



IEA Bioenergy
Technology Collaboration Programme

Country Update – India

Gasification of Biomass and Waste

D Mohana Rao and Rajesh Badhe, IOCL R&D Centre

IEA Bioenergy : Task 33 meeting

20.10.2023

The IEA Bioenergy Technology Collaboration Programme (TCP) is organised under the auspices of the International Energy Agency (IEA) but is functionally and legally autonomous. Views, findings and publications of the IEA Bioenergy TCP do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

Technology Collaboration Programme

by **iea**

Outline

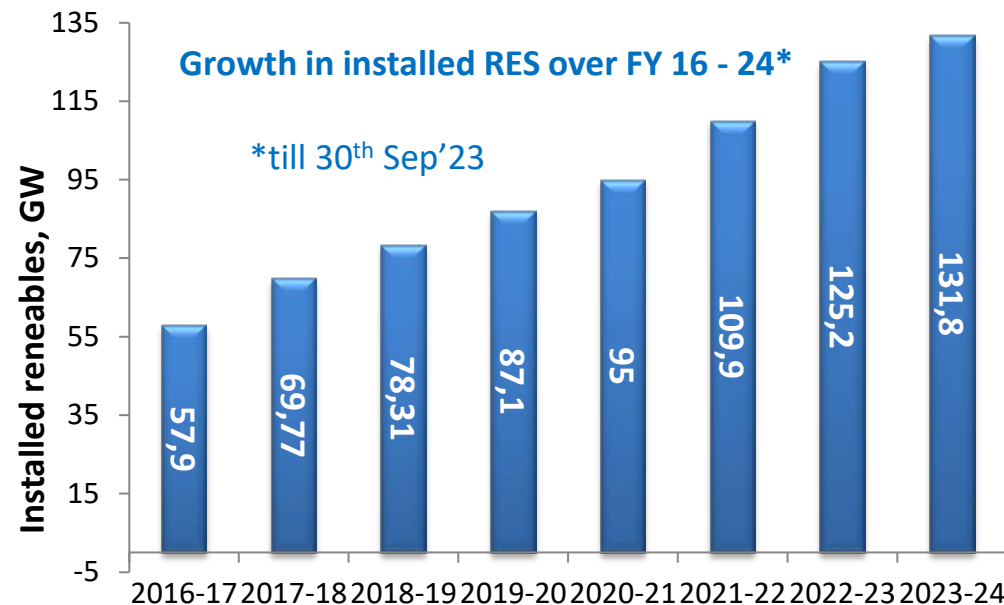
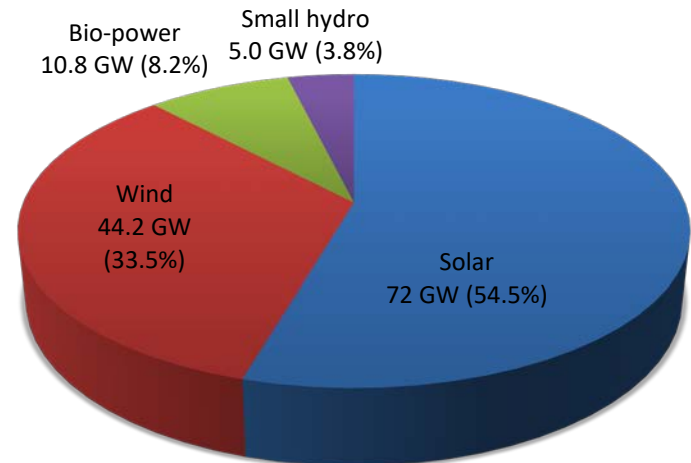
- Share of bio-energy in India's energy basket
- Bio-energy deployment in India
- National bio-energy programme
- National green hydrogen mission
- Biomass gasification based hydrogen generation
- Demonstration of fuel cell buses



Share of bioenergy in India's energy basket

- Total primary energy demand in 2022 : ~1005 MTOE
- Coal is the top energy source with a share of 46%, followed by oil (24%)
 - Share of biomass energy : ~20%
 - Share of natural gas : ~5%
 - Primary electricity (hydro, nuclear, solar, and wind) : 4%
- Installed power capacity as on Sep'23 : ~425 GW
 - Share of RES: ~ 31% (132 GW)
 - Biomass & waste to power capacity : ~10.8 GW
- Installed RES increased at a fast pace over the past few years, posting a CAGR of 15% between 2016-23
- Ambitious target of 500 GW RES capacity by 2030

Break up of RES as on 30th Sep'23



Bio-energy deployment in India

- Annual biomass generation - 750 MMT
- Surplus biomass availability - 230 MMT/year

Electricity and heat energy

- Biomass gasification – electricity & thermal energy generation
- Bagasse based cogeneration
- Biomass co-firing in existing coal based power plants

Compressed Bio Gas (CBG)

- Sustainable Alternative Towards Affordable Transportation (SATAT) scheme launched by MoPNG in Oct'18
- PSU Oil Marketing Companies invite Expression of interest to procure CBG from potential entrepreneurs
- As on 30th Sep'23, 2189 active LOIs and 48 plants commissioned

Bio-ethanol

- Second generation (2G) ethanol bio-refineries using cellulosic and lignocellulosic materials like rice/ wheat straw, corn cobs, cotton stalk etc.
- PSUs Oil Companies are in the process of setting up 12 2G ethanol plants in various parts of the country
- One 2G ethanol plant commissioned



Biomass co-firing in coal based power plants

- Union Ministry of Power vide revised policy dated 08th Oct'21 mandated co-firing of 5-10% biomass in all thermal power plants
- The Ministry had ordered that all thermal power plants ensure 5% co-firing compliance by Oct'22
- National mission on biomass co-firing - **SAMARTH** (Sustainable Agrarian Mission on use of Agro Residue in Thermal Power Plants)
- As on May'23, about **1.64 lakh tons** of biomass co-fired in **47 thermal power stations**
- India has around **180 thermal power plants**; & many power plants are not compiling with the policy on biomass co-firing
 - Due to biomass pellets **supply & demand constraints**



Update on National Bio-energy Programme

- Ministry of New and Renewable Energy(MNRE) promoting Bio-energy programmes in India
- MNRE notified the National Bio-energy Programme for a period 01.04.2021 to 31.03.2026 with an outlay of Rs.858 crore under Phase-I
- The Programme being implemented in two phases
- The National Bio-energy Programme comprises of :
 - **Waste to Energy programme** - for generation of biogas/ bio-CNG/ power/ producer or syn gas from urban, industrial and agricultural wastes/residues
 - **Biomass programme** - setting up of biomass briquette/pellet manufacturing plants, & support to biomass (non-bagasse) based cogeneration projects
 - **Biogas Programme** - setting up of family & medium size biogas plants in rural areas
- **Global Biofuels Alliance (GBA)** launched on 10th Sep'23 at the G20 summit. GBA attempt to bring countries together to co-develop, accelerate technological advances in production processes, and advocate for the use of biofuels particularly in the transport sector.



Update on National Green Hydrogen Mission

- Honorable prime minister launched NGHM on India's 75th Independence Day
- Main objective of the mission – to make India global hub for production, usage & export of green hydrogen and its derivatives
- The mission will lead to significant decarbonisation of the economy and reduce dependence on fossil fuel imports
- Green hydrogen policy framed by GOI for implementation by all the concerned stakeholders
- Union Cabinet approved NGHM on 04th January, 2023, with an initial outlay of Rs 19,744 Cr from FY 2023-24 to FY 2029-30
- Mission covers biomass based hydrogen production systems. Hydrogen/ ammonia produced from biomass named as GREEN
- Proposed to initiate focused pilots to arrive at workable models for biomass based green hydrogen production



Source : National Green Hydrogen Mission, January, 2023

Green Hydrogen Standard for India

- MNRE published “Green Hydrogen Standard for India” on 18th Aug’23
- **GH₂ from electrolysis** : Non-biogenic greenhouse gas emissions arising from water treatment, electrolysis, gas purification, drying, and compression shall not be greater than 2 kg CO₂e/kg Hydrogen, taken as an average over last 12-month period
- **GH₂ from biomass** : non-biogenic greenhouse gas emissions arising from biomass processing, conversion of biomass to hydrogen, gas purification, drying, and compression shall not be greater than 2 kg CO₂e/kg Hydrogen, taken as an average over last 12-month period
- Detailed methodology for measurement, reporting, monitoring, on-site verification, and monitoring and certification of green hydrogen and its derivatives shall be specified by MNRE
- **Bureau of Energy Efficiency (BEE)** shall be the nodal authority for accreditation of agencies for all the monitoring, verification, and certification for green hydrogen production projects



R&D roadmap for green hydrogen ecosystem

Mission Mode Projects (0-5 years)

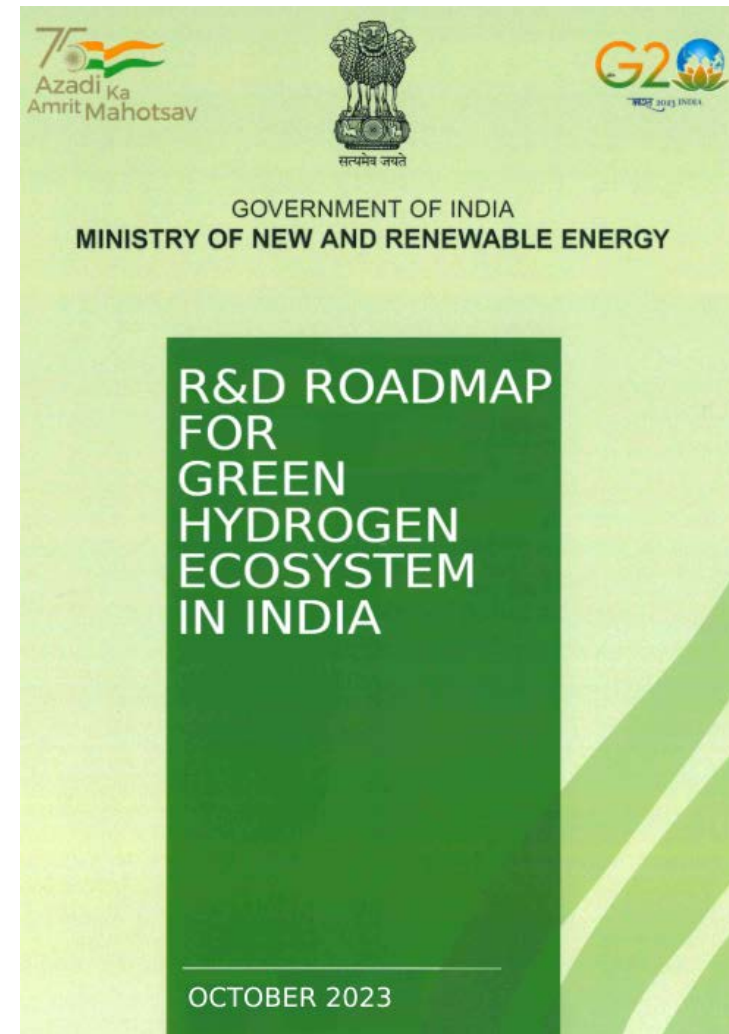
- Development of feedstock agnostic biomass gasification technology for hydrogen production
- Development of ultra-efficient biomass gasifiers through improved reactor designs

Grand Challenge Projects (0-8 years)

- Demonstration of biomass gasification-based hydrogen generation

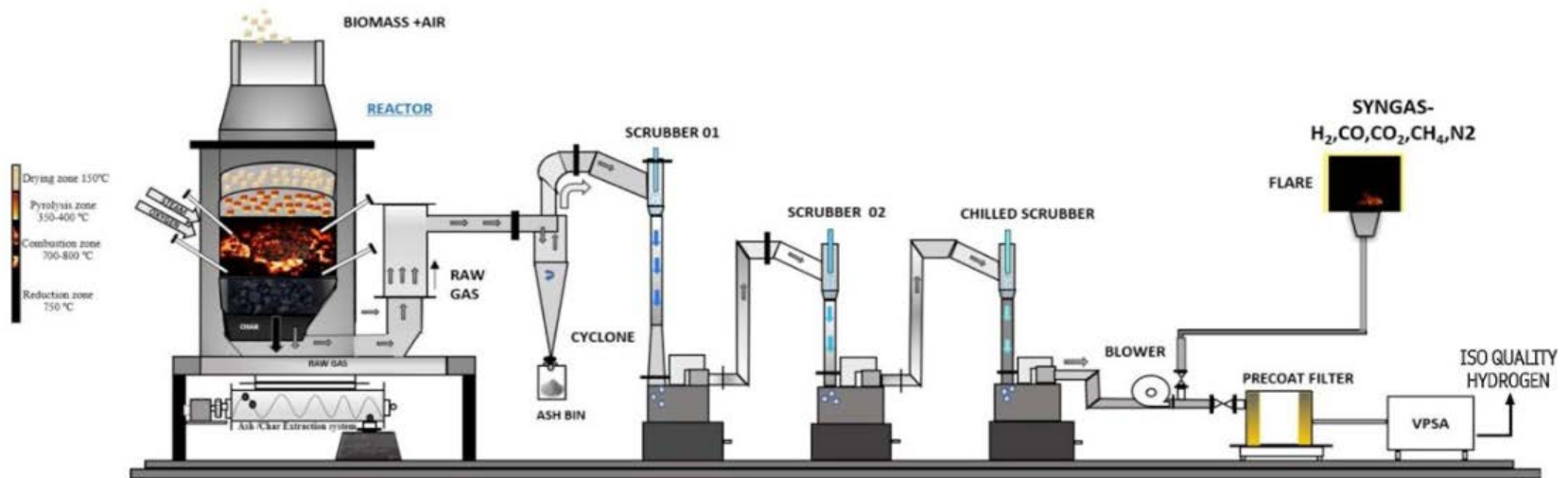
Blue Sky Projects (0-15 years)

- Novel technologies for the conversion of biomass to hydrogen
- Waste to hydrogen



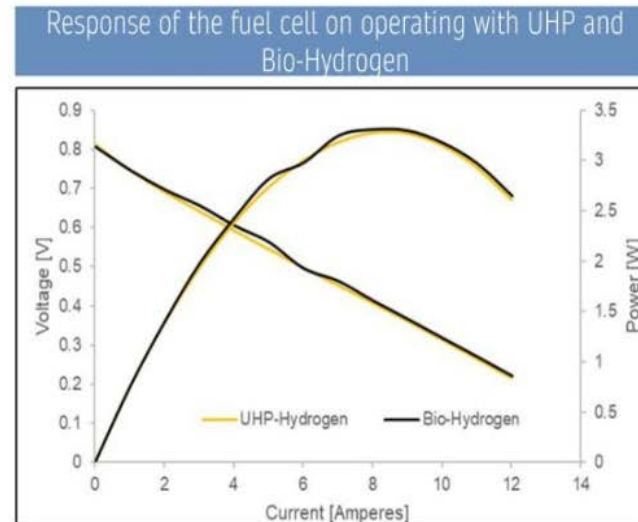
Update on biomass gasification based H₂ generation

- Indian Institute of Science and Indian Oil Corporation Ltd. jointly working on
 - Development and demonstration of biomass gasification based hydrogen generation technology
 - Generate fuel cell-grade hydrogen
- Down draft fixed bed gasification system with oxygen and steam
- Generated syngas subjected rigorous gas cleaning
- Vacuum pressure swing adsorption (VPSA) system



Demonstration of bio-hydrogen generation

- Demonstrated production of fuel cell grade bio-H₂ in a 5 kg/h H₂ generation system using woody biomass
- Average hydrogen yield in syngas : 100 – 105 g/ kg biomass
- Hydrogen recovery in VPSA : 70 – 72%
- A small fuel cell system extensively tested using generated bio-hydrogen



The fuel cell was operated for 250 hours under controlled, long duration testing using Bio-Hydrogen. No deterioration on fuel cell performance was observed.

Characterization of Mixed Agro Residue Pellets (ARP)

Parameter	Mixed ARP	Casuarina wood
Ash	15 – 20%	1.2 – 1.5%
Volatiles	68.1 – 72.1%	85.8 – 87.9%
Fixed carbon	14.2 – 16.4%	10.87 – 11.5



Mixed Agro Residue Pellets (ARP)

- Reactivity of the mixed ARP measured using Thermo Gravimetric Analysis, & compared with woody biomass
- Mixed ARP have lower reactivity compared to woody biomass
- Mixed ARP have lower ash melting temperature

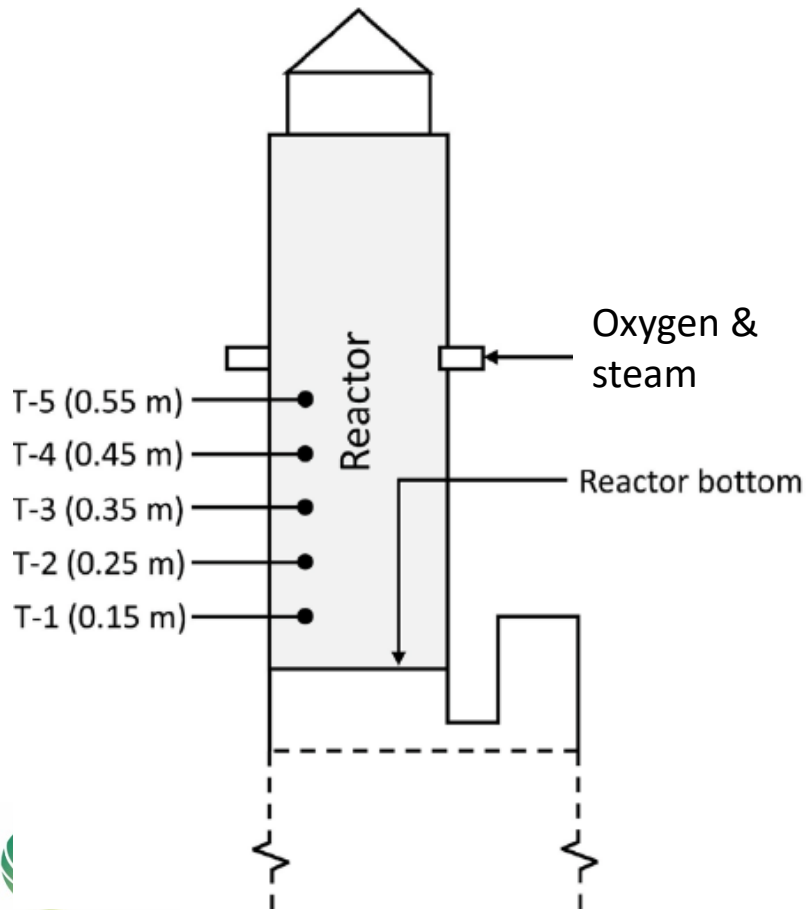
Parameter	Unit	Mixed ARP	Spruce Wood
Initial deformation temperature	°C	900	1210
Softening temperature		950	1275
Hemispherical temperature		980	1312
Fusion temperature		1090	1340

For smooth operation, gasifier to be operated below the initial mixed ARP ash deformation temperature i.e. 900 deg C

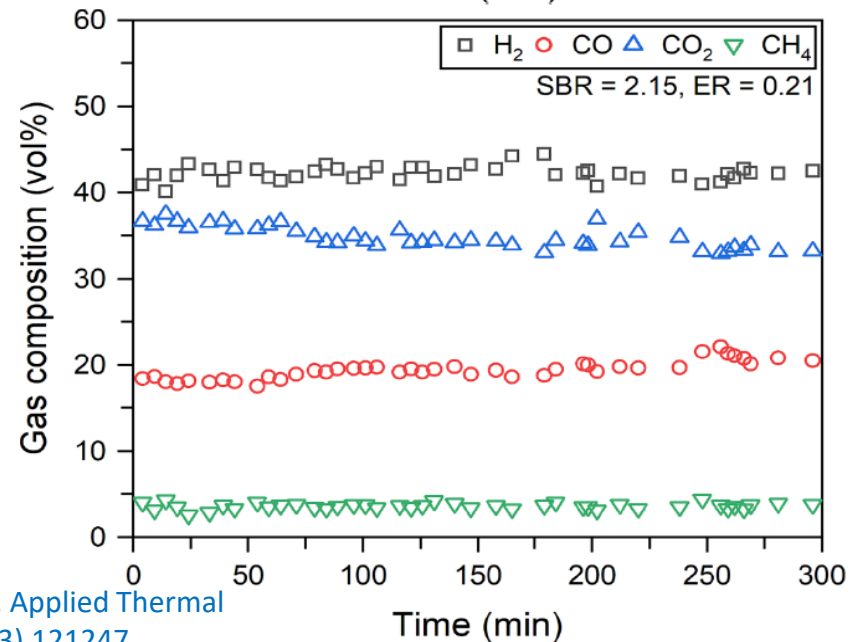
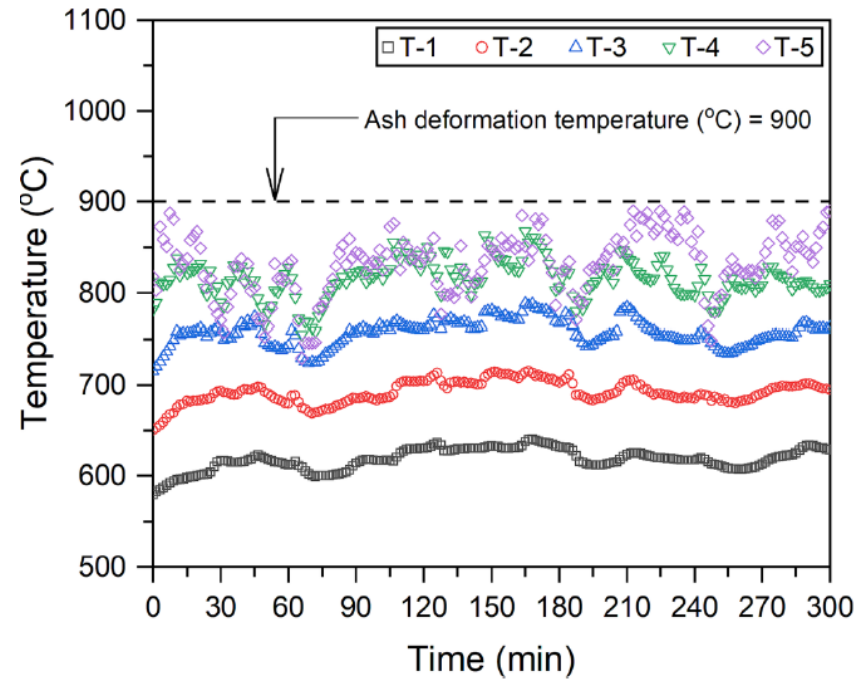


Oxy-steam gasification of Mixed ARP

- Gasifier was operated at an SBR and ER of 2.15 and 0.21, respectively
- High char extraction rate to maintained for smooth clinker free operation
- Average feed consumption rate: 12.5 kg/hr



Downdraft gasifier



Source : A Singh et al. Applied Thermal Engineering 234 (2023) 121247

Average composition and LHV of syngas

Biomass	Mixed ARP	Corncoobs [13]	Casuarina wood chips [8]
Reactor type	Downdraft		
Operating conditions	<i>SBR/ER</i> : 2.15/ 0.21	<i>SBR/ER</i> : 2.30/ 0.24	<i>SBR/ER</i> : 2.5/0.3
Steam/oxygen mixing ratio (mass basis)	5.9	6.1	–
Gas composition (vol%)			
Hydrogen (H ₂)	42.2 ± 0.9	45.1 ± 0.7	51.7
Carbon monoxide (CO)	19.4 ± 1.0	20.8 ± 0.9	12.8
Carbon dioxide (CO ₂)	34.8 ± 1.3	30.2 ± 1.2	–
Methane (CH ₄)	3.6 ± 0.4	3.9 ± 0.2	–
<i>LHV</i> (MJ/Nm ³)	8.3 ± 0.2	8.1 ± 0.2	7.5



BDEP for 10 kg/h hydrogen generation demo plant

- Basic Design and Engineering Package (BDEP) for 10 kg/h demo plant prepared
- BDEP covers process flow diagram (PFD), heat and mass balance calculations, process control philosophy, piping and instrumentation diagram (P&ID), equipment list, equipment layout, equipment process data sheet, design of critical equipment, instrument process datasheet etc.
- BDEP reviewed and vetted by IndianOil's design group
- Preparation of technical specification for procurement of 10 kg/h hydrogen generation demo plant under progress
- 10 kg/hr hydrogen generation demo plant will be set up at IndianOil R&D, Faridabad



IndianOil unveils hydrogen fuel cell buses

- Plan to undertake operational trials of 15 fuel cell buses on the identified routes in Delhi, Haryana, and UP
- Hon'ble Minister of Petroleum and Natural Gas launched two hydrogen fuel cell buses on 25th September, 2023 to undertake trial runs in Delhi
- Two hydrogen refueling stations are under advanced stages of installation
- Plan to launch 13 more fuel cell buses are under progress



Source : <https://www.thehindu.com/news/national/indianoil-unveils-indias-first-green-hydrogen-run-bus-that-emits-just-water/article67344306.ece> www.ieabioenergy.com

Thank You

