



# **Government College of Engineering, Yavatmal** (Affiliated to, Dr. Babasaheb Ambedkar Technological University)

## **DEPARTMENT OF ELECTRICAL ENGINEERING**

### **A Report on** **Two Days Workshop on “Impact of Inverter-based Resources on Power Systems”**



**A workshop organized under the aegis of**  
**IOE and NCPRE**  
**IIT Bombay**  
**4th and 5th November 2024**



### **Organized & Managed By:**

**Institution of Eminence (IOE) and National Centre for Photovoltaic Research and Education (NCPRE)**

### **Venue:**

**Victor Menezes Convention Centre, IIT Bombay**



# **Government College of Engineering, Yavatmal**

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## **About the workshop:**

India has also embarked on large-scale renewable integration with the power grid. With the increasing penetration of Inverter-Based Resources (IBRs) in power systems, new stability challenges are emerging that involve adverse control interactions between the IBRs themselves and between IBRs and other power system components. Several incidents of adverse control interactions among IBRs have been reported by various utilities around the world, including in India. Several new challenges are also likely to emerge in the future when “grid-forming” capabilities are introduced in inverter control. The analysis and mitigation of these problems is therefore of great practical interest.

In this context, IIT Bombay is arranging a workshop on “Impact of Inverter-based Resources on Power Systems” on 4th and 5th November 2024. The workshop will focus on

1. IBR controls and grid interactions.
2. Generic modeling of inverter based resources for positive-sequence stability studies and EMT studies, guidelines for their modeling and the verification of generic models with measurements.
3. Present and future scenario in India for grid-integration of renewable energy. Practical challenges faced. The workshop is being organized as a part of the outreach activities of IOE (Institute of Eminence) implementation cell and the National Centre for Photovoltaic Education and Research (NCPRE) IIT Bombay

## **Speakers:**

1. Prof Vijay Vittal, Ira A. Fulton Chair Professor (2005) and ASU Foundation Professor in Electric Power Systems at Arizona State University. Prof Vittal will be visiting IIT Bombay in November 2024 as a D. J. Gandhi Distinguished Visiting Professor.
2. Faculty members from IIT Bombay.
3. Guest speakers from industry/academia

## **Target Audience:**

Professionals working in industry/utilities/research organizations, Faculty Members in Educational Institutions and Post Graduate /Under Graduate Students working on issues related to grid integration of IBRs.

## **Schedule:**

Workshop will commence on 4th November 10:00 am and conclude on 5th November 4:00 pm (tentative). The detailed schedule will be published in due course. Venue Victor Menezes Convention Centre, IIT Bombay.



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## Participants Detail:

| Sr. No. | Name of Participants      | Profile   |
|---------|---------------------------|---|
| 1.      | Dr. S. M. Shinde          | Assistant Professor in Electrical Engineering Det.<br>Government College of Engineering, Yavatmal |
| 2.      | Mr. Afatab Habib Sheikh   | Student Id: 2210121293512<br>Student of Final Year Electrical Engineering Dept.                   |
| 3.      | Mr. Chinmay Lalit Naphade | Student Id: 2210121293506<br>Student of Final Year Electrical Engineering Dept.                   |



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## Detailed Schedule of workshop:

### “Impact of Inverter-based Resources on Power Systems”

#### Day One: 4<sup>th</sup> November 2024

| Time                | Activity   | Speaker   |
|---------------------|--|---|
| 9:30 am – 10:00 am  | Registration   |   |
| 10:00 am – 11:15 am | Introduction/Setting the Context<br>IBR Control and Grid Interactions. | Prof. A.M.Kulkarni, IIT Bombay  |
| 11:15 am – 11:30 am | Tea Break  |   |
| 11:30 am – 12:45 pm | Renewable Integration in India:<br>Operational experiences             | Mr. M. Venkateswara Rao, Grid-India,<br>Mumbai                                |
| 12:45 pm – 1:45 pm  | Lunch Break  |   |
| 1:45 pm – 3:00 pm   | Outlook of Solar in India in the coming years                          | Mr Atulya Kumar Naik, General Manager<br>(Energy Management Department), SECI |
| 3:00 pm – 3:15 pm   | Tea Break  |   |
| 3:15 pm – 4:30 pm   | Transmission Planning for renewable<br>integration in the Indian grid. | Mr Ajay Dahiya, Central Transmission<br>Utility of India Ltd, Gurgaon         |

#### Day Two: 5<sup>th</sup> November 2024

| Time                | Activity   | Speaker  |
|---------------------|--|--|
| 9:30 am – 11:00 am  | Generic modeling of inverter based<br>resources for positive-sequence stability<br>studies | Prof. Vijay Vittal, ASU, USA   |
| 11:00 am – 11:15 am | Tea Break  |  |
| 11:15 am – 12:45 pm | Verification of generic models with<br>measurements.<br><br>Generic EMT models             | Prof. Vijay Vittal, ASU, USA   |
| 12:45 pm – 1:45 pm  | Lunch Break  |  |
| 1:45 pm – 3:15 pm   | Protection for IBR systems   | Dr. O.D Naidu, Senior Principal Scientist,<br>Hitachi Energy Research, Bangalore |
| 3:15 pm – 3:30 pm   | Tea Break  |  |
| 3:30 pm – 4:30 pm   | Renewable Integration and DC grids   | Prof Himanshu Bahirat, IIT Bombay  |
| 4:30 pm – 4:45 pm   | Conclusion   | Prof A.M.Kulkarni  |





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## Day 1 of Workshop:

The workshop commenced with an inaugural address by **Prof. A. M. Kulkarni**, Workshop Coordinator, IIT Bombay, who welcomed the participants and introduced the central theme of the event: the evolving role of inverter-based resources (IBRs) in power systems, particularly in light of the rapid growth of renewable energy technologies such as solar and wind. **Prof. A. M. Kulkarni** emphasized the importance of understanding the technical, operational, and regulatory challenges posed by IBRs to traditional power grids.





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## Session 1:

The workshop officially began with a comprehensive address by **Prof. A.M. Kulkarni**, who provided an overview of the event and set the tone for the discussions to follow. Prof. Kulkarni began by explaining the growing relevance of inverter-based resources (IBRs) in the global power systems landscape, emphasizing the key motivation for the workshop: **understanding the impact of inverter-based resources on grid stability, reliability, and performance.**

### Motivation Behind the Workshop:

Prof. Kulkarni highlighted several key motivations for organizing this workshop:

- **Rise of Renewable Energy:** The integration of renewable energy sources like **solar and wind** into national grids is rapidly increasing. These energy sources are often coupled with power electronic inverters to interface with the grid.
- **Technological Shifts:** Unlike traditional fossil fuel-based generation, **inverter-based resources (IBRs)** do not provide natural grid support such as inertia or reactive power. This creates new challenges for power system operators, making it essential to develop and understand advanced solutions for managing grid dynamics.
- **Grid Modernization:** As the energy transition accelerates, grid modernization is crucial to manage the growing penetration of IBRs while maintaining stability, security, and efficiency.

### Challenges in Integrating Wind and Solar Resources:

Prof. Kulkarni further elaborated on the key **challenges** posed by the interfacing of renewable resources, specifically wind and solar, with the grid:

#### 1. Intermittency and Variability:

- Both **solar power** and **wind power** are intermittent and weather-dependent. This variability introduces significant challenges in ensuring grid reliability and balancing supply and demand in real-time.
- The **uncertainty in generation** from these resources can lead to frequent frequency and voltage disturbances, requiring robust control strategies.

#### 2. Inverter Characteristics:

- The integration of wind and solar systems into the grid is facilitated by **power electronic inverters**. However, the characteristics of these inverters differ substantially from traditional synchronous generators, which provide natural inertia and fault ride-through capabilities.
- **Inverter-based resources** can lack the capability to contribute to **system inertia**, making the grid more vulnerable to disturbances.



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## Disturbances and their Impact:

The integration of inverter-based resources can lead to several **disturbances** in power systems:

- **Frequency Instability:** Traditional power systems rely on the rotational inertia of synchronous generators to regulate frequency fluctuations. However, IBRs, such as solar and wind systems, provide no such inertia, leading to the potential for **rapid frequency deviations**.
- **Voltage Fluctuations:** Inverters need to ensure **voltage regulation** by providing reactive power support. Without proper regulation, high levels of inverter-based generation could lead to **voltage instability** and **poor power quality**.
- **Harmonics and Flicker:** Power electronic devices can introduce **harmonics** into the system, which could affect grid stability and the performance of other equipment connected to the grid.

These challenges necessitate careful **design of control algorithms** for inverters, to provide virtual inertia, support voltage regulation, and enhance fault ride-through capabilities.

## Characteristics of Wind and Solar Interfacing:

Prof. Kulkarni discussed the **interface characteristics** of both **wind** and **solar** energy systems, with a focus on how they interact with the grid:

- **Solar Power Systems:**
  - Solar inverters are typically based on **voltage-source converters (VSCs)** and can operate at **maximum power point tracking (MPPT)** to ensure efficient energy extraction.
  - However, the output of solar inverters is highly dependent on solar irradiation, and rapid changes in sunlight (e.g., cloud cover) can lead to rapid fluctuations in power output, requiring sophisticated control methods for managing these dynamics.
- **Wind Power Systems:**
  - Wind turbines are connected to the grid via **doubly-fed induction generators (DFIGs)** or **full-converter wind turbines**. Both types of wind turbines interface with the grid through inverters, which provide active and reactive power control.
  - Wind power, too, is intermittent, influenced by wind speed and direction, which complicates the real-time control and grid integration.



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## Power Electronics in Inverter-based Resources:

The final part of Prof. Kulkarni's presentation focused on the role of **power electronics** in enabling the integration of inverter-based resources:

- **Power Electronics for Grid-Forming Inverters:** Traditional synchronous generators provide grid-forming capabilities, whereas IBRs typically operate as grid-following systems. The challenge, Prof. Kulkarni noted, is to develop **grid-forming inverters** that can maintain grid stability even in the absence of traditional generation.
- **Advanced Control Strategies:** The use of **digital signal processors (DSPs)**, **field-programmable gate arrays (FPGAs)**, and **microcontrollers** in inverters allows for more precise and responsive control of power flow, voltage, and frequency.

Prof. Kulkarni concluded by stressing that **continuous innovation** in power electronics, control systems, and grid integration technologies is essential to successfully meet the challenges posed by high penetration levels of inverter-based renewable energy systems.



## Session 2:

The session on "Renewable Energy Integration in India: Operational Experience" by Mr. M. Venkateshwar Rao, Manager, WRLDC, Grid India, Mumbai. The session provided valuable insights into the current status and challenges of integrating renewable energy into India's power grid.

Mr. Rao highlighted India's significant strides in increasing renewable energy capacity, particularly in solar and wind, as part of the nation's commitment to achieving its climate goals. He discussed the operational experience of managing the variability and intermittency of renewable sources, emphasizing the importance of grid stability and reliability. Key challenges mentioned included balancing supply and demand, maintaining voltage and frequency control, and ensuring smooth integration of renewables without compromising grid performance.





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He also outlined ongoing initiatives to address these challenges, such as enhancing forecasting capabilities, upgrading transmission infrastructure, and exploring energy storage solutions like battery storage and pumped hydro storage. Mr. Rao emphasized the need for a flexible and responsive grid, along with policies that encourage innovation in grid management and private sector participation.

The session concluded with a discussion on the future potential of renewable energy in India, underlining the importance of continued collaboration between government, industry, and technical experts to achieve a sustainable energy transition.

The insights shared by Mr. Venkateshwar Rao were instrumental in understanding the operational complexities and solutions involved in large-scale renewable energy integration in India.



## Session 3:

"Outlook of Solar Energy in India: Future Prospects" was led by Mr. Atulya Kumar Naik, General Manager of the Energy Management Department at SECI (Solar Energy Corporation of India). Mr. Naik provided a comprehensive overview of the growth trajectory of solar energy in India, discussing both the current state and the outlook for the coming years.

Mr. Naik outlined India's ambitious solar energy targets, aiming for 500 GW of non-fossil fuel capacity by 2030, with solar playing a central role in achieving these goals. He discussed the rapid expansion of solar power installations across the country, driven by favorable government policies, technology advancements, and a competitive market environment. Mr. Naik also emphasized the role of large-scale solar parks, rooftop solar installations, and the growing importance of hybrid solutions, such as solar-wind combinations, in meeting energy demands.



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Looking ahead, Mr. Naik highlighted several key opportunities for solar energy, including advancements in solar panel efficiency, reduction in costs, and the potential for greater integration with storage technologies to address intermittency challenges. He also touched upon the role of policy reforms, grid modernization, and international collaborations in further boosting India's solar sector.



## Session 4:

The workshop session on "Transmission Planning for Renewable Energy Integration in the Indian Grid" was led by Mr. Ajay Dahiya, from the Central Transmission Utility of India Ltd. (CTU), Gurgaon. The session focused on the critical role of transmission infrastructure in facilitating the integration of renewable energy into India's national grid.

Mr. Dahiya discussed the challenges associated with integrating large-scale renewable energy sources, particularly solar and wind, which are often located in remote areas far from demand centers. He explained the need for a robust transmission network that can efficiently transfer renewable power from these generation sites to consumption hubs while maintaining grid stability and reliability.

The session highlighted ongoing initiatives and projects aimed at strengthening India's transmission infrastructure, such as the development of dedicated transmission corridors for renewable energy, upgrading existing lines, and introducing advanced technologies like high-voltage direct current (HVDC) systems. Mr. Dahiya emphasized the importance of long-term transmission planning to accommodate the growing share of renewable energy, including forecasting demand, improving grid flexibility, and enhancing grid resilience against fluctuating renewable generation.



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He also discussed the need for improved coordination between different stakeholders, including generation companies, transmission utilities, and regulatory bodies, to ensure the timely and efficient development of the transmission network. Furthermore, Mr. Dahiya touched on the role of policy support, funding mechanisms, and international collaborations in accelerating the transmission planning process.

The session concluded with a call for continued innovation and investment in transmission infrastructure to enable seamless integration of renewable energy, ensuring a stable, reliable, and sustainable power grid for the future.

Mr. Dahiya's insights provided a comprehensive understanding of the transmission planning process and its critical importance in supporting India's renewable energy ambitions.







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## Day 2 of Workshop:

### Session 1 & 2:

On Day 2 of the workshop, Prof. Vijay Vittal from Arizona State University (ASU), USA, delivered an insightful session on *"Generic Modeling of Inverter-Based Resources for Positive Sequence Stability Studies and Verification with Measurements."* The session was a deep dive into the technical aspects of modeling inverter-based resources (IBRs), such as solar photovoltaics (PV) and battery energy storage systems (BESS), for analyzing power system stability.

Prof. Vittal began by addressing the growing role of IBRs in modern grids, particularly as renewable energy sources like solar and wind continue to make up a larger share of the energy mix. Unlike conventional synchronous generators, which provide inherent grid support through their rotating masses, IBRs rely on power electronics and inverters. This key difference means that IBRs respond to grid disturbances in a way that requires specialized models for accurate stability analysis, particularly for positive sequence stability studies.

He explained how generic models of IBRs are essential for assessing their impact on grid stability. These models help simulate how inverters behave during grid faults, frequency fluctuations, or voltage variations, providing insights into how renewable energy sources can be integrated without compromising the stability of the system. Prof. Vittal also highlighted the specific challenges that arise when trying to simulate inverter behavior, such as their fast dynamic responses, nonlinear characteristics, and dependency on control strategies like voltage or current regulation.

The session concluded with an engaging discussion on the future directions of inverter-based resource modeling, including improvements in real-time monitoring, adaptive control strategies, and international collaborations to share best practices in grid stability management.







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## Session 3:

The workshop session on "*Protection for Inverter-Based Resource (IBR) Systems*" was presented by Dr. O.D. Naidu, Senior Principal Scientist at Hitachi Energy Research, Bangalore. This session focused on the critical issue of protection schemes and strategies for inverter-based resources (IBRs), such as solar photovoltaics (PV) and battery energy storage systems (BESS), which are becoming increasingly integrated into power grids.

Dr. Naidu began by highlighting the unique challenges that IBRs pose to traditional protection schemes. Unlike conventional synchronous generators, IBRs are connected to the grid through power electronic inverters, which behave differently during faults and disturbances. This requires rethinking conventional protection methods, which were designed for synchronous generators, and adapting them to the characteristics of IBRs.

The session covered various protection challenges associated with IBRs, including their fast response times, the impact of power electronics on fault currents, and issues related to fault detection, coordination, and isolation. Dr. Naidu emphasized that traditional overcurrent and distance protection schemes might not be effective in systems with high penetration of IBRs, especially due to the low fault currents typically provided by inverters during faults.





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## Session 4:

The workshop session on *"Renewable Integration and DC Grids"* was presented by Prof. Himanshu Bahirat from IIT Bombay. The session focused on the emerging role of Direct Current (DC) grids in supporting the integration of renewable energy sources into the power system.

Prof. Bahirat began by discussing the growing challenges associated with integrating intermittent renewable energy sources like solar and wind into the existing AC-based grid infrastructure. He explained that DC grids offer several advantages in addressing these challenges, particularly in terms of efficient power transmission and reduced losses when dealing with renewable energy sources, which are often generated in DC form (e.g., solar PV).

The session delved into the concept of hybrid AC-DC grids, where DC grids are used to directly integrate renewable energy generation and storage systems, such as solar panels and batteries, into the wider power grid. Prof. Bahirat highlighted the efficiency benefits of DC grids, especially in terms of reducing conversion losses and enabling easier connection of renewable generation sources located in remote areas.

He also addressed the technical and operational challenges of DC grid integration, including voltage control, protection schemes, and system stability. Prof. Bahirat emphasized the importance of advanced power electronic converters and control systems in managing the complexities of DC grid operations and ensuring smooth integration with the broader AC grid.







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## Conclusion:

The two-day workshop on *"Impact of Inverter-Based Resources on Power Systems"* concluded successfully on 5th November 2024. Prof. A.M. Kulkarni, Workshop Coordinator from IIT Bombay, delivered the closing remarks, expressing his gratitude to all participants, speakers, and organizers for their valuable contributions.

Prof. Kulkarni summarized the key takeaways from the workshop, emphasizing the critical role of inverter-based resources (IBRs) in the future of power systems, particularly in the context of renewable energy integration. He noted the insightful sessions on topics such as the operational experience of renewable integration, protection schemes for IBR systems, DC grid integration, and advanced modeling techniques for stability studies. The discussions highlighted the challenges and innovative solutions necessary for the successful integration of IBRs, which are becoming integral to modern power grids.

He thanked the esteemed speakers, including Prof. Vijay Vittal, Dr. O.D. Naidu, and Prof. Himanshu Bahirat, for their expert presentations and thought-provoking discussions. Their expertise provided the participants with a deeper understanding of the technical, operational, and policy aspects surrounding IBRs and their impact on grid stability and security.

Prof. Kulkarni also extended his sincere thanks to the participants for their active engagement, thoughtful questions, and contributions throughout the workshop. He acknowledged the collective effort of the organizing team, the Institute of Eminence (IOE) and the National Centre for Photovoltaic Research and Education (NCPRE) at IIT Bombay, whose support made the event possible.

In closing, Prof. Kulkarni encouraged all participants to apply the knowledge gained from the workshop in their research, projects, and professional work, contributing to the continued advancement of inverter-based technologies in power systems. He expressed hope for continued collaboration and future workshops to address the evolving challenges and opportunities in this field.

The workshop concluded with a note of thanks to all attendees for making the event a success, and a reminder to stay connected for future discussions and initiatives in the realm of renewable energy and power systems.





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## Permission letter from GCOEY to attend Workshop at IIT Bombay:

दि. २१ ऑक्ट २०२४

प्राचार्य,

शासकीय अभियांत्रिकी महाविद्यालय,

यवतमाळ.

विषय: आयआयटी बॉम्बे येथे कार्यशाळेत सहभागी होण्यासाठी परवानगी आणि आर्थिक सहाय्याबाबत विनंती.

मार्फत: विभाग प्रमुख, विद्युत अभियांत्रिकी विभाग, शासकीय अभियांत्रिकी महाविद्यालय, यवतमाळ.

आदरणीय महोदय,

मी, अफताब हबीब शेख आणि चिन्मय ललित नाफडे, विद्युत अभियांत्रिकी विभागातील विद्यार्थी, आपल्या कृपाशिर्वादने आयआयटी बॉम्बे येथे होणाऱ्या दोन दिवसीय कार्यशाळेत सहभागी होण्याची संधी मिळाली आहे. या कार्यशाळेचे शीर्षक "इम्पॅक्ट ऑफ इन्व्हर्टर-बेस्ड रिसोर्सेस ऑन पॉवर सिस्टिम्स" आहे आणि ही कार्यशाळा IOE आणि NCPRE यांच्या विद्यमाने ४ व ५ नोव्हेंबर २०२४ रोजी आयोजित करण्यात आली आहे.

या कार्यशाळेमध्ये सहभागी होण्यामुळे आम्हाला पॉवर सिस्टिम्समध्ये इन्व्हर्टर-बेस्ड रिसोर्सेसच्या उपयोगाबद्दल सखोल ज्ञान मिळेल, तसेच विद्युत अभियांत्रिकी क्षेत्रातील नवीन तांत्रिक प्रगतीची माहिती मिळवण्याची संधी मिळेल. ही कार्यशाळा आमच्या शैक्षणिक आणि व्यावसायिक विकासासाठी अत्यंत महत्त्वपूर्ण ठरेल.

आपण आम्हाला या कार्यशाळेत सहभागी होण्यासाठी दोन दिवसांची परवानगी द्यावी, तसेच प्रवास व निवास यासाठी महाविद्यालयाच्या वतीने आर्थिक सहाय्य दिले जावे, अशी आम्ही नम्र विनंती करतो. आपल्या मदतीमुळे आम्हाला या महत्त्वपूर्ण कार्यशाळेत सहभागी होऊन महाविद्यालयाचे नाव उज्ज्वल करण्याची संधी मिळेल.

आमच्या विनंतीचा सकारात्मक विचार करून कृपया लवकरात लवकर परवानगी व आर्थिक सहाय्य मिळावे, ही विनंती आहे.

**कार्यशाळेचे तपशील पुढीलप्रमाणे आहेत:**

- कार्यशाळेचे शीर्षक : इम्पॅक्ट ऑफ इन्व्हर्टर-बेस्ड रिसोर्सेस ऑन पॉवर सिस्टिम्स
- आयोजक : IOE आणि NCPRE, IIT बॉम्बे
- दिनांक : ४ व ५ नोव्हेंबर २०२४
- विद्यार्थी : अफताब हबीब शेख, चिन्मय ललित नाफडे

धन्यवाद!

आपले विद्यार्थी,

१. अफताब हबीब शेख

२. चिन्मय ललित नाफडे

Recomend  
with or w/o  
TR/DA  
21/10/24

Permitted  
TR & DA  
to be borne  
by students  
Principal  
Government College of Engineering,  
Yavatmal







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## IIT Bombay Registration Confirmation E-mail to participants:



**Re: Registration Confirmation//2 Day Workshop on "Impact of Inverter-based Resources on Power Systems"//4th - 5th November 2024**

1 message

ashwini24 <ashwini24@ee.iitb.ac.in>  
To: Anil <anil@ee.iitb.ac.in>

Fri, Oct 11, 2024 at 12:31 PM

Dear Participant,

Greetings from NCPRE!

Thanks for your registration for the IEO/NCPRE workshop on "Impact of Inverter-based Resources on Power Systems" to be held during 4-5 November 2024.

We hereby confirm your registration for the workshop.

If there are any changes in your plan to participate, please inform us so that we can make appropriate logistical arrangements.

Thank you.

—

Regards,  
Ashwini Bangera  
Sr. Project Assistant  
NCPRE, IIT Bombay,  
Powai, Mumbai.  
Contact: 022-21593582



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## Workshop Photos:







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## Feedback:

I am pleased to provide my feedback on the two-day workshop on *"Impact of Inverter-based Resources on Power Systems"* held on 4th and 5th November 2024 at IIT Bombay, organized under the aegis of IOE and NCPRE. The workshop provided an excellent platform for understanding the evolving role of inverter-based resources (IBRs) in the context of renewable energy integration and grid stability.

The sessions were exceptionally well-curated, covering a broad range of topics including the operational impact of IBRs, inverter modeling for stability studies, protection schemes, and the future of DC grids. The insights shared by eminent speakers such as Prof. Vijay Vittal, Dr. O. D. Naidu, and Prof. Himanshu Bahirat were of immense value. Their expertise in the field helped to clarify many of the challenges related to IBR integration, particularly regarding system stability, fault detection, and grid management in the face of increasing renewable penetration.

I particularly appreciated the technical depth of the presentations and the practical solutions discussed for ensuring smooth integration of IBRs into existing power systems. The interactive Q&A sessions fostered a collaborative atmosphere, allowing participants to engage with the speakers and other attendees on key issues.

The workshop was organized efficiently, and I found the topics highly relevant to my research and professional interests. The knowledge gained from this workshop will undoubtedly contribute to advancing my understanding of power system dynamics in the context of renewable energy and inverter-based technologies.

I would like to extend my sincere thanks to the organizers, speakers, and IIT Bombay for providing such an insightful and well-executed workshop. It was a rewarding experience, and I look forward to participating in future events of this nature.

Thank you once again for this excellent opportunity.

**Dr. S. M. Shinde**

Asst. Professor in Electrical Engineering Dept.

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# **Government College of Engineering, Yavatmal**

**(Affiliated to, Dr. Babasaheb Ambedkar Technological University)**

## **Students Feedback:**

I would like to express my gratitude for the opportunity to attend the two-day workshop on "*Impact of Inverter-based Resources on Power Systems*" held at IIT Bombay on 4th and 5th November 2024. The workshop provided a great learning experience, particularly with the focus on the integration of inverter-based resources (IBRs) in modern power systems.

The sessions were informative and well-structured, with expert speakers like Prof. Vijay Vittal, Dr. O.D. Naidu, and Prof. Himanshu Bahirat sharing their knowledge on important topics such as inverter modeling, protection mechanisms, and the role of IBRs in grid stability. I gained valuable insights into the technical challenges and solutions for integrating renewable energy sources effectively into the grid.

The interactive nature of the workshop, along with the Q&A sessions, allowed me to engage deeply with the material and broaden my understanding of the subject. Overall, the workshop was highly beneficial, and I look forward to applying the knowledge gained to my studies and future work.

Thank you to the organizers and speakers for such an enriching experience.

- **Mr. Afatab H. Sheikh**

**(Student Id: 2210121293512)**

Attending the two-day workshop on "*Impact of Inverter-based Resources on Power Systems*" at IIT Bombay was an enriching experience. The workshop, organized under IOE and NCPRE, covered essential topics related to the integration of inverter-based resources (IBRs) into the power grid.

The sessions were well-organized and delivered by leading experts like Prof. Vijay Vittal, Dr. O.D. Naidu, and Prof. Himanshu Bahirat, who provided deep insights into the technical aspects of inverter modeling, grid stability, and protection mechanisms for IBRs. I especially appreciated the focus on real-world applications and the challenges of managing IBRs in large-scale systems.

The interactive discussions and Q&A sessions were valuable in clarifying concepts and offering practical solutions to the challenges faced in renewable energy integration. I gained a better understanding of how IBRs can shape the future of power systems.

I am grateful to the organizers for hosting such an informative event, and I look forward to applying the knowledge gained in my future academic and professional endeavors.

- **Mr. Chinmay L. Naphade**

**(Student Id: 2210121293506)**