

Green Shipping Programme



The Green Shipping programme demonstrates TERI's research capabilities in supporting sustainable utilization of resource across key sectors including ports, shipping, and waterways. The programme hosts the National Centre of Excellence on Green Ports and Shipping (NCoEGPS) that was set up to support the Ministry of Ports, Shipping and Waterways (MoPSW) and keys stakeholders in fostering carbon neutrality and circular economy in India's maritime sector in line with changing global and national regulatory landscape. The programme actively engages in industry advisory services on various environmental, social, and governance (ESG) dimensions. It undertakes cutting-edge scientific and policy research in promoting commercially viable and sustainable solutions derived from biobased routes, anchored on the principles of circularity, towards greening India's maritime sector and beyond.

Our Key Areas

National Centre of Excellence on Green Ports and Shipping

The **National Centre of Excellence on Green Ports and Shipping (NCoEGPS)** is a unique partnership between the MoPSW, Government of India and TERI that was instituted to identify scalable green solutions while supporting developing regulatory framework to drive the change. It is supported by major ports in India including, Cochin Shipyard Limited, Deendayal Port Authority, Paradip Port Authority, and VO Chidambaram Port Authority.

Thrust areas and expertise

- Empower '**Make in India**' in ports, coastal, and inland waterways by identifying and developing state-of-the-art technologies and products
- Provide relevant support in developing policies, regulations and standards for green transitions, facilitate collaboration with relevant organizations in India and outside
- Enable fast-track innovations in order to provide most appropriate solutions to various challenges in these sectors
- Provide competency in human resources in key maritime sector-based organizations.

These objectives are achieved through various scientific and technical assessments, active engagement with key national and international entities, demonstration of key technologies through pilot projects, and maintaining a knowledge hub on sustainability initiatives in the maritime sector, etc.

The Centre engages into cross-divisional collaborative work on various areas including: (i) Developing a low-energy Consumption Port; (ii) Developing renewable energy generation/sourcing roadmap for ports; (iii) Project on Just in Time arrival of ships; (iv) Market-based mechanism/economic measures; (v) Supporting biofuel adoption in existing marine vessels; and (vi) Green fuels adoption roadmap.

The Centre is also the technical knowledge partner for the '**Green Port Initiatives**' being developed under the **Neel Arth Vision Implementation** (NAVIC Cell) and the special working group on **Safety Standards and Environmental Sustainability** developed to drive **Harit Nauka Guidelines** of the MoPSW.

The activities under the programme are supported by two divisions: (i) **Resource Efficiency and Governance (REG)** and (ii) **Advanced Biofuels**, which apart from actively supporting the NCoEGPS engage into various scientific research and advisory-related services.

Resource Efficiency and Governance

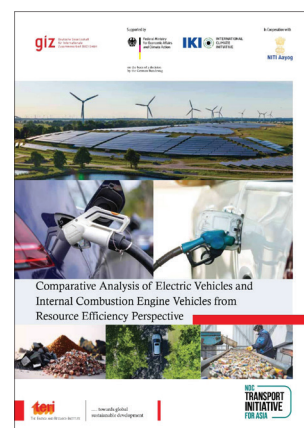
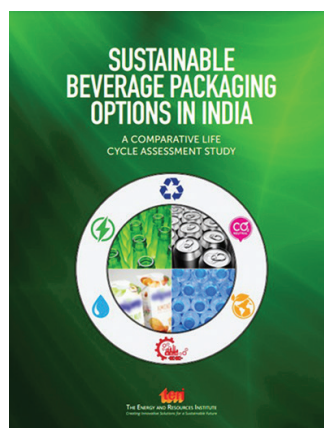
The Resource Efficiency and Governance (REG) Division leads TERI's work around **sustainable consumption and production** (SDG12) supporting public policy actors and businesses, to

drive sustainable use of natural resources along product and service life cycles. Using evidence-based decision tools and state-of-the-art life cycle assessment frameworks, the division provides comprehensive understanding of resource efficient solutions in key sectors that support India's achievement of **Mission LiFE** and **SDG12**.

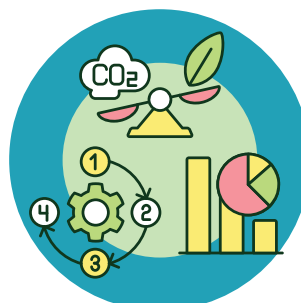
Many of these key findings are leveraged by leading Indian and global brands for their sustainability reporting initiatives while supporting ESG compliance. The division actively engages with relevant ministries, businesses, think tanks, consumers and other stakeholders advocating strategic approach to critical mineral resource security and use of secondary material use for achieving successful policy change.

Thrust areas and expertise

- Material flows, life cycle assessment of materials, processes and products in key sectors including mining, traditional and modern energy (including hydrogen), shipping and maritime sector, packaging, automotive, chemicals, defence equipments, etc., based on ISO 14000 series



- Environmental impact and social sustainability assessments of energy and non-energy minerals mining, agricultural, infrastructure projects, etc., based on ISO 26000 series
- Comprehensive market needs/demand assessments of various critical material sources
- Accounting of mineral resources extraction as per the Government Accounting Standards Advisory Board (GASAB) framework
- Support relevant ministries and government departments in developing policies and critical inputs around emerging



Life Cycle Assessment



Ecosystem Evaluation



Agriculture Policy

economic instruments, trade and circularity, mapping emerging technologies, process performance benchmarking and standards setting, and the like.



Economic and Policy Analysis

Recent accomplishments

The division delivers customizable analytical tools that can be used by organizations and brands in assessing environmental impacts and footprints across product and service life cycles. In recent months, the division has completed several innovative research on ecological footprints of products and process in selected sectors including benchmarking thereby providing meaningful insights to consumers, brands and government for strategic and policy decisions. These include the following:

- Sustainability potential of aluminium as a sustainable beverage packaging solutions across major markets: India, Vietnam, and Thailand
- Driving sustainability in India's mobility through fuel choices
- Supporting India's leading airlines in developing a transformation roadmap for adoption of sustainable aviation fuels
- Helping India's defence sector in understanding economic and environmental benefits through use of simulators
- A comprehensive first-of-its-kind material flows of various plastics in India and potential of adopting circularity.

Advanced Biofuels

The Advanced Biofuels division is divided under two distinct Areas: (i) Microbial Biofuels and Biochemicals (MBB); and (ii) Pyrolytic Biofuel, Biochar, and Green Chemicals (PBGC).

Microbial Biofuels and Biochemicals

The Microbial Biofuels and Biochemicals (MBB) Area engages in research and demonstration of technologies for biofuel and

biochemical production through microbial interventions using select microorganism (specific to the biomolecule) as host. The Area focuses on bioprocesses using broad spectrum feed (commercial-grade sugar as well as nonedible lignocellulose and algae biomass) with a view to make the processes less energy intensive and more cost effective.

Thrust areas and expertise

The Area covers:

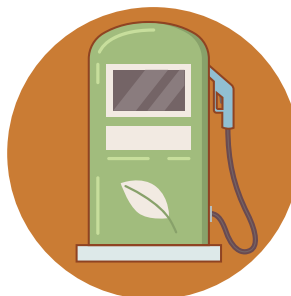
- Biomass hydrolysis
- Feedstock production and improvement (microalgae)
- Fermentative production of biofuels
- Fermentative production of biochemicals
- Downstream recovery of biochemicals and nutraceuticals
- Customized biocommodity formulation



Biomass Hydrolysis



Feedstock Production and Improvement (Microalgae)



Fermentative Production of Biofuels



Fermentative Production of Biochemicals



Downstream Recovery of Biochemicals and Nutraceuticals



Customized Biocommodity Formulation



Optimization of process parameters for enhanced productivity of biomolecules

Tata Chemicals Ltd (TCL)-TERI Centre of Excellence

Set up in 2023, the TCL-TERI Centre of Excellence at TERI Gram, Gwal Pahari, has specific infrastructure facility for

demonstration of technologies for upstream production of microbial-based biochemicals and their downstream recovery through employment of an integrated circular bioeconomy approach to achieve zero waste discharge.

Sustainable Solutions

The technologies and processes developed by the Area include production (on a pilot or demonstration scale) of bio-hydrogen from marine algae, agri-residue biomass;



Establishment of TERI-TCL Centre of Excellence at TERI Gram



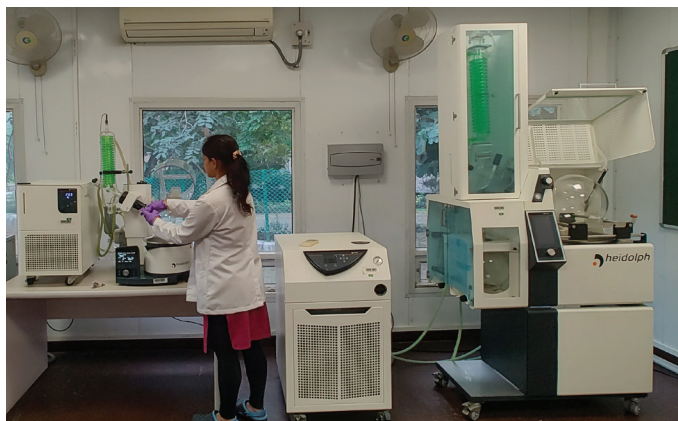
Pilot-scale demonstration of biochemical production

2,3 Butane diol (precursor of bio-jet fuel) products from sugarcane industry distillery spent, commercial sugar, and lignocellulose biomass; bio-ethanol products from molasses and algae biomass; bio-pigments; high value biochemicals such as lactic acids, 1,3 propane diol, butanol, short chain organic acids; and bio-based enzyme production for industrial applications. TERI has a research facility at a coastal site in Mumbai, which carries out cultivation of marine algae at 1,00,000 litre scale using sunlight, sea water, CO₂, and low-cost commercial grade nutrients. Its aim is to deploy algal biotechnology for enhanced marine algae productivity vis-à-vis its lipid productivity.

Some major projects taken up under this Area include:

- Adoption of biofuels for maritime transportation under the NCoEGPS

- Indo-German bilateral workshop on 'Future Energy Carriers: Advancing bio-circular economy for clean energy'
- Pilot-scale 2,3 Butane diol production by *Enterobacter* strain TERI CT and its downstream purification



Pilot-scale demonstration for downstream recovery of biochemicals and biomolecules

- Development of a pilot-scale process for dark fermentative hydrogen production by *Enterobacter cloacae* strain TERI DT1 from lignocellulose biomass, second generation feedstock
- Pilot-scale dark fermentative bio-hydrogen production using *Clostridium butyricum* as host, from sugarcane molasses in a bio-refinery approach.

Pyrolytic Biofuel, Biochar, and Green Chemicals

The Pyrolytic Biofuel, Biochar, and Green Chemicals (PBGC) Area focuses on research, technology development, and consultancy in areas of thermochemical and catalytic conversion of agro-industrial biomass and waste residues—such as algae, waste/scrap plastics, used cooking oil (UCO)—into advanced biofuels (SAF/bio-jet fuel, biodiesel, refinery grade pyrolytic bio-crude) and other by-products—such as biochar and high porosity activated carbons.

TERI maintains a Thermochemical Conversion Laboratory that conducts research in pyrolysis technology for production of biofuel, biochar, and activated carbon.



TERI's Pyrolysis Research Laboratory

The Area has a centre in Bengaluru that focuses on biodegradable plastic and nanocomposite materials. The team has successfully fabricated and characterized a variety of environment-friendly composites and nanocomposites and studied the optimization issues related to end applications.

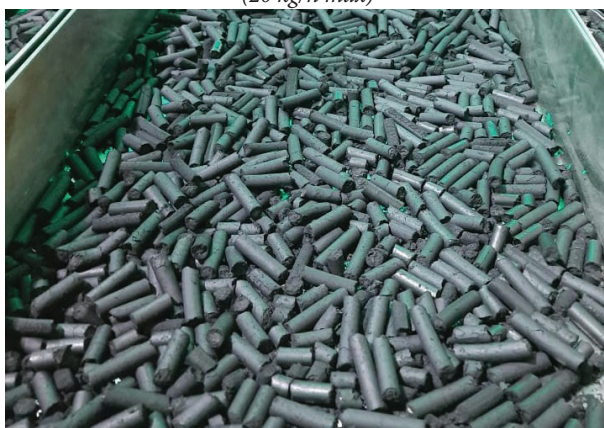
Sustainable Solutions

TERI has a few patented technologies in this field, and is currently engaged with development of some others as listed below:

- **Pyrolysis Research (Patented Technology TRL 5):** TERI Lab runs a gas fired auger pyrolyser unit, using dual mode heating-gas and electricity, along with a unit for downstream catalytic bio-oil upgradation (both liquid and gas) to conduct research into conversion of different biomass feedstocks/agro-industrial residues into biofuel and biochar.
- **Biodiesel (Technology Status TRL 4):** A two stage, inhouse acidic and basic ionic liquid (IL) catalysed process has been developed for production of biodiesel from renewable oil feedstocks, like UCO and marine algal lipid (conversion efficiency over 95%).
- **Industrial Green Chemical (Pilot-scale technology developed TRL 4):** A process of making acrylic acid through



TERI's patented gas-fired auger continuous pilot pyrolysis unit (20 kg/h max)



Pyrolytic biochar-based green pellet

ally-alcohol pathway from renewable glycerol has been developed and patented by TERI.

- **SAF from Biomass, Agro-residues and, Marine algal lipid (TRL 3):** With the global aviation industry poised to enhance use of Sustainable Aviation Fuels (SAF), TERI has initiated work on converting biomass pyrolysis oil and marine algal lipid into SAF.

Thrust areas and expertise

The Area covers:

- Thermochemical conversion
 - Biochar
 - Biofuels
 - Industrial green chemicals
- Consultancy and policy research



Thermochemical Conversion



Biochar



Biofuels



Industrial Green Chemicals



Consultancy and Policy Research



Way Forward

The activities to be undertaken by the NCoEGPS will help the decision makers at national and sub-national level with framework to implement sustainability measures through electrification of operations, as well as adoption and use of renewable energy, biofuels, and green infrastructure.

MBB (Microbial Biofuels and Biochemical) research leads along with its establishment of state-of-the-art infrastructure facility provides a great platform for demonstration of bioprocesses for integrated production of high value biochemicals and biofuels at Technology Readiness Level 7 (TRL 7). MBB is looking forward for partnering with domain-

specific industries for joint demonstration of bioprocesses for biochemical and biofuel production that can pave the way for commercialization of these biobased products.

The PBGC Area's strength in green fuel (including biofuel), biochar, and bioplastic areas can be leveraged for the genesis of full-fledged dedicated Centres, with industrial partnerships. We are also working towards developing strategic research partnerships with institutions of national and international importance.



**THE ENERGY AND
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Creating Innovative Solutions for a Sustainable Future

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