NATIONAL PH.D. PROGRAM IN AUTONOMOUS SYSTEMS

Management and automation systems for energy management in buildings and industrial processes

Ph.D. candidate

Zohreh SHAHROUEI

Cycle

XXXIX

Tutors

Prof. Elio USAI

Dr.Ing. Marco BARBAGELATA

1. Description of the research program

The framework for the proposed thesis is part of ongoing projects at the industrial partner, funded either by private companies or public agencies, as well as at the Department of Electrical and Electronic Engineering, funded by the PNRR.
The aim of the project is the study and development of tools for the energy management of the use of energy either in a civil contest or in industrial settlements. The full exploitation of renewable energy sources should be achieved by distributed control and optimization algorithms, possibly considering the specific characteristics of the users and producers connected in the network.
The role of explicit or implicit energy storage systems, e.g., batteries and building structures respectively, will be considered in the optimization procedures as well as the knowledge of behavioural and meteorological forecasts. To this aim, models of the single user or producer will be analysed and developed by means of both physical modelling and data-based approaches.
The design of the energy management and optimization system should be versatile enough to adapt to the monitoring, security, and automation level of the building or of the industrial activity, depending on the specific application.
The main goals of the program are detailed below:

- Define a flexible approach for the energy management in civil and industrial applications.
  Taking int account the variability of the context, a theoretic approach that can be properly suited for different energy management situation will be studied and developed, specifying its validity conditions.
- Identify a set of performance indexes that can be used for the optimisation of the use of energy.
  The management of a complex system can require the use of proper performance indexes suited for economic and technical purposes that depend on the application. This implies the development of different tools.
- Application of optimisation approaches in specific cases.
  Considering the applicative cases handled by STAM during the PhD course period, the studied and developed approaches will be suited for the use case and tested in a real applicative context.

2. Schedule of the research activities

First academic year (planned)

	Description	**Period**	**Activity Abroad / At the Company**
Distributed optimal control	Investigation and study of classic and latest optimisation control approaches in a multi agent framework, in the presence of uncertainty	11/2023 - 10/2024	NO
Modelling energy systems	Study and development of dynamical and logical models of energy consume and storage systems, based both on physical principles, historical data, and process connections	02/2024 - 10/2024	NO

Second academic year (planned)

	Description	**Period**	**Activity Abroad / At the Company**
Modelling an industrial or civil energy system	A specific application proposed by STAM will be analysed and its characteristics will be defined, and a model will be developed for energy optimisation purposes	11/2024 - 04/2025	NO
Optimisation of an energy system	One, or multiple, performance indexes will be developed for optimisation purposes and proper optimisation procedures and approaches will be tested preliminary by simulation and then on available real data sets at STAM	05/2025 - 10/2025	YES (STAM)

1. Third academic year (planned)

	Description	Period	Activity Abroad / At the Company
Development of advanced techniques for energy management	New approaches and algorithms for the energy management/optimisation in a not fully structured contest will be studied and developed	11/2025 - 04/2026	YES (Alboorg University)
Comparative studies and analysis	The various approaches for the management/optimisation of energy systems will be compared to identify pros and cons of each studied approach, with respect to clear use cases	05/2026 - 11/2026	YES (STAM)

3. Training and research activities plan

First academic year (planned)

	Description	Period	Final Exam	ECTS
A. Ph.D. courses	EECI International Graduate School on Control – Optimization and control of complex multi-agent systems	February 2024	Yes	4
	SIDRA Summer school	July 2024	Yes	4
	Metodologie di analisi e ottimizzazione energetica (PhD course on Industrial Eng., UniCA)	(to be decided)	Yes	4
B. Master's degree courses	Networked control systems and security (M. Franceschelli)	Spring 23/24 semester	Yes	5

C. Soft skill courses	1 course at UniCA	(to be decided)	No	1
D. Participation to seminars	-------			

E. Participation to international congresses or workshops	-------			

F. Presentation of research products at international congresses or workshops	-------			

	TOTAL OF ECTS FOR TRAINING ACTIVITIES			**18**
G. Individual research activity	950 hours of individual study and research	11/23-10/24		38
H. Supervision of students	-------			
I. Integrative teaching activities	-------			
J. Preparation of manuscripts for conferences or journals	100 hours for preparing manuscripts to be presented/submitted in the 2nd year	06/24-10/24		4
	TOTAL OF ECTS FOR RESEARCH ACTIVITIES			**42**
	TOTAL OF ECTS			**60**

Second academic year (planned)

	Description	Period	Final Exam	ECTS
A. Ph.D. courses	SIDRA Summer school	July 2025	Yes	4
	1 PhD course at UniCA	(to be decided)	Yes	4

B. Master's degree courses	Supervisory Control and Monitoring (C. Seatzu, E. Usai)	Fall 24/25 semester	Yes	9

C. Soft skill courses	1 course at UniCA	(to be decided)	No	1
D. Participation to seminars	10 hours of seminars	(to be decided)	NO	2

E. Participation to international congresses or workshops	3 days conference	(to be decided)		3

F. Presentation of research products at international congresses or workshops	1 presentation at a conference	(to be decided)		2

	TOTAL OF ECTS FOR TRAINING ACTIVITIES			**25**
G. Individual research activity	575 hours of individual study and research	11/24-10/25		
H. Supervision of students	-------			
I. Integrative teaching activities	-------			
J. Preparation of manuscripts for conferences or journals	300 hours for preparing manuscripts to be presented/submitted in international conferences/journals	11/24-10/25		12
	TOTAL OF ECTS FOR RESEARCH ACTIVITIES			**35**
	TOTAL OF ECTS			**60**

Third academic year (planned)

	Description	Period	Final Exam	ECTS
A. Ph.D. courses	SIDRA Summer school	July 2026	Yes	4
B. Master's degree courses				
C. Soft skill courses				
D. Participation to seminars	10 hours of seminars	(to be decided)	NO	2
E. Participation to international congresses or workshops	3 days conference	(to be decided)		3
F. Presentation of research products at	1 presentation at a conference	(to be decided)		2

	international congresses or workshops				
		TOTAL OF ECTS FOR TRAINING ACTIVITIES			**11**
G.	**Individual research activity**	825 hours of individual study and research			
H.	**Supervision of students**	-------			
I.	**Integrative teaching activities**	-------			
J.	**Preparation of manuscripts for conferences or journals**	400 hours for preparing manuscripts to be presented/submitted in international conferences/journals			16
		TOTAL OF ECTS FOR RESEARCH ACTIVITIES			**49**
		TOTAL OF ECTS			**60**

4. List of the publications written by the candidate in the triennium

To do/plan

Zohreh SHAHROUEI

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