विज्ञान एवं प्रौद्योगिकी विभाग
DEPARTMENT OF
SCIENCE & TECHNOLOGY

सत्यमेव जयते

INDIAN INSTITUTE OF SCIENCE
भारतीय विज्ञान संस्थान

CREST | Center for Research on Energy Storage Technologies

DST-IISc Energy Storage Platform on Supercapacitors and Power Dense Devices

A research platform to develop and engineer techno-economically viable, power dense electrochemical energy storage solutions through active collaboration and accelerated technology development

Amararaja Batteries
NED Energy
Mesha Energy Solutions

भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

QUOTES

"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

Established in 1909, IISc is India's leading institution of advanced education and research in the sciences and in engineering. From its beginnings, IISc has laid equal emphasis on fundamental investigations and the solution of practical problems in such a setting. IISc realizes that energy security and self-reliance are of national importance and therefore, energy research is a strategic area of research at IISc. Especially, energy storage is critical to the mass adoption of clean energy sources. DST-IISc Energy Storage Platform on Supercapacitors and Power Dense Devices brings together our strengths in fundamental chemistry and energy storage to help accelerate the development of techno-commercially viable energy storage solutions.

Prof. Anurag Kumar, Director, IISc Bengaluru

Development of electrochemical energy storage devices with high power density including supercapacitors will be the primary research emphasis at the center. Such a Center for Research on Energy Storage Technologies (CREST) could enable the fast-paced translation and subsequent commercialization of energy storage technologies. We plan to position the center as a national facility that provides access to the latest in energy storage research while also providing access to facilities for industry and academia. We hope that research at this center would lead to a transformative change in the adoption of both grid-integrated and off-grid clean energy solutions in India.

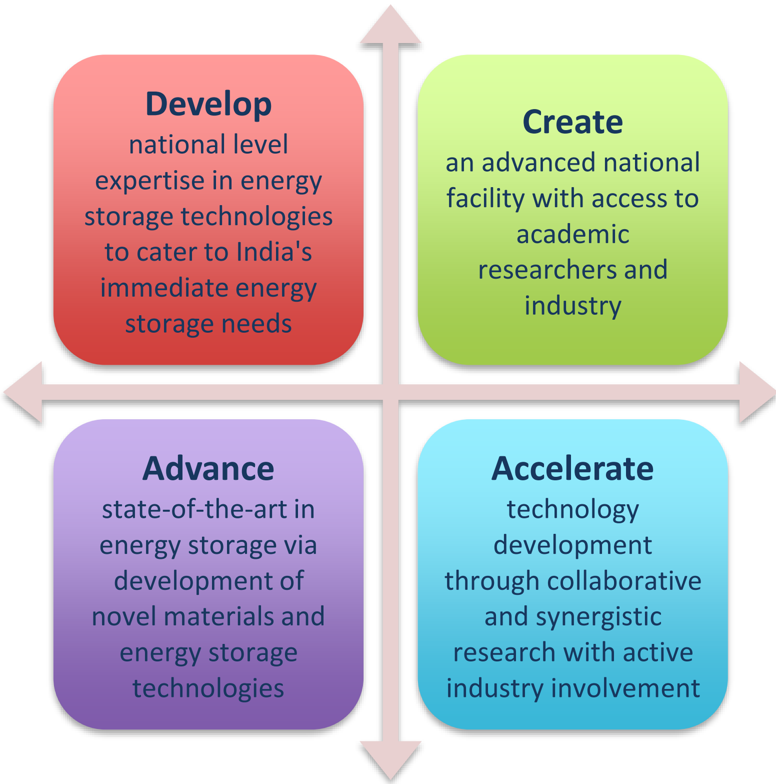
Prof. Naga Phani B Aetukuri, Center Head and Project Coordinator, IISc Bengaluru

The development of electrochemical energy storage devices, with techno-economic attributes suitable to meet the clean energy adoption goals of India, is a national priority.

PREAMBLE

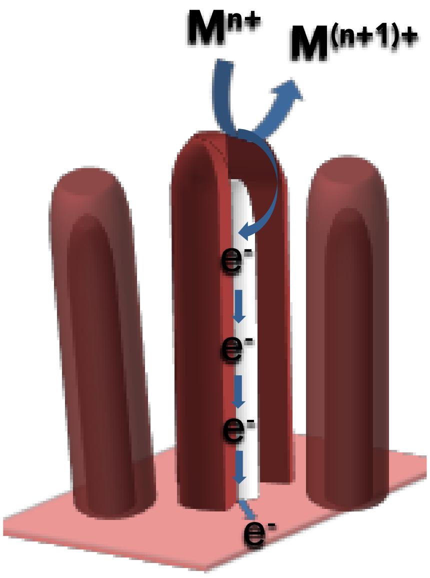
Over the next decade, India is positioned to take a paradigm leap towards the adoption of renewable energy sources for meeting the nation's ever increasing energy requirement. For example, 175 GW of solar and wind energy installations by the year 2022 is the Indian government's target for rapidly transforming India's clean energy landscape. Although, both solar and wind energy installations have reached an economically viable price-point, the intermittency in energy generation from these sources is a huge impediment to their mass adoption. Therefore, to manage intermittency, techno-economically viable electrical energy storage will be indispensable to India's planned adoption of renewable energy sources. A related, but distinct ambitious national agenda is the mass-market electrification of transportation. It is targeted that by 2030, 60 million vehicles in India should be electrically powered (Global Energy Outlook 2017, by IEA). This is a herculean task given that only 4800 electric vehicles are on the road in India as of 2016. As is the case with the adoption of renewable energy sources for the grid, the mass adoption of electric vehicles is also limited by the techno-economic viability of electrical energy storage.

Clearly, electrical energy storage is indispensable for the integration of renewable energy sources to the electric grid and for the electrification of transportation. Therefore, the overarching objective of this multi-institutional Center is to enable accelerated technology development of techno-economically viable electrochemical energy storage solutions that have the potential to catapult India to a leadership role in energy storage and clean energy technologies. Rapid prototyping and technology transfer to industry is also a priority. In due course of time, we anticipate that CREST will be an Indian national center for advancing energy storage research with industry support. Our team comprising of researchers from the Indian Institute of Science (IISc), IIT Hyderabad, IIT Madras, Pondicherry University and CECRI Karaikudi, brings in expertise from various facets of electrochemical energy storage including intercalation chemistry, redox flow batteries, supercapacitors, and beyond Li-ion batteries, into a unified synergistic working group. Commercialization- or application-driven development through active collaboration will be the primary driving force for research while also developing next-generation storage technologies that perform beyond existing electrochemical energy storage devices. For example, we will be developing prototype-devices of soluble lead redox flow batteries and aqueous Na-ion batteries where the basic battery chemistry has already been demonstrated and performance optimization is necessary for product development. In due course of time, we anticipate that CREST will be an Indian national center for advancing energy storage research with industry support.



RESEARCH AREAS

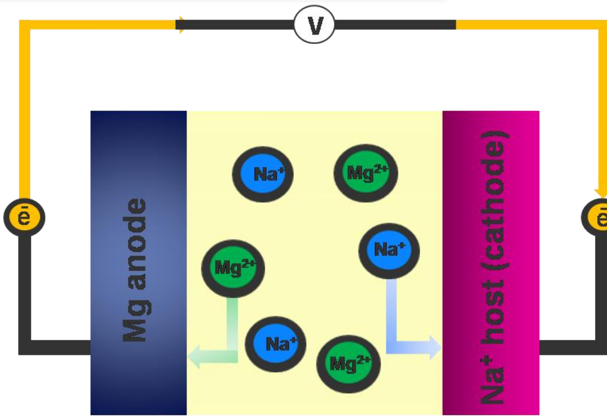
Electrochemical Supercapacitors



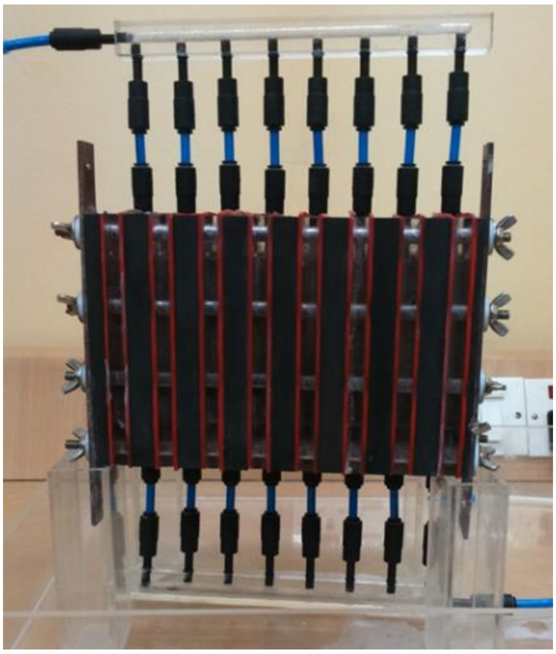
A major thrust for the center's activities is the development of asymmetric electrochemical supercapacitors with high energy density coupled with the high power densities of supercapacitors. Asymmetric supercapacitors (ASCs) provide higher operating voltage in comparison to symmetric supercapacitors and therefore offer high energy densities while not compromising on power density. Research at the center will focus on ASCs with a novel core-shell design that could yield single cell potentials of ~2 V. These supercapacitors employ aqueous electrolytes and are therefore expected to offer high current densities. A related research activity concerns the development of Li-ion hybrid ultracapacitors with a single cell voltage of > 4 V. The high voltages enable high energy and power densities in these ASCs that employ Li-ion electrode materials for the positive electrode and carbon fiber electrodes with nano architectures as the negative electrode.

Ion Intercalation Batteries

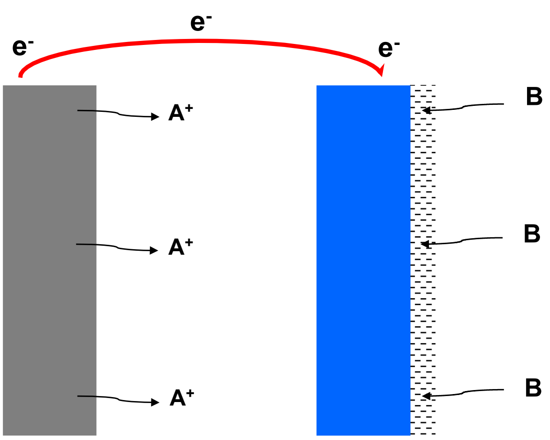
The abundance and availability of lithium and cobalt (in $LiCoO_2$-based Li-ion batteries) could limit widespread adoption of Li-ion batteries. The limited to non-availability of minerals bearing Li and Co within India also necessitates the development of energy storage technologies that utilize elements with high natural abundance within India. Therefore, our research will also involve the development of low cost, high-rate and long cycle Na-ion batteries, development of mixed-ion electrolytes that are necessary for the development of Na/Mg hybrid batteries and also the development of more sustainable organic electrode materials with capacities comparable to state-of-the-art Li-ion battery electrodes. The use of metallic electrodes such as Mg in Na/Mg batteries will also be researched so as to enable high energy density chemistries that employ metallic negative electrodes.



RESEARCH AREAS



Redox flow batteries (RFBs) provide the flexibility to decouple energy and power density of an electrochemical energy storage system. Furthermore, redox flow batteries can be operated at room temperature with a wide operation temperature window. An important storage activity under this theme is the development of large-scale soluble-lead redox flow batteries employing a novel auxiliary electrode concept. In addition, we are embarking on an ambitious research program to develop high voltage (~3 V) non-aqueous redox flow batteries. This project involves a synegetic interdisciplinary effort involving organic molecule synthesis and electrochemical device design. If successful, we would have invented a novel high energy and power density flow battery system with applications in instantly rechargeable electric vehicle batteries.

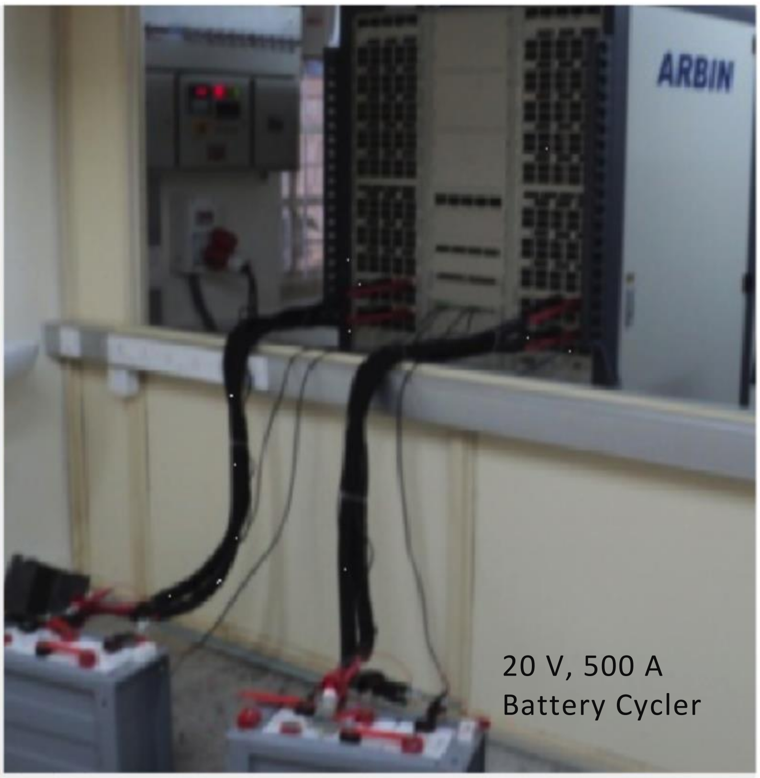


Chemical conversion batteries offer very high energy densities and could potentially offer higher power densities when compared to state-of-the-art lithium ion batteries. They are considered as promising alternatives for future energy needs. However, several outstanding challenges such as poor cycle life and dendrite growth on metallic negative electrodes serious limit their commercial development. As part of a futuristic strategic development of energy storage devices, this Center's resources will also be devoted to research and development of designer electrolytes/electrolyte additives for large discharge capacity metal-oxygen batteries; porous carbon networks for high surface area cathodes for metal-oxygen batteries; bi-functional catalysts for advanced Zn-air batteries; and membranes and separators for Li-S and Na-S batteries.

Redox Flow Batteries | Chemical Conversion Batteries

Facilities | Indian Institute of Science, Bengaluru

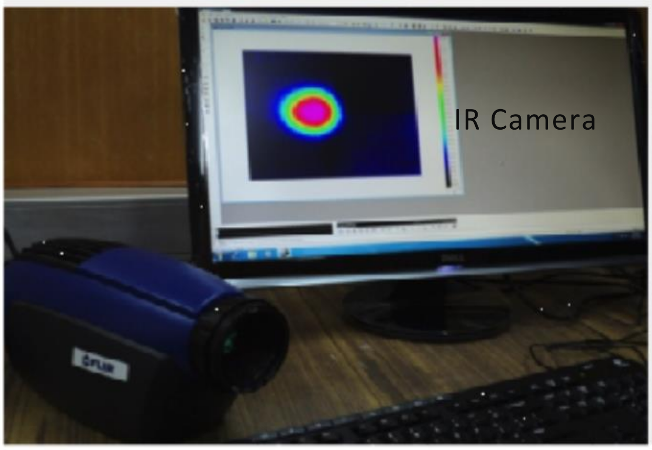
Scanning Electron Microscope



20 V, 500 A
Battery Cycler

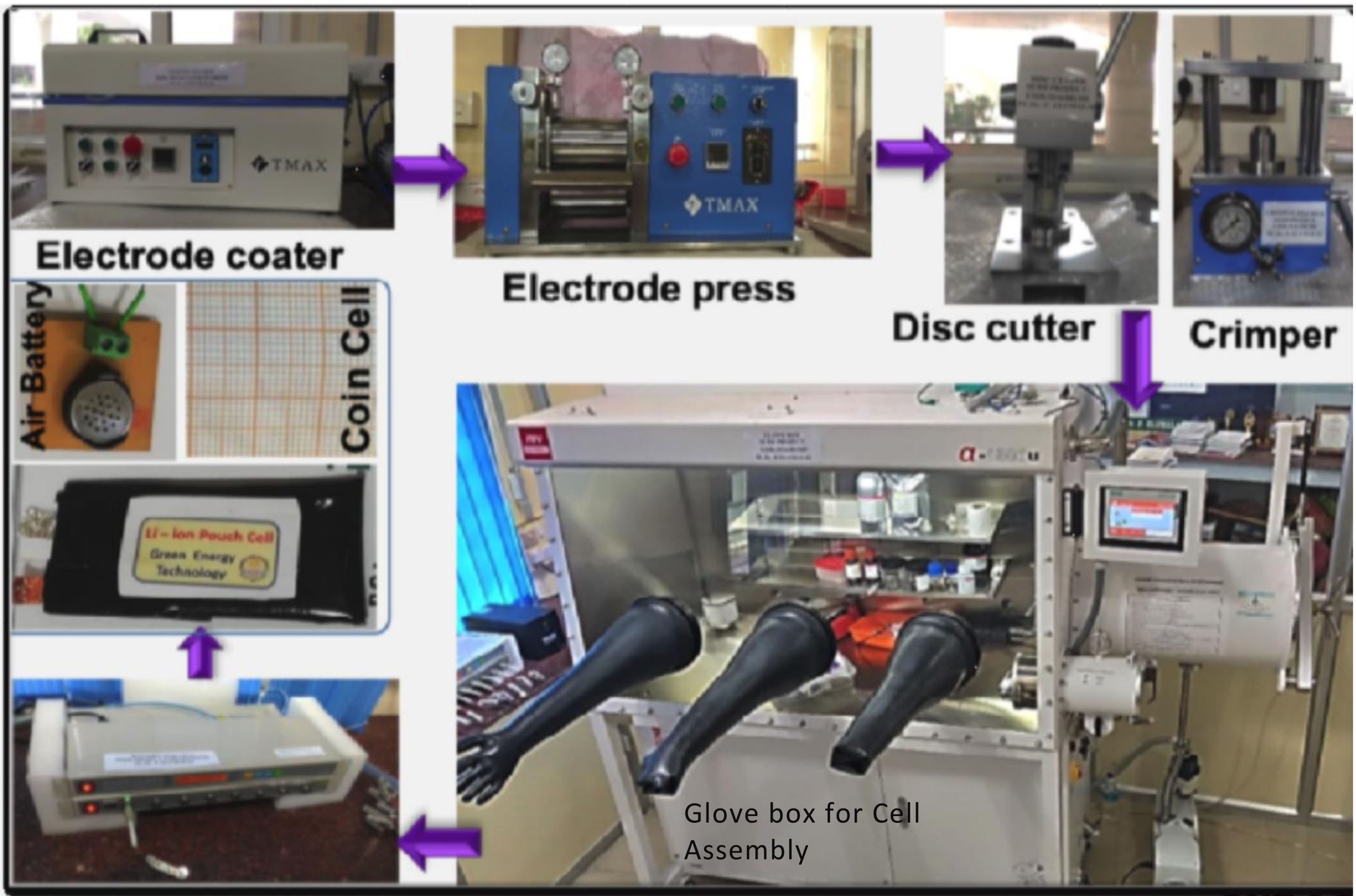
In-operando
Electrochemical X-ray
Diffractometer

Hybrid Ultracapacitors Developed and
being tested at IISc

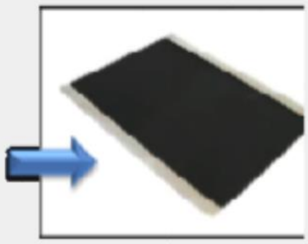


IR Camera

100 V, 300 A
Battery Cycler

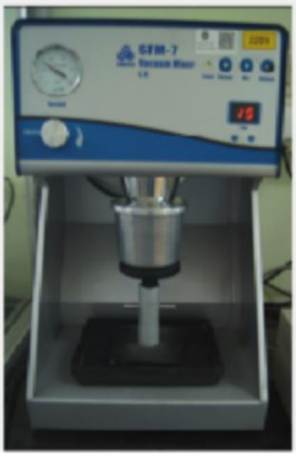


Glove box for Cell Assembly



Battery Electrode Coating Unit

X-ray Photoelectron Spectroscopy Tool



NMR Unit

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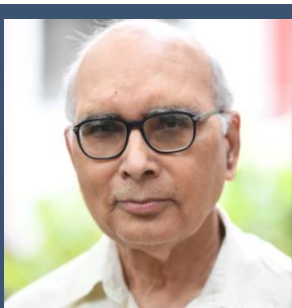

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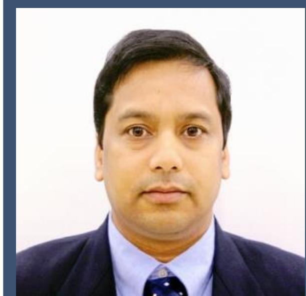

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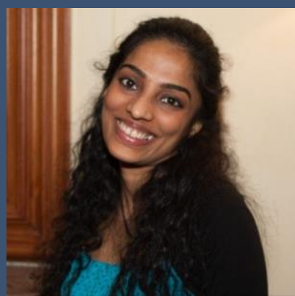

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