PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Andrea Scalfati

XXX Cycle

Training and Research Activities Report – Second Year

Tutor: Maurizio Fantauzzi, Diego Iannuzzi

1. **Information**

   a. Andrea Scalfati, MS in Electrical Engineering - University of Naples Federico II
   b. PhD Student, XXX Cycle - ITEE – University of Naples Federico II
   c. No fellowship (full time worker for the Italian Ministry for Education, University and Research, High School professor in electrical engineering, on study leave from 2015-03-26)
   d. Tutor: prof. Maurizio Fantauzzi, prof. Diego Iannuzzi

2. **Study and Training activities**

   a. Courses
      - Game theory and analysis of competitive dynamics for industrial systems (Prof.ssa Lina Mallozzi)
      - Introduzione a Matlab (Prof.ssa Alessandra D'Alessio)
      - Communicating and Disseminating your Research Activity (prof. Mo Mansouri)
      - Modelli, metodi e software per l'Ottimizzazione (proff. Antonio Sforza, Claudio Sterle)

   b. Seminars
      - La sintesi sonora dell'ing. Hammond, 09/11/15
      - Verifica e Validazione di sistemi Safety critical, 04/12/15
      - The Evolution of Railway Signaling Systems, 10/12/15
      - Linee di indirizzo della ricerca energetica: la prospettiva europea, 16/12/15
      - Radar Adaptivity - Antenna Based Signal Processing Technique, 12/02/16
      - Gielis Transformations in the Natural Scienses and Technology, 17/02/16
      - Perception based sound recording and reproduction, 22/02/16
      - Speech Technologies at Trinity College – Dublin, 02/03/16
      - Microcontrollori di misura, 21/03/2016
      - The Development of a Fast Pick-and-Place,Robot with an Innovative Cylindrical Drive, 16/05/16
      - Embedded software validation, 25/05/2016
      - Automated generation of dynamic parking maps based on crowd-sensing, 10/10/16
      - Extracting WinAPI Call Graphs for Inferring Malicious Behaviours "Ricardo J. Rodríguez, 10/10/16

   c. External courses

      None

3. **Research activity**

   a. Title

Optimal Sizing of Distributed Energy Resources in DC Microgrids

   b. Study

The research activity focuses on the development and application of new methodologies to solve the problem of optimally sizing the Distributed Energy Resources (DERs) included in a DC Microgrid, investigating the economic viability of the microgrid deployment and determining the optimal mix of DERs for installation.

Microgrids can offer unprecedented economic and reliability benefits to electricity consumers, but these benefits must be scrutinized and compared with the microgrid investment cost for ensuring a complete return on investment and foster microgrid deployments. On the other end, an accurate assessment of microgrid economic benefits is a challenging task due to significant uncertain data involved, complexity of system model and market dynamics, and difficult representation of the economic value for some outcomes, such as reliability improvements.
Nevertheless, efficient planning models are required for ensuring the economic viability of microgrid deployments and further justifying investments based on cost-worth analyses in uncertain conditions.
Although the Microgrid optimal operation and control has been extensively studied in the literature, the research on the Microgrid planning problem is limited. Moreover existing studies often overlook some important factors in the planning process, such as data uncertainty, and don't guarantee an adequate representation of real conditions which affect the operation financial balance and thus the Microgrid Total Cost of Ownership (TCO) or the Return On Investment (ROI).
Another significant factor to be considered in the planning process is the integration of DERs with flexible electrical loads (which represent a new relevant characteristic of the smart grids scenario), such as EV chargers or different appliances, like dish washing machines in residential applications, whose running times can be scheduled in given shifting windows.

c. Research description

During the second year oh PhD course, two distinct methodologies were studied and their application to the problem investigated: an analytical approach and a mathematical programming approach (via a Mixed Integer Linear Programming formulation of the problem).

First topic: analytical approach

The analytical approach, starting from a matrix formulation of the DC microgrid load-flow equations and a first-order approximation of bus voltages, guarantees the minimization of power losses on network resistances over a prefixed time period, by proper sizing and control of an energy storage system (ESS) connected to the same microgrid, respecting isoperimetric constraints on the energy stored in energy storage devices. The objective function can be replaced with another function aimed at minimizing a weighted sum of power losses and cost of the storage system.

Second topic: mathematical programming approach

Mathematical Programming offer suitable methodologies for building a compact yet sufficiently precise model of the microgrid planning problem in an efficient formulation, i.e. a Mixed Integer Linear Program (MILP), for which finite convergence to optimality is guaranteed and efficient off-the-shelf software is available.
A MILP model was developed for the microgrid planning problem, considering a DC microgrid with an assigned base load and some flexible loads, with assigned power, number and duration of respective working cycles to be held in prefixed time windows.
The formulation is aimed at minimizing the Total Cost of Ownership of the microgrid, via optimal sizing and control of DERs like Distributed Generators (DGs) and Energy Storage Systems (ESSs) and optimal control of flexible loads, respecting a set of technical and financial constraints.

Future work: dealing with uncertainties

The variety of uncertainties sources (i.e. forecasting errors in loads, variable renewables generation, market prices, unintentional islanding events) requests an optimization framework able to deal with them while preserving computational solvability.
Different approaches are possible, like Stochastic Optimization and/or Robust Optimization.
This will be the object of the research activity during the third year of PhD course.

4. **Products**
   a. Publications:
      a.i. Published works

Conference paper “Planning of an Experimental Platform with Power Hardware In the Loop Features” (M. Fantauzzi, D. Iannuzzi, M. Pagano, M.C. Roscia, A. Scalfati), DOI: 10.1109/ICRERA.2015.7418659

a.ii. Works in preparation

Journal paper “Sizing energy storage systems in DC networks: a general methodology based upon power losses minimization” (M. Fantauzzi, D. Lauria, F. Mottola, A. Scalfati), submitted for publication on Applied Energy, now under review

b. Patents:

None

5. **Conferences**

ICRERA 2015, 4th International Conference on Renewable Energy Research and Applications, Palermo, Italy – 22-25 November 2015; presentation of the paper "Planning of an Experimental Platform with Power Hardware In the Loop Features”

6. **Activity abroad**

None

7. **Tutorship**

a. Tutorship of the student Tommaso Imperato for his M.Sc. Thesis “Strutture di conversione statica dell’energia per la realizzazione di microreti in continua”, discussed 14/03/2016(Supervisor prof. Diego Iannuzzi, Co-supervisor ing. Andrea Scalfati)

8. **Credit Summary**

Student: Name Surname									Tutor: Name Surname								Cycle XXX									
andrea.scalfati@unina.it									maurizio.fantauzzi@unina.it																	
									diego.iannuzzi@unina.it																	
	Credits year 1								Credits year 2								Credits year 3									
		1	2	3	4	5	6			1	2	3	4	5	6			1	2	3	4	5	6			
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Total	Check
Modules	24		3	3	3	12		21	15		3	6			8	17	3							0	38	30-70
Seminars	6		0,4	0,8			1,8	3	8	2,2	1,1	0,7	0,7		0,4	5,1	3							0	8,1	10-30
Research	30	10	4	4	4	4	6	32	40	8	6	6	8	6	8	42	60							0	74	80-140
	60	10	7,4	7,8	7	16	7,8	56	63	10,2	10	13	8,7	6	16	64	66	0	0	0	0	0	0	0	120	180

Lecture/Activity	Type	Credits	Certification	Notes
Game theory and analysis of competitive dynamics for industrial systems (Prof.ssa Lina Mallozzi)	Ad hoc module	3	x	
Introduzione a Matlab (Prof.ssa Alessandra D'Alessio)	Ad hoc module	3	x	
Communicating and Disseminating your Research Activity (prof. Mo Mansouri)	Ad hoc module	3	\	Prof. Iandoli should send the certification to PhD courses coordinators
Modelli, metodi e software per l'Ottimizzazione (proff. Antonio Sforza, Claudio Sterle)	Ad hoc module	8	x	
La sintesi sonora dell'ing. Hammond	Seminar	0,8	x	
Verifica e Validazione di sistemi Safety critical	Seminar	0,4	x	
The Evolution of Railway Signaling Systems	Seminar	0,6	x	
Linee di indirizzo della ricerca energetica: la prospettiva europea	Seminar	0,4	x	
Radar Adaptivity - Antenna Based Signal Processing Technique	Seminar	0,5	x	
Gielis Transformations in the Natural Scienses and Technology	Seminar	0,3	x	
Perception based sound recording and reproduction	Seminar	0,3	x	
Microcontrollori di misura	Seminar	0,5	x	
Speech Technologies at Trinity College – Dublin	Seminar	0,2	x	

The Development of a Fast Pick-and-Place,Robot with an Innovative Cylindrical Drive	Seminar	0,3	x	
Embedded software validation	Seminar	0,4	x	
Automated generation of dynamic parking maps based on crowd-sensing	Seminar	0,2	x	
Extracting WinAPI Call Graphs for Inferring Malicious Behaviours	Seminar	0,2	x	