



PhD in INGEGNERIA DELL'INFORMAZIONE / INFORMATION TECHNOLOGY - 38th cycle

Research Area n. 3 - Systems and Control

**PNRR_352 Research Field: REAL TIME CONTROL AND OPTIMIZATION OF POWER GRIDS
WITH DISTRIBUTED GENERATION AND STORAGE**

Monthly net income of PhDscholarship (max 36 months)

€ 1400.0

In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity

**Motivation and objectives of the research
in this field**

To enable the transition from centralized to distributed generation and a sharp increase of renewable sources like wind and solar, as required to meet the goals of sustainability and security of our energy systems, the power system of all industrialized countries must be transformed and endowed with smart, efficient, and reliable control and automation systems. The goal of this doctoral research program is to develop innovative optimization and control solutions that are required to carry out this transformation. In particular, the focus will be on the control and optimization of battery energy storage systems for grid applications and on the integration of distributed generation in the grid.

Notwithstanding the large number of contributions in the literature on these topics, there are still many open issues related to, for example, the time varying nature of sources, loads, and grid topology, component aging, communication delays that need to be systematically addressed and represent a barrier to the real-world use of theoretical results tested only in simplified simulation environment. The developed approaches, theoretically sound and practically usable, will be applied to real test cases provided by a major player in this sector, to demonstrate their effectiveness.



<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The thesis will study methods for energy management in systems with large populations of distributed resources with mid-low power capacity, interacting through communication channels subject to time-varying delays and possible topology modifications. The developed methods must guarantee an optimal usage of the resources (BESS, flexible loads, renewable sources,...) , handling uncertainty and variations in the system structure, by means of the estimation of uncertain dynamics and the adaptation of control laws, based on the adequate exploitation of historic data sets generated by the system during normal operation through machine learning techniques. The project will produce novel distributed decision-making algorithms, able to compensate variability in the characteristics of the agents participating the operation, using the available information and data to quantify the uncertainty in the environment. The proposed solutions must be scalable and robust against variations of the characteristics of the agents, such as aging and topology of the system. The employed methods and techniques include model-based and data-driven modeling and simulation of energy systems and components, set membership uncertainty quantification, model predictive control, convex and global non-convex optimization, control system design in presence of communication delays and distributed/hierarchical architectures, real-time implementation of control and optimization solutions.</p>
<p>Educational objectives</p>	<p>In addition to the training goals that are common to the whole curriculum in Systems and Control of the PhD in Information Technology, pertaining to advanced control, estimation and machine learning methods and transferable skills, this program will have a focus on power grid automation and optimization: the PhD candidate is expected to develop deep knowledge of advanced solutions for the generation, distribution, storage and consumption of electricity to improve reliability and sustainability of the system.</p>
<p>Job opportunities</p>	<p>Upon completion of the three-years-long program, the Doctoral graduate will have strong theoretical and</p>



	practical knowledge in the field of smart grid, automation for power systems, optimization-based control and estimation, which will allow her/him to pursue either a career in industry, with either a R&D or a project management role in the field of power systems and products and more in general of control and automation for industrial systems, or in academia, deepening the fundamental research on distributed and time-varying systems.
Composition of the research group	1 Full Professors 2 Associated Professors 1 Assistant Professors 7 PhD Students
Name of the research directors	Prof. Fredy Orlando Ruiz Palacios

Contacts

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<https://ruiz.faculty.polimi.it/>

Additional support - Financial aid per PhD student per year (gross amount)

Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad

Amount monthly	700.0 €
By number of months	6

National Operational Program for Research and Innovation

Company where the candidate will attend the stage (name and brief description)	Hitachi Energy Italy S.p.A, Settore: soluzioni per la gestione e automazione di reti elettriche e dei sistemi di accumulo (Battery Energy Storage Systems, BESS) Sito: https://www.hitachienergy.com/it/it
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	Hitachi America - Research & Development, Energy Research Center, North Carolina, United States Settore: Ricerca-sviluppo sui sistemi energetici avanzati. Sito: https://www.hitachi.us/rd/solutions/energy.html
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Attinenza alla tematiche, alle missioni/componenti prescelte del bando PNRR v. D.M. 352,

**art.6**

La ricerca oggetto di questa borsa di dottorato è coerente con i fabbisogni di incremento dell'efficienza energetica e della sostenibilità del sistema di generazione, distribuzione e accumulo dell'energia elettrica, al fine di rendere possibile la transizione verso l'utilizzo massivo e prevalente di fonti di energia rinnovabile.

La ricerca è pienamente coerente con la Missione 2 "Rivoluzione verde e transizione ecologica" del Piano Nazionale di Ripresa e Resilienza (PNRR), in particolare la componente 2 "Energia rinnovabile, idrogeno, rete e mobilità sostenibile". La ricerca è inoltre coerente con la Missione 1 "Digitalizzazione, innovazione, competitività, cultura e turismo" nella sua componente 2 "digitalizzazione, innovazione e competitività del sistema produttivo" con riferimento alla produzione di beni e servizi innovativi per la gestione delle reti elettriche attuali e del futuro.

Impresa, presso cui si svolgerà l'attività esterna

Nome: Hitachi Energy Italy S.p.A,

Settore: soluzioni per la gestione e automazione di reti elettriche e dei sistemi di accumulo (Battery Energy Storage Systems, BESS)

Sito: <https://www.hitachienergy.com/it/it>

Mesi previsti: 6

Attività: produzione e commercializzazione di prodotti e processi per l'ottimizzazione e il controllo in tempo reale di reti e microreti elettriche con generazione e accumulo distribuiti

Collaborazioni pregresse: tre contratti di ricerca svolti negli anni 2019, 2020, 2021, 2022 per un totale di 90.000,00 EUR di contributo, risultanti finora in una domanda di brevetto e una pubblicazione congiunta, altre due pubblicazioni in fase di stesura.

Ente, università, azienda, centro di ricerca presso cui si svolgerà il periodo di studio e ricerca all'estero.

Nome: Hitachi America - Research & Development, Energy Research Center, North Carolina, United States

Settore: Ricerca-sviluppo sui sistemi energetici avanzati.

Sito: <https://www.hitachi.us/rd/solutions/energy.html>

Mesi previsti: 6

Attività: Sviluppo di soluzioni per la gestione di sistemi energetici tramite predizione di rinnovabili, ottimizzazione di risorse distribuite, operazione di sistemi di stoccaggio, modellistica e simulazione di sistemi distribuiti.

All information regarding educational activities, personal funding, regulations and obligations of Ph.D. candidates are available on the web site <https://dottoratoit.deib.polimi.it/>

