



Project Proposal for Ph.D.

Project Details (The research problem must clearly indicate the need for an interdisciplinary approach)

Project Title	AI-Enabled Optimization of Biochar Production from Biomass Pyrolysis and Its Application in Soil Carbon Sequestration
Project Summary (Minimum 500 and maximum 2000 characters)	Biochar produced through biomass pyrolysis is well-established as a promising material for long-term soil carbon sequestration and agricultural soil amendment. However, the wide variability in biomass feedstock, pyrolysis process parameters, and resulting biochar properties presents a complex multi-dimensional optimization challenge that conventional approaches cannot fully address. This interdisciplinary project integrates artificial intelligence and machine learning with biomass thermochemical conversion and life cycle sustainability assessment to develop intelligent frameworks for biochar production optimization and soil carbon sequestration evaluation. The research combines AI-driven process modelling, digital twin architectures, and sensor-based real-time monitoring with pyrolysis process engineering, techno-economic analysis, and environmental impact assessment. Supervisor 1 contributes expertise in AI/ML algorithm design, cyber-physical systems, sensor data analytics, and edge-computing platforms for real-time process control. Supervisor 2 brings expertise in biomass pyrolysis, catalytic biochar production, life cycle analysis (LCA), techno-economic assessment (TEA), and AI-augmented process simulation for sustainability. Neither discipline alone can address the full pipeline from feedstock characterization through optimized pyrolysis to validated soil carbon storage outcomes. The PhD scholar will work at the intersection, developing predictive models linking pyrolysis parameters to biochar quality, building digital twin frameworks for process monitoring, and integrating AI-driven LCA tools to quantify net carbon-negative impact of biochar-amended soils.

Ph.D. Supervisors* (Supervisor 1 and Supervisor 2 cannot be from the same department of IITD)			
Role	Name of Faculty	Academic Unit in IITD/Institute/University	Email ID (Official)
Supervisor 1*	Prof. Santhosh Sivasubramani	Centre for SeNSE, IIT Delhi	ssivasub@sense.iitd.ac.in
Supervisor 2	Prof. Pushpraj Patel	Centre for Rural Development and Technology (CRDT), IIT Delhi	ppatel@rdat.iitd.ac.in

*Supervisor 1 must be from IIT, Delhi.

+All cells in this table are mandatory fields that need to be filled by faculty for consideration of proposal.

\$The date of superannuation of supervisors should be at least three years from the date of registration of selected candidates.

Project requirements (Student qualifications, experience required, etc)

*The candidate will be shortlisted based on common shortlisting criteria decided by ScRC (SIRe)

Essential Qualifications:
- M.Tech./M.E. in Chemical Engineering, Environmental Engineering, Energy Systems, Computer Science, or related discipline;
Desirable Skills:
- Experience with machine learning / deep learning frameworks (Python, TensorFlow/PyTorch)
- Familiarity with biomass conversion, pyrolysis, or biochar characterization
- Exposure to life cycle assessment (LCA) tools or process simulation (e.g., ASPEN) is an advantage
- Strong analytical, programming, and experimental skills

Valid GATE/NET/JRF qualification is preferred.

Source of fellowship/funding and project number (CSIR/UGC/DBT/ICMR/ICAR/NEET-PG/DST-INSPIRE/IRD/FITT Project details, if any)
Full-time Institute Assistantship (FIA) from SIRE

Role of Faculty Members involved:	
Supervisor-1	Prof. Santhosh Sivasubramani (Supervisor 1) will guide the PhD scholar on: - Design and development of AI/ML models for pyrolysis process parameter optimization and biochar property prediction - Digital twin architecture and cyber-physical system design for real-time pyrolysis process monitoring and control - Sensor data analytics and edge-computing integration for field-deployable soil carbon monitoring - Overall computational framework, research methodology, and project coordination
Supervisor-2	Prof. Pushpraj Patel (Supervisor 2) will guide the PhD scholar on: - Biomass pyrolysis process design, catalytic biochar production, and feedstock characterization - Life cycle analysis (LCA) and techno-economic assessment (TEA) of biochar production pathways - Environmental impact evaluation and carbon-negative process design for soil sequestration applications - Experimental biochar characterization, soil carbon sequestration, and process simulation (ASPEN)

- Note :-**
- Approval from the respective DRC/CRC/ScRC of your Department/Centre/School will be required for using the "Full-time Institute Assistantship (Category-wise) (FIA)" for selecting the students in SIRE.
 - Declaration:-** Faculty members, please ensure that you have at least 3 years of service left before superannuation along with adequate sitting space & lab facilities for the SIRE student.
 - PI/s are also encouraged to submit joint proposals with AIIMS, NII, JNU and institutes with which IITD has an existing MoU. If the Co-PI (Supervisor 2) is from outside IITD, kindly share his/her detailed CV.
 - If a research scholar is to be considered for selection under the project fellowship, then the project should have a minimum of two-year duration remaining.
 - A candidate applying with a valid JRF/INSPIRE/any national level fellowship should have at least two-year validity from the date of joining the Ph.D. program.
 - The third supervisor’s name (if required) can be added only after the formation of Student Research Committee (SRC) subject to a strong recommendation of SRC and subsequent approval from the competent authority.
 - If Institute fellowship is being sought, then DRC approval of the parent department of Supervisor 1 is required at the time of selection.