IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**AI/ML Powered Data Driven Approach for Reliability Estimation & Enhancement of Wind Turbine Generator**	
Project Number	**IMURA1281**	
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IITB Department:		

Research Clusters:

Highlight which of the Academy's CLUSTERS this project will address?
*(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*

1	*Material Science/Engineering (including Nano, Metallurgy)*
2	***Energy, Green Chem, Chemistry, Catalysis, Reaction Eng***
3	*Math, CFD, Modelling, Manufacturing*
4	***CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control***
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*
8	*HSS, Design, Management*

Research Themes:

Highlight which of the Academy's Theme(s) this project will address?
(Feel free to nominate more than one. For more information, see www.iitbmonash.org)

1	***Artificial Intelligence and Advanced Computational Modelling***
2	*Circular Economy*
3	***Clean Energy***
4	*Health Sciences*
5	*Smart Materials*
6	***Sustainable Societies***
7	*Infrastructure*

The research problem

Background

The energy transition to renewables is taking place rapidly, with wind energy playing a pivotal role in decarbonization of the energy sector. Globally wind energy has seen tremendous growth from 350 GW in 2014 to more than 1.2 TW in March 2025, with forecasted 2 TW by 20230. Therefore, ensuring secure and reliable operation of wind power plants is critical for operational efficiency and ensuring grid stability.

However, the operational challenges of wind turbine generators (WTGs)—ranging from electrical faults and mechanical wear to unpredictable environmental conditions— pose significant risks to consistent energy output and long-term asset integrity. These challenges are amplified in remote or offshore installations where maintenance is logistically complex and economically burdensome.

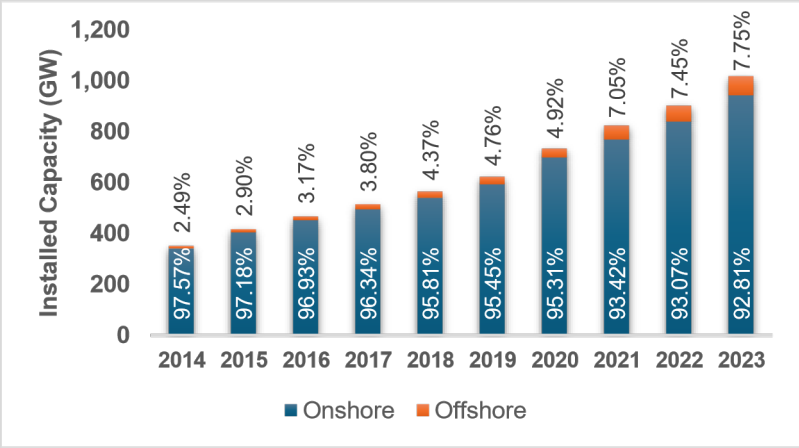

Figure 1: Sector wise growth of wind installations (Source: IRENA)

Despite advancements in design, control systems, and condition monitoring, failures in subsystems such as generators, power electronics, and gearboxes remain common, leading to unplanned downtimes and revenue losses. Therefore, improving the reliability of WTGs requires a multi-disciplinary approach, combining insights from electrical engineering, data analytics, materials science, and real-world operational data.

This proposal aims to investigate and enhance the reliability of wind turbine generators through a combination of fault analysis, predictive maintenance strategies, and system-level modeling. The research will be carried out at IIT Bombay and Monash University in collaboration with Suzlon, leveraging real-time field data, design insights, and industry experience. By identifying root causes of failure, improving predictive diagnostics, and developing reliability-centered design and maintenance frameworks, the project seeks to contribute meaningfully ongoing efforts in improving turbine performance and reducing lifecycle costs.

Project aims

The project aims to:

1. To analyze historical reliability data of wind turbine generators and identify critical failure modes and their root causes.
2. Develop machine learning and statistical approaches for estimation of component degradation and minimize unplanned outages.
3. Develop data driven methodology to accurately estimate the reliability of wind power plants.

How skills/experience of the IITB and the Monash supervisor(s) support the proposed project

Monash team involves international leader of the topic and well-recognised individuals. Dr. Terrence W.K. Mak is currently a faculty member in the Department of Data Science & AI of the Faculty of IT. He is located in the Optimisation disciple group. He is an active member of the Monash Energy Institute and the Monash Data Futures Institute. He has obtained a PhD (2018) from the Australian National University, a MPhil (2011) & a BSc (2009) from the Chinese University of Hong Kong. He was a Postdoc Fellow in Georgia Tech and a Research Associate in University of Michigan. He has worked with his fomer PhD & Postdoc supervisor Prof. Pascal Van Hentenryck for over 10 years through University of Melbourne, Australian National University, University of Michigan, and Georgia Tech, and over 5 years with his former Master & Bachelor supervisor Prof. Jimmy Lee in Chinese University of Hong Kong. He has experience over multiple research domains and has publications spanning over computer science (AI/ML/differential privacy), electrical engineering (power/natural gas/control), and operations research (MILP/NLP).

He is an interdisciplinary researcher and his research domain lies on the intersections of three traditional academic research areas ---

- mathematical & combinatorial optimization,
- machine learning, and
- energy systems (including electric power transmission systems and natural gas pipeline systems).

His primary focus is to seek for novel methodologies combining both machine learning and optimization to solve grand climate change challenges in the energy sector to prepare for the future era. He is particularly interested tackling problems on:

- energy sustainability,
- net-zero emissions,
- climate-change resiliency,
- disaster management.

IIT Bombay team includes Prof. Zakir Rather who is leading Grid Integration Lab at IIT Bombay (**GIL**) working closely on renewable energy integration, electric vehicle charging infrastructure, grid operation under high penetration of RE and EVs, cybercity of power sector microgrid and power electronics application. he is an electrical engineer by training, with PhD from Aalborg University, Denmark. He has been working in renewable energy (RE) and electric mobility sector for past 11 years, with around 4 years of RE industry experience in Europe. He, in close collaboration with the Danish National transmission system operator, Energinet.dk, has extensively worked on the Danish grid. He is currently working as Associate Professor with the Department of Energy Science and Engineering, Indian Institute of Technology (IIT) Bombay, where the focus of his work continues to be on grid integration of renewables, grid integration of Electric Vehicles (EVs), power system operation under high penetration of renewable generation and EVs. He is an Editor of IEEE Transactions on Sustainable Energy, Editor of IETE Technical Review, Guest Editor of International Journal of Power and Energy Systems, a Senior Member of IEEE, IEEE Power & Energy Society, IEEE Smart Grid Community, IEEE Industrial Electronics Society, and Danish Smart Grid Research Forum. He is also involved in various committees on RE integration, EV charging standard committees and smart grid initiative related task forces. His areas of research interest include grid and system integration of wind and solar power, power system dynamics, EV charging infrastructure and EV grid integration, hydrogen storage, data centre, smart and micro grids, and WAMPACS.

What is expected of the student when at IITB and when at Monash?

Highlight how the project will gain from the students stay at IITB and at Monash

Expected outcomes

Highlight the expected outcomes of the project

The expected outcomes are:

1. Identification of major WTG failure modes.
2. Predictive models capable of early fault detection and degradation tracking.
3. Technical Report: Failure Mode and Root Cause Analysis
4. Technical Report: WTG reliability estimation
5. Software tool: Predictive Maintenance and Reliability Monitoring Dashboard

How will the project address the Goals of the above Themes?

How well the IITB and the Monash supervisor(s) know each other

Provide details of previous collaborations (if any). For new collaborators, have you had a chance to meet each other in person or through VC or Skype?

Potential RPCs from IITB and Monash

Provide names of the potential research progress committee members (RPCs) and describe why they are most suited for the proposed project

Capabilities and Degrees Required

A highly motivated applicant with background in Electrical Power engineering/Energy Systems/Data Science/Computer Science or any renewable energy related background with strong commitment to quality research. Any prior experience in renewable energy, AI/ML, optimisation, data science will be of added value.

Necessary Courses

Name three tentative courses relevant to the project that the student should complete during his/her coursework at IITB (the student will require to secure 8 point in these courses)

Potential Collaborators

Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.

Select up to **(4)** keywords from the Academy's approved keyword list **(available at http://www.iitbmonash.org/becoming-a-research-supervisor/)** relating to this project to make it easier for the students to apply.