ESPOB at IIT Delhi would bring together different expertise for the development of redox flow battery, ion-battery and photo-electrochemical water splitting technologies using earth abundant materials. The objectives and deliverables are met via four domain areas: (i) graphene(Gr)/modified Gr/C$_3$N$_4$ (ii) mixed-metal oxides/transition metal oxides/perovskites (iii) organic-inorganic hybrid materials (iv) Molecular and Kinetic Simulation and Device Level Modelling.
The collaborative platform provided by the centre would bring best minds together and is expected to lead to research and technology outputs of immense value for clean energy driven growth. This would also accelerate innovation in clean energy domain for cost effective, reliable and robust solutions.

Dr. Harsh Vardhan
Union Minister for Science & Technology, Earth Sciences, Environment, Forests and Climate Change - Government of India

Accelerated discovery of energy materials has the potential to make clean energy harnessing more efficient and affordable. The centre would develop materials which can address the issues of variability and uncertainty intrinsic to clean energy sources and provide research led disruptive solution

Prof. Ashutosh Sharma
Secretary to the Government of India, Department of Science and Technology

ESPOB presents an exciting opportunity for researchers engaged in different aspects of electrochemical energy storage to work together. Such an interdisciplinary approach is required to provide sustainable solutions for meeting the ever-growing energy requirements of the nation. IIT Delhi is privileged to host this centre as the nucleating site for providing a leadership role in renewable energy storage research and implementation.

Prof. V. Ramgopal Rao
Director, IIT Delhi

Materials for Energy Conservation and Storage Platform (MECSP), a theme based initiative by DST to support feasibility assessment of fresh idea/concepts including various emerging and disruptive materials technologies for the potential use in energy storage devices. This brings investigators engaged previously in different DST, SERB and Ministries projects to work together to deliver solution to energy conservation and storage solutions particular to renewable energy sources.

Dr. Suddhasatwa Basu
Project Coordinator
Aim and Objectives of the Centre

- Develop next generation materials and India-centric scalable energy storage technology
- Material development work on doped-carbonaceous materials
- Develop low cost and efficient hybrid organic-inorganic membrane
- Create human resource pool by training to electrochemical storage technologies
- Network with industry and other institutions (national and international) with complementary skills
- Disseminate knowledge through short courses and workshops to industry and academia

Overview of Activities at the Centre

- **Doped Carbonaceous materials** *(doped-graphene, nanotube, nanofiber), porous carbon nanomaterials, composites of carbon with transition metal oxides*
  - Developing electrochemical exfoliation of graphite for graphene with very low scatter
  - Synthesis of graphene suspension with bilayer or trilayer content greater than 80%
  - Build synthesis protocol that can target a level of defect density (guided by DFT)
  - Modelling and electrochemical characterization to examine electrochemical behaviour
  - Formulating anode fabrication method to improve capacity retention and cell performance

- **Mixed Metal Oxides, single/multiple transition metal oxides and (Binary/Ternary) Semiconductor**
  - Synthesis of cathode materials for rechargeable Na-ion, Al-ion Battery and separator for Metal-ion Batteries
  - Electrochemical characterization, modelling and design optimization of Li-ion battery cathodes
  - Non-PGM based oxygen reduction reaction (ORR) and oxygen reduction reaction (OER) catalysts
  - Materials for PEMFC and Electrolyser
  - Photo-electrochemical Water Splitting

Ceramic Coated Paper-based Separator for Li-ion Batteries
Overview of Activities at the Centre

➢ Organic-Inorganic Hybrid Polymer Electrolyte, ionic liquid based polymer gel electrolytes.
  • Hybrid electrolyte for VRFB
  • OER-ORR coupling over NiMnO$_x$ based Composite Photo-electrocatalysts
  • NiCo$_2$O$_4$–RGO composite based hybrid material for solar driven water splitting

➢ Molecular and Kinetic Simulation and Device Level Modelling.
  • Study the binding mechanism in pristine, hydroxylated carbon nanotube, and carbon nanotube with glycerine additive to understand the binding energy trends of VO$_2^+$ over these surfaces
  • Understand reactivity trends of several metal and bimetallic catalysts as cathode materials in a PEMFC

➢ Recycling of Spent Li-ion Battery.
  • Development of new efficient processes both for metal dissolution and formulating marketable products
  • Process identification related to precursor, material, electrode and battery manufacturing
  • To recover cobalt, lithium and other metal values from Li-ion batteries
Facilities

Semi-automated Ceramic Separator Fabrication Equipment

- Heating Chamber
- Compactor
- Rotating Ring Disk Electrode setup
- Control panel
- Compaction controller
- Paper (without coating)

Fabrication process of cathode material for Na-ion batteries

- Rotating Ring Disk Electrode setup
- Tape Casting Unit
- BET Surface Area Analyzer
- Stirring
- Coating
- Drying
- Calendering
- Assembled Cell
- Crimping
- Cell assembly
- Disk cut

Testing
Facilities

Gas chromatographer for Product Analysis

Electrochemical CO₂ Reduction Setup

Vanadium Redox Flow Battery

Low temperature Fuel Cell Test Station
Investigators and Collaborators

Prof. Sudhhasatwa Basu, Director, CSIR-Institute of Minerals & Materials Technology, Bhubaneswar; Dept. of Chem.Eng., IIT Delhi sbasu@iitd.ac.in
Research focus: Materials for Storage Devices, Interfacial and Electrochemical engineering

Prof. Anil Verma, Administrator CEMAS Dept. of Chemical Engineering, IIT Delhi anilverma@iitd.ac.in
Research focus: electrochemical reduction of CO₂, Fuel cell, Redox Flow Batteries

Prof. Anupam Shukla, Dept. of Chemical Engineering, IIT Delhi anupam.shukla@iitd.ac.in
Research focus: Membrane synthesis and separation, Electrochemical systems

Prof. Amit Gupta, Dept. of Mechanical Engineering, IIT Delhi agupta@iitd.ac.in
Research focus: Energy Storage, Microfluidics, Flapping Wing Aerodynamics.

Prof. Rajendra S. Dhaka, Dept. of Physics, IIT Delhi rsdhaka@iitd.ac.in
Research focus: Nanoparticles of complex oxides, Thin films of Na-ion battery materials

Prof. Ali Haider, Dept. of Chemical Engineering, IIT Delhi haider@iitd.ac.in
Research focus: Solid oxide fuel cells, Heterogeneous catalysis, Biofuels, Biorenewable chemicals

Prof. Aninda Jiban Bhattacharyya, IISc Bengaluru anindajb@iisc.ac.in
Research focus: Electrodes and Electrolytes for Rechargeable Batteries, Fuel cells, Supercapacitors

Prof. Ali Haider, Dept. of Chemical Engineering, IIT Delhi
Research focus: Solid oxide fuel cells, Heterogeneous catalysis, Biofuels, Biorenewable chemicals

Dr. Mamata Mohapatra IICT-IMMT, Bhubaneswar mamata@immt.res.in
Research focus: Recovery of Lithium, Cobalt, Manganese, Graphite from spent battery

Prof. Rajendra Nath Basu, CSIR - CGCRI, Kolkata rnbasu@cgcri.res.in
Research focus: Solid Oxide Fuel Cell and Electrolyser Cell, Lithium-ion Battery

Dr. Vatsala Rani J., IICT-CSIR, Hyderabad vatsala@ict.res.in
Research focus: Development of electrode and electrolyte materials for Mg-ion, Al-ion batteries.

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Dr. Rajalakshmi Natarajan, CFCT, ARCI, Chennai rajalakshmi@arci.res.in
Research focus: Fuel cell systems, Hydrogen Storage

Prof. Vijay Ramani, Washington University in St. Louis ramani@wustl.edu
Research focus: Electrochemical engineering, renewable and sustainable energy technologies, materials science

ESPOB Conceptualized by:
Dr. Ranjith Krishna Pai and Dr. Sanjay Bajpai

Dr. Ranjith Krishna Pai
Scientist, (TMD: Energy & Water), DST
Ministry of Science and Technology
Government of India
ranjith.krishnapai@gov.in

Dr. Sanjay Bajpai
Head (TMD: Energy & Water), DST
Ministry of Science and Technology
Government of India
sbajpai@nic.in