

# Materials for Energy Roadmap

Updated as of 16 February 2024

## OVERALL STRATEGIES

### Needs for Government Facilities and Lab

- Continuous support for ADMATEL
- National centralized testing facility for electrochemical characterization, prototyping, failure analysis, etc.

### Needs for Human Resources

- Human resource and institution building for electrochemical characterization, prototyping, failure analysis, among others

### R&D Program / Project Needs

- Supercapacitor R&D Program
- Fuel Cell R&D Program
- Local and international collaborative R&D
- NICER-CAMCET Program components (2021-2024):
  - Project 1: Biomass-Derived Nanomaterials as Novel Electrocatalyst Components for DEFC
  - Project 2: Fabrication of Nanostructured Silica-based Nanocomposite Membranes for PEMFCs
  - Project 3: Plant-Derived Biochar as Fabric-Based Electrode Materials for Supercapacitor Devices
- DOST-MOST: The Development of High-performance and Low-cost Membrane Electrode Assembly for Alkaline Fuel Cell Based on Ion/Electron Dual Conducting Catalyst Layers (2021-2023)

### S&T Policy Initiatives

- Ensure communication of government policy incentives and benefits to stakeholders

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- Design and development of components, electrode flow, electrocatalysts, electrolyte, ionomer membrane, hydrogen and liquid fuel, catalyst support; Pt-free and metal-free catalysts.
- Reduction of frictional losses/ Cost reduction of Flywheel
- New catalysts with low overpotentials for oxygen reduction to make the system more efficient, cost-effective and bifunctional
- Air electrodes with high electrochemical activity and lower polarization / resistance
- Low cost organometallic catalysis for air electrode

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- Development of energy storage devices
- Hybrid capacitors (composite hybrids and battery type)
- Advanced technologies on Lead-Acid and Li-ion;
- Mobile energy sources (wearables and ambient energy harvester)

## R&D SOLUTIONS

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- Fabrication and testing of single cell, electrolyser, metal air battery
- Upscale production of components. Design and integration of fuel stack
- Develop non-aqueous flow battery systems with wider cell operating voltages to improve efficiency.

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- Upscale production of components
- Design and integration of fuel stack

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Development of smart energy systems

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- Post lithium ion batteries (multivalent element, Na-ion batteries, solid state batteries)
- Post silicon semiconductor substrates including silicon carbides (SiC) and Gallium nitride (GaN)

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- Establishment of a robust research and testing infrastructure
- Development of electrode materials for EDLC and pseudocapacitor, separators, and electrolytes
- Conducting polymers and electrolytes

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Use of computational methods

2021

2020

Supercapacitor and Fuel Cell R&D Programs initialized; Fuel Cell and Electrolyser R&D Program

2022

- Computational Analysis on reduction of CO<sub>2</sub>
- Battery interfaces and ORR electrocatalysis for next generation instruments for energy and storage conversions.

2023

2024

- Established Energy Research and Innovation Center
- Assistance for spin-off and startups
- Developed business models and pricing for its services
- Fabrication of novel materials as anode electrode for high power generation Al battery

2025

- Energy Systems integration and application
- Transportation (battery for electric vehicle charger)
  - Stationary (pump storage hydropower, compressed and liquid air) energy storage superconducting magnetic energy storage; Flywheel, etc.

Small portable energy system for small or lightweight applications e.g. mobile medical bracelets or field sensors

2026

- Enhanced capabilities, functionalities and applications
- Medium scale energy systems like power banks or longer lifecycle disaster relief/ rural handhelds like radios and high powered flashlights

2027

- Enhanced capabilities, functionalities and applications
- Implementation of wider scale such as long term and reliable internet of things networking or monitoring in an industrial setting

2028

- Advanced capabilities, functionalities, and applications
- Large scale applications as energy storage devices focused on long distance transportation

## VISION

Provision of enabling technologies for applications beneficial to society.

## OVERALL OUTCOME

Locally-developed products and services intended for supercapacitors, fuel cells, and batteries

## MILESTONES



# List of Materials for Energy Projects (for the whole duration of the roadmap)

R&D Technologies	Project Title	Budget Allocation ('000)							Status
		2022	2023	2024	2025	2026	2027	2028	
Materials for Energy	NICER CAMCET Project 1. Biomass-Derived Nanomaterials as Novel Electrocatalyst Components for Direct Ethanol Fuel Cells	4,209,356.80	4,179,356.80						Ongoing (DOST-GIA)
Materials for Energy	NICER CAMCET Project 2. Fabrication of Nanostructured Silica-based Nanocomposite Membranes for Proton Exchange Membrane Fuel Cells (PEMFCs) Applications	2,869,893.34	2,760,768.84						Ongoing (DOST-GIA)
Materials for Energy	NICER CAMCET Project 3. Plant-Derived Biochar as Fabric-Based Electrode Materials for Supercapacitor Devices	2,775,241.60	3,813,641.60						Ongoing (DOST-GIA)
Materials for Energy	The Development of a High-Performance and Low-Cost Membrane Electrode Assembly for Alkaline Fuel Cell Based on Ion/Electron Dual Conducting Catalyst Layers	8,000,000.00							Ongoing (DOST-GIA)
Materials for Energy	e-Asia JRP: "Designing High Entropy Alloy Surfaces for Catalytic Applications Using Atomistic Calculations and Materials Informatics Investigations"	9,995,768.88	2,499,768.88	2,499,768.88					Ongoing (PCIEERD-GIA c/o PCMD)



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R&D Technologies	Project Title	Budget Allocation ('000)							Status
		2022	2023	2024	2025	2026	2027	2028	
Materials for Energy	Sustainable Green Energy from Hydrogen Evolution Reaction via 2D Janus Nanosheet Electrocatalysts (SGEHER2DN ANO): Density Functional Theory Calculations	2,365,232.48	957,232.48						Ongoing (DOST-GIA)
Materials for Energy	Renewable Energy-Powered Production of Net Zero Energy Carriers: from Emerging Catalysis to Process Engineering			1,757,273.00	1,661,249.00	1,581,323.00			Ongoing (DOST-GIA)
Materials for Energy	Metal Oxide Hybrid Structured Barriers for Stable Energy Devices (SEA-EU)	4,903,062.04	3,066,010.96						Ongoing (PCIEERD-GIA) c/o PCMD

