am-12:00pm
Block 4:	12:00pm-1:00pm

Monday 19th July: The OPF Problem and Convex Relaxations

Professor Steven Low

Block 1. Power flow models and solutions
AC power flow, DC power flow
Power flow computation methods
Block 2. OPF and semidefinite relaxations
OPF problems: QCQP, polar form, DC OPF
Non-convexity, Semidefinite relaxations
Equivalence
Block 3. Analytical properties
NP hardness
Exact relaxations
No spurious local optima
Block 4. Other convex relaxations
Quadratic convex relaxation
Strong SOCP relaxation

Tuesday 20th July: OPF for Distribution Networks

Professor Steven Low

Block 1. Branch flow models for radial networks
DistFlow equations, generalization, linearization
Forward-backward sweep methods
Block 2. OPF and semidefinite relaxation
OPF in brach flow models
SOCP relaxation, exact relaxation
Block 3. Multi-phase unbalanced radial networks
Generalized DistFlow model
Semidefinite relaxations, linearization
Block 4. Example and application
Example: OPF, relaxation, exactness
Application: DER-based voltage control

Professor Steven Low
Gilloon Professor, *Caltech*
Honorary Professor, *The University of Melbourne*

Prof. Low is the Gilloon Professor of Engineering and Applied Science at Caltech and an Honorary Professorial Fellow of the EEE Department at the University of Melbourne. His current research focuses on power systems and has made an impact in both academia and industry. He is a Fellow of IEEE and ACM and has been awarded the 2021 IEEE INFOCOM Achievement Award and the 2021 ACM SIGMETRICS Test of Time Award. Read more about Prof. Low.

Wednesday 21st July: Orchestration of Distributed Energy Resources (DER) and Active Distribution Networks

Professor Nando Ochoa

Block 1. The role and challenges of OPF in distribution	
	From fit and forget to Active Networks to DER orchestration
	Opportunities, modelling challenges, and practical aspects
Block 2. OPF and DER-rich distribution networks	
	DER orchestration and hosting capacity calculations using OPF
	Interactive session using an OPF tool developed in AIMMS
Block 3. Three-phase OPF: Lessons learned from large-scale realistic implementations	
	Quadratically-constrained three-phase OPF, linearised three-phase OPF
	Case study using a realistic MV-LV network
Block 4. DER and network integrity: Meter-level operating envelopes	
	Concept of operating envelopes, calculations and challenges
	Case study using a realistic MV-LV network

Thursday 22nd July: Decision-Making Under Uncertainty due to Renewables

Dr Maria Vrakopoulou

Block 1. Renewable energy integration challenges	
	Review of dynamic operation, equilibrium points
	Ancillary services
	Forecast errors and power flows
Block 2. Stochastic OPF with approximate solutions	
	Classic stochastic formulations
	Chance-constrained and robust OPF
	The scenario optimization
Block 3. Stochastic OPF with AC-feasible solutions	
	AC-QP, SDP OPF reformulations
	The non-convex scenario optimization
Block 4. Co-optimization of energy and reserves	
	Control policies for reserve deployment
	Reserves from thermostatically controlled loads Aggregated storage dynamics
	Pricing impact

Professor Nando Ochoa
Professor of Smart Grids and Power Systems,
The University of Melbourne

Prof. Nando Ochoa is a Professor of Smart Grids and Power Systems at the Department of Electrical and Electronic Engineering. He is an IEEE PES Distinguished Lecturer, an Editorial Board Member of the IEEE Power and Energy Magazine, and an IEEE Senior Member. From 2011 to 2021, Prof. Ochoa worked with The University of Manchester, UK. Prior to this he was a Research Fellow in Energy Systems at the University of Edinburgh, UK.
Read more about Prof. Ochoa.

Dr Maria Vrakopoulou
Lecturer in Power Systems,
The University of Melbourne

Dr. Maria Vrakopoulou is a Lecturer (Assistant Professor) in the Power and Energy Systems Group at the University of Melbourne. She obtained her Ph.D. degree from ETH Zurich, Switzerland, and then pursued her research as a post-doc at the University of Michigan, Ann Arbor, USA for a year. Maria was then also awarded a three-year Marie Curie post-doctoral fellowship to join the University of California, Berkeley, USA, and ETH Zurich, Switzerland.
Read more about Dr. Vrakopoulou.

Friday 23rd July: DER Flexibility and Techno-Economic Modelling

Professor Pierluigi Mancarella

Block 1. Modelling flexibility from DER aggregation	
	Power system flexibility and role of DER
	Characterization of DER flexibility
	DER flexibility metrics and maps
	OPF methodologies to build flexibility maps
	Illustrative case studies
Block 2. Flexibility from distributed multi-energy systems	
	Multi-energy DER and multi-energy node concept
	Multi-energy flexibility maps
	Impact of multi-energy networks on DER flexibility
	Illustrative case studies
Block 3. Smart districts and community energy systems	
	Modelling of buildings and community-level DER
	Integrated energy network modelling
	Multi-energy OPF
	Illustrative case studies
Block 4. Distributed energy marketplaces and grid services	
	Aggregators, Virtual Power Plants, and Distribution System Operator
	Value stack by co-optimised provision of local and system-level services
	Value mapping methodologies and business case opportunities for different stakeholders
	Illustrative case studies

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

Prof. Pierluigi Mancarella is the Chair Professor of Electrical Power Systems at the University of Melbourne, Australia, and Professor of Smart Energy Systems at the University of Manchester, UK. He obtained the MSc and PhD degrees from the Politecnico di Torino, Italy, did his post-doc at Imperial College London, UK, and has held several visiting positions, including NREL, Colorado, Ecole Centrale de Lille, France, Universidad de Chile, and Tsinghua University, China. He is an IEEE PES Distinguished Lecturer and an Editor in several prestigious journals. Read more about Prof. Mancarella here.

For more information, visit https://electrical.eng.unimelb.edu.au/power-energy or www.energy.unimelb.edu.au

Contact us
Melbourne Energy Institute
The University of Melbourne
Level 4, Mechanical Engineering Building 170
200 Grattan Street
The University of Melbourne
Parkville, Vic 3010
mei-info@unimelb.edu.au

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