Decarbonizing Shipping in India Pathway for Sustainable Growth

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Webinar on Knowledge Session on Decarbonizing Shipping in India

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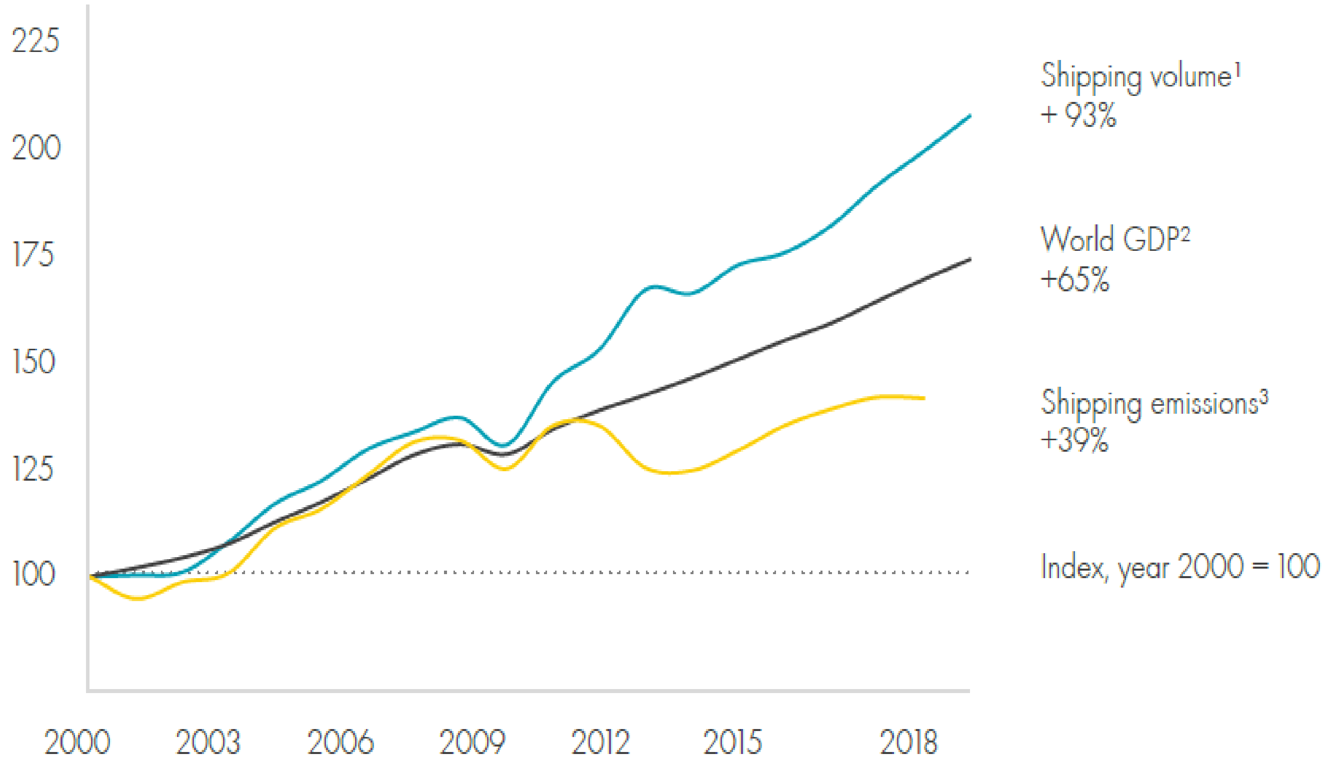
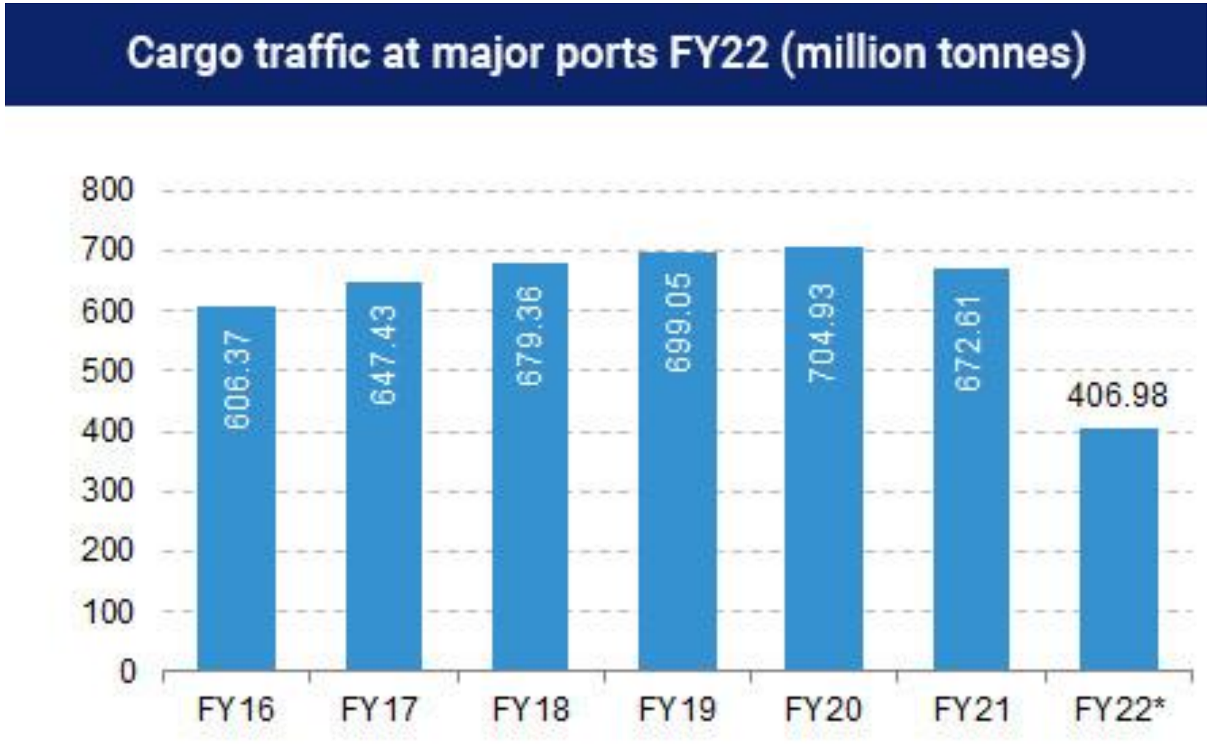
Growth in Global Shipping and Emissions



- Between 2000 and 2018, global GDP increased by approximately 65% while international shipping volumes increased by 93% over the same period.
- Industry currently accounts for around 2.7% of global CO_2 emissions, but emissions are geographically concentrated across East-West trade routes
- Bulk carriers, oil tankers and container ships account for around 85% of all shipping activity

Indian Shipping Industry – Current Status



- Around 95% of India's trading by volume and 70% by value is done through maritime transport
- India has 12 major and 200+ notified minor and intermediate ports.
- Under the National Perspective Plan for Sagarmala, six new mega ports will be developed in the country.
- The Indian ports and shipping industry play a vital role in sustaining growth in the country's trade and commerce.
- India is the sixteenth-largest maritime country in the world with a coastline of 7,516.6 kms.
- India's key ports had a capacity of 1,598 million tonnes per annum (MTPA) in FY22.
- However the utilization has not been adequate

Imperative of Decarbonizing India's Shipping sector

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- Currently about 99% of the energy demand from coastal shipping sector is met by fossil fuels, with fuel oil and marine gas oil (MGO).
- As per IMO, an unchecked measure may take GHG emissions associated with the shipping sector to anywhere between 50% and 250% by 2050 in comparison to 2008 emission levels.
- Based on IMO's objective the MoPSW has set target to reduce GHG emission in Indian shipping sector to 30% by 2030.
- Green shipping sector is the most pivotal element in evolving a sustainable blue economy
- For a thriving blue economy sector, India has a sustainable and efficient shipping sector

Sustainable Transformation in India’s Shipping Sector – Emerging Options

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- Biofuel blending with existing fuels
- Ensure Just in Time Arrivals
- Greening Port Infrastructure
- Harnessing Renewable Energy
- Green Fuel Bunkering
- Transition to fuel cell technology for long haul shipping
- Market based measures to facilitate transition

Industry Perspective on Alternative Fuels

Fuel	Part of future mix? (% participants)	Engine type	View on technology maturity	View on applicability to shipping	Advantages	Disadvantages
Green Hydrogen	65%	Combustion	Medium	Medium	Cross-sector applications – possibly faster R&D	Cost Low energy density Cryogenic storage conditions
		Electric (fuel cell)	Low	High	Less space for engine and better specs than combustion	
Green Ammonia	55%	Combustion	Medium	High	Relatively high energy density Port experience in handling	Cost Toxicity
		Electric (fuel cell)	Low	High	Less space for engine and better specs than combustion	
Biofuels	10%	Combustion	High	Low	Easy to implement in current engines	Limited feedstock, unlikely to be available to shipping
Methanol	10%	Combustion	Rarely mentioned	Rarely mentioned	Rarely mentioned	Rarely mentioned
Batteries	< 5%	Electric	High	Low	Mature technology	Extremely low energy density – size and weight of batteries
Nuclear	< 5%	Heat	Medium	Low	Mature technology	Very high investment, social aversion

Source: Based on Perception of 82 senior shipping leaders that represent almost all segments of the shipping industry
Shell, 2022

Potential Roadmap

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1. Scale Up Customer Demand	2. Global Regulatory Alignment	3. Cross-sector Research and Development	4. Scale-up Controlled Pilot Projects
5. Coordinated Industry Commitments	6. Flexible and Modular Designs	7. Port Coalitions	8. Investor Pressure
9. Green Finance	10. Scale-up Fuel production	11. Scale-up Bunkering Infrastructure	12.Operational Efficiency

About NCoEGPS

NCoEGPS
National Centre of Excellence in Green Port & Shipping

The Ministry of Ports, Shipping and Waterways (MoPSW), Government of India, and The Energy and Resources Institute (TERI) entered into a memorandum of agreement (MoA) in November 2022 in order to develop the National Centre of Excellence for Green Port and Shipping (NCoEGPS) on policy and regulatory support to the MoPSW, for developing regulatory framework and alternate technology adoption road map for green shipping to foster carbon neutrality and circular economy in shipping sector in India.

Objectives

The specific objectives of the formation of NCoEGPS include the following:

- To empower 'Make in India' in port, coastal, and inland water transport and engineering by developing state-of-the-art technologies and application products.
- To enable fast-track innovations in order to provide most appropriate solutions to various challenges in these sectors.
- To create a pool of competent manpower to the industry equipped with state of the art theoretical and practical knowhow.
- Self-sufficiency in providing (i) short-term solutions through scientific studies, (ii) technology development, and (iii) technical arm in identifying and analysing complex problems and solving issues.

About NCoEGPS: Thrust and Scope

Thrust Areas

In order to achieve the objectives, the NCoEGPS will focus on the following five broad areas:

1. Policy, regulatory, and research
2. Human resource development
3. Network: Key partners and strategic collaborators
4. Explore: Area of work, outcomes, projects and resources
5. Engage: Past events, upcoming events, dissemination

Scope for NCoEGPS Activities

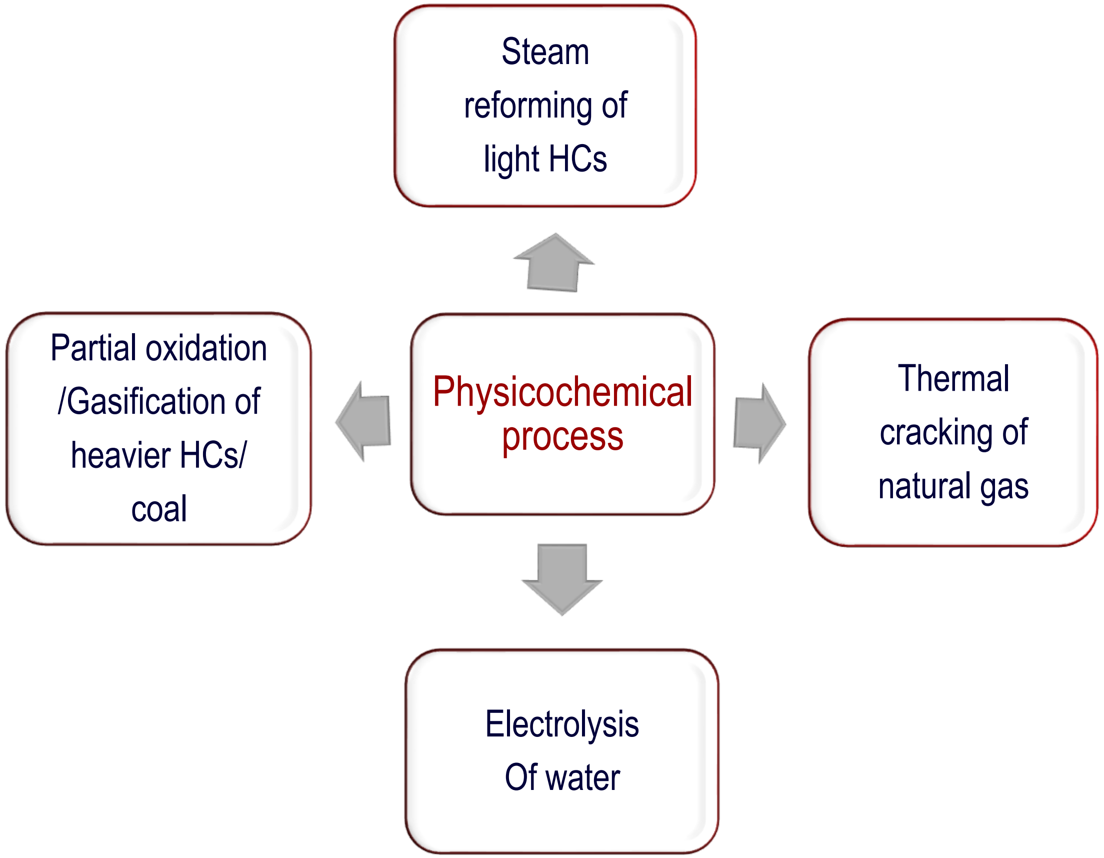
The NCoEGPS will act as a technological arm of MoPSW for providing the needed support on Policy, Research and Co-operation on Green Shipping areas for Ports, DG Shipping, CSL, and other institutions under the umbrella of MoPSW. The Centre will be a host of several technological arms to support the port and shipping sector and will provide solutions to a variety of problems through scientific research. It will focus on the following areas.

1. Energy Management: Energy management tools, waste energy recovery systems
2. Emission Management: Alternate, clean energy/fuel, emission control and monitoring
3. Renewable Energy and Green Hydrogen: Enhance generation, utilization
4. Sustainable Maritime Operations: Novel technologies and approaches

Hydrogen a source of energy transition in Shipping: Initial Leads from TERI

Hydrogen production physico-chemical routes

- ❖ High energy intensive
- ❖ Emits green house gas



- ❑ More than 90% of H_2 is produced from hydrocarbons,
- ❑ Only about 7-9% H_2 is produced through electrolysis of water

Hydrogen production through biological routes

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Less energy intensive/ Environmentally friendly / sustainable

Dark Fermentation

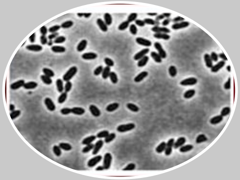
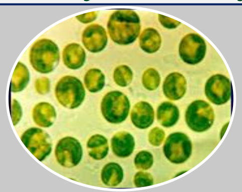
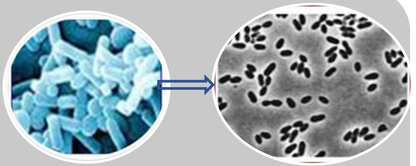


Photo Fermentation



Photosynthetic process



Integration of dark fermentation process with photo fermentation process

Hydrogen production by different unique microbes through different pathways

Clostridium , *Enterobacter*, *Bacillus*

- High rate of H_2 evolution,
- Waste reduction along with H_2 production
- Produces valuable metabolites like acetic, butyric and lactic acid

Limitations;

- Hydrogen yield efficiency is low compared to the photo fermentation process

Rhodobacter
Rhdopseudomonas

- High theoretical conversion yields
- Complete conversion of organic acid (substrates) to H_2 & CO_2

Limitations;

- Requires light as source of energy
- Hydrogen evolution rate is low

Microalgae; *Spirulina*

- Water is the feed stock
- Simple products H_2 and O_2

Limitations;

- Rate of reaction is low
- Low light conversion efficiencies
- Oxygen release

- Simple, less expensive and can produce H_2 at higher rate
- High H_2 yield
- By product of dark fermentation process can serve as the substrate for photo-fermentation
- Second process required light as energy

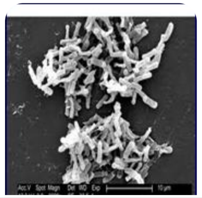
Hydrogen production through dark fermentation route

Significance

* High rate of H_2 evolution, organic waste reduction
* Produces valuable metabolites; acetic, butyric and lactic acid

1 ton sugar - 130 pounds of H_2

Dark fermentative Hydrogen producing microbes

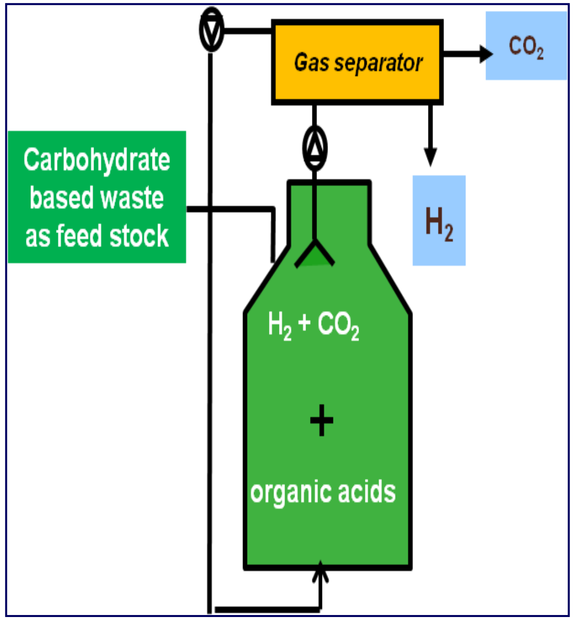


Clostridium
Obligate anaerobe

Enterobacter
facultative anaerobe

Citrobacter
facultative anaerobe

Bacillus sp.
facultative anaerobe



Hydrogen production yield;

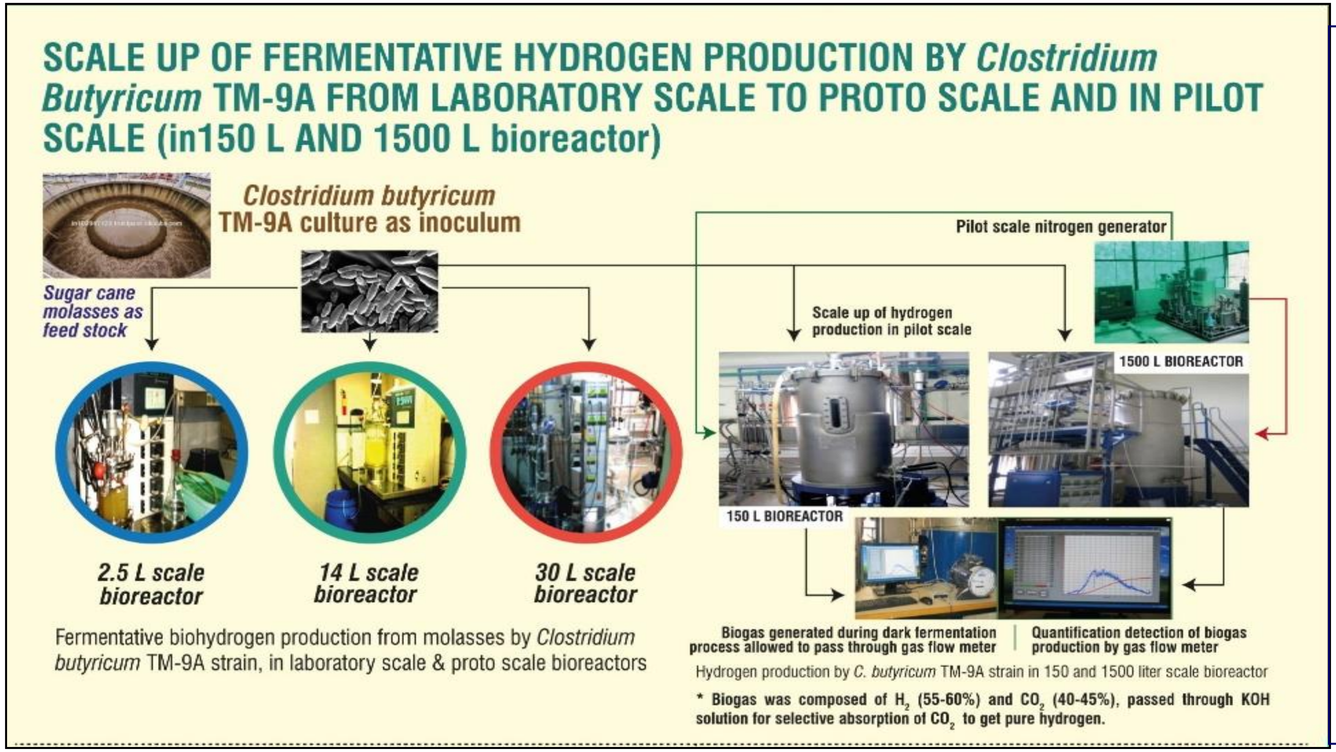
4 mol H_2 + 2 mol of acetate per mole of glucose

$$C_6H_{12}O_6 + 2H_2O \rightarrow 2CH_3COOH + 2CO_2 + 4H_2$$

Biohydrogen production through Dark fermentation route

TERI leads

Demonstration for bioH_2 production from molasses in 1 m^3 (1000 L) scale



- Biogas composition: (60% H_2 & 40 % CO_2).
- In 18 hour, 2300 liter pure H_2 generated
- High value metabolites; Acetic acid and Butyric acid (0.45-0.5% in the Fermentation broth)

Way Forward: To demonstrate the process in 10 m^3 scale

Biohydrogen production through Dark fermentation route

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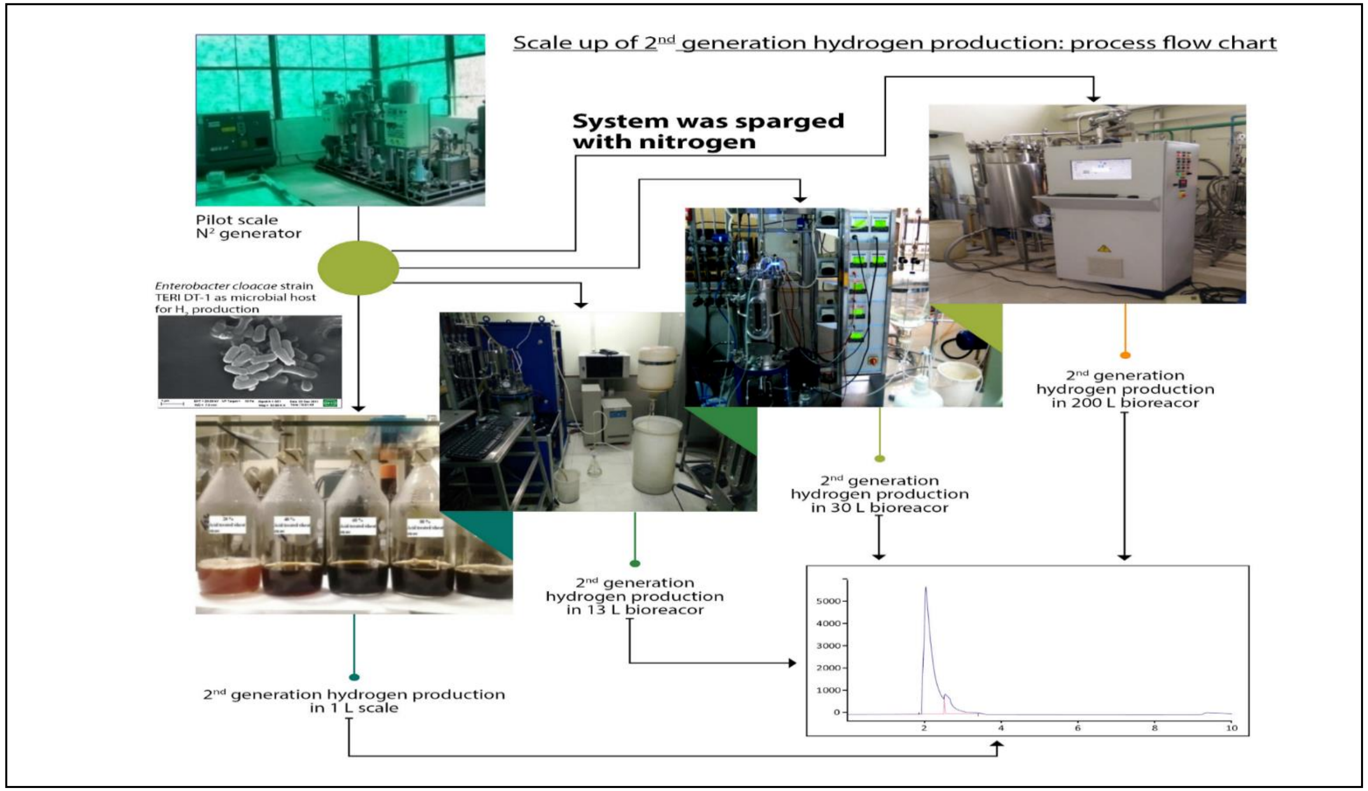
Demonstration for bioH_2 production from agriculture residue biomass in 0.1 m^3 (100 L)scale



- Biogas composition; (55% H_2 & 45 % CO_2).
- In 16 hour, 200 liter pure H_2 generated
- Metabolites; Acetic acid & ethanol

Way Forward: To demonstrate the process in 1 m^3 and 10 m^3 scale

Thank you