

International Federation of Automatic Control

# 9<sup>th</sup> IFAC Symposium on Control of Power and Energy Systems CPES 2015

New Delhi, India, 9–11 December 2015

## PROCEEDINGS

Edited by

**Sukumar Mishra**

*Indian Institute of Technology Delhi*



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## **MESSAGE**

It has been a great honour and privilege for the Institute to host the 9th IFAC symposium on Control of Power and Energy Systems (CPES) 2015. At Indian Institute of Technology Delhi, we work for excellence in scientific and technical education and research to serve the society and industry. The Institute thrives hard to produce new research and innovations in field of engineering, sciences and management and has tremendous potential to produce quality research in terms of patents, journals etc. The 9th IFAC symposium on Control of Power and Energy Systems (CPES) 2015 provides a common platform for people from academics and industry from different parts of world to interact on various issues and their solutions in field of power and energy systems.

The institute is located in the heart of National capital, New Delhi with lush green environmental friendly campus. The institute is actively involved in research and development of renewable energy and promotes use of sustainable energy resources. The institute has installed roof top solar plant of capacity 1 MW. The significant research contributions made by the faculty of the institute has brought international recognition.

I thank the IFAC technical and financial committee for choosing Indian Institute of Technology, Delhi.

On behalf of the institute I extend a hearty welcome to all the delegates and participants.

I wish the deliberations a grand success.

**Prof. Bhim Singh**  
**Head, Department of Electrical Engineering**  
**Indian Institute of Technology Delhi, India**



## **MESSAGE**

It is good to note that 9th IFAC symposium on Control of Power and Energy Systems (CPES) 2015 has been organized and hosted by the Department of Electrical Engineering, IIT Delhi.

The Department of Electrical Engineering has been playing a vital role in producing scientists and technologists of highest caliber ever since it was established in the year 1961. The department runs two under graduate programmes and 6 post-graduate programmes to cater to the ever challenging needs of technical excellence in all areas of electrical engineering such as Integrated Electronics and Circuits, Tele-communications, Computer Technology, Control & Automation, Power Systems, Power Electronics, Electrical Machines and Drives.

In addition to the strong undergraduate programs, the department has been playing a pioneering role in producing world class postgraduates and research scholars. The infrastructure and laboratories facilities are upgraded from time to time and provide adequate opportunities for students and researchers to learn and innovate. The department has distinguished faculty, all holding Ph.D. degrees from renowned institutes in India and abroad. There are two Fellows of IEEE in the department and many other faculty members are Fellows of several national and international scientific bodies. The faculty of the department has been constantly carrying out research on many cutting edge technologies and regularly publishes in IEEE and other top international journals. The department also undertakes many research projects sponsored by both the government and the industry.

The department's prime thrust being on quality research in several areas falling under the ambit of this international symposium, it would go a long way in enriching the knowledge of the researchers and faculty members.

On behalf of the department, I extend a hearty welcome to all the dignitaries, resource persons, delegates and student participants.

**Prof. Radhakant Padhi**  
**President**  
**Automatic Control and Dynamic Optimization Society**  
**(Indian NMO of IFAC)**



## **MESSAGE**

As the President of the Automatic Control and Dynamic Optimization Society (ACDOS), which is the NMO of IFAC in India, with great pleasure I greet all participants of the 9th IFAC Symposium on Control of Power and Energy Systems (CPES) - 2015 and sincerely offer my thanks and gratitude for their keen interest and enthusiastic participation in this event. I am quite happy that this important IFAC event has been organized in India for the first time, which happens to be the fourth IFAC event held in India after ACDOS was officially recognized as an NMO of IFAC in 2012. I am quite sure that this event will open up many more IFAC events such as workshops, symposiums and conferences on regular basis and the process will galvanize the community in India. India is also currently having an ambitious objective of closing the huge gap that exists between demand and supply of her energy needs to uplift the quality of life of its citizens and hence this technical event is perhaps being done in the right time at the right place.

This workshop was hosted at the prestigious Indian Institute of Technology (IIT) Delhi, which is one of the best scientific institutes of India. I am sure all attendees enjoyed the ambience of the institute. The capital city of Delhi is a modern city with direct flight connectivity to most cities of the world. Commuting within the city is also very convenient with a fabulous metro rail network, city buses, cab services etc. It can also be noted that Delhi has a very rich history and offers historic monuments, museums, temples etc. to visitors. One can easily spent a couple of days in Delhi exploring those. The city of Agra, which hosts the famous Taj Mahal (one of the Seven Wonders of the World) is not too far away either. I am happy to know that the conference organizers made arrangements for visiting these places for interested participants.

This was surely a high-quality event, ably organized by my dynamic colleague Prof. Sukumar Mishra, the NOC Chair, and his illustrious committee members. I am sure you have found the IFAC CPES 2015 stimulating and rewarding. I am also sure that you had an enjoyable time in Delhi.

Finally, I invite all of you to become members of Automatic Control and Dynamic Optimization Society. All necessary information about it can be found at [www.acdos.org](http://www.acdos.org)

**Prof. Sukumar Mishra**  
**National Organizing Committee Chair**  
**Indian Institute of Technology Delhi, India**



## **MESSAGE**

It was my pleasure to get the opportunity of organizing the 9th IFAC Symposium on Control of Power and Energy Systems (CPES)-2015 at IIT Delhi, Hauz Khas, New Delhi, India. Dwindling fossil fuel resources, rise in global energy consumption and increasing demand for electricity along with fears of climatic change are driving the decision makers and scientists to thrive for development of sustainable and viable technologies. Our current power generation technology is heavily fossil-fuel dependent and it is now a world-wide consensus to replace these conventional ways by a more energy efficient and sustainable technology.

Today's electric power systems have grown in size and complexity with an ever increasing demand. The objective is no longer to just cater the power demand but to also maintain system security, reliability and good power quality. Renewable energy sources offer an alternative way of clean power generation minimizing our dependence on fossil fuel based generations. However, one of the issues associated with present renewable energy technologies is their inherently variable nature of power generation, posing various technical issues with regard to the secure operation of power system. Their increased penetration has now given birth to micro-grids and active distribution networks demanding even higher quality research and innovation in the area of power system control.

The symposium provided an excellent opportunity and a common platform for eminent experts and researchers to discuss some of the issues and challenges in the area of control of electric power system and energy systems. Continuing the tradition of the IFAC symposiums on Power Plants and Power Systems Control, this symposium showcased novel research results on the topics like smart grid technologies, design, simulation and real time operation of control and operation of renewable energy systems, micro-grids, distributed networks, HVDC transmission systems and FACTS, etc. The discussion provided great challenges to all the participants to resolve some of the short-comings in the area of control energy sources and devise newer and alternative solutions.

Lastly I extend my heartfelt thanks to the various IFAC Technical committees for technically sponsoring and DST for financially sponsoring this international symposium to be organized at IIT Delhi. I also thank all the editors, associate editors, reviewers, session chairs, co-chairs, authors and all the members of the national organizing committee and the international program committee without whose contribution this event would not have been possible.

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