

Waste to Wealth via H2

25/08/23

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Introduction

Climate change : GHG effect : Making Human Survival Difficult?

Climate Change Impact



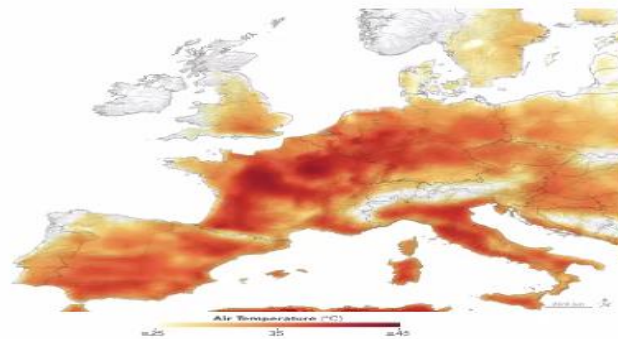
Australian Wildfires



Polar Vortex: -46°C as Chicago River turns to Ice



London Floods



Heat Wave in Europe



Drought in Africa

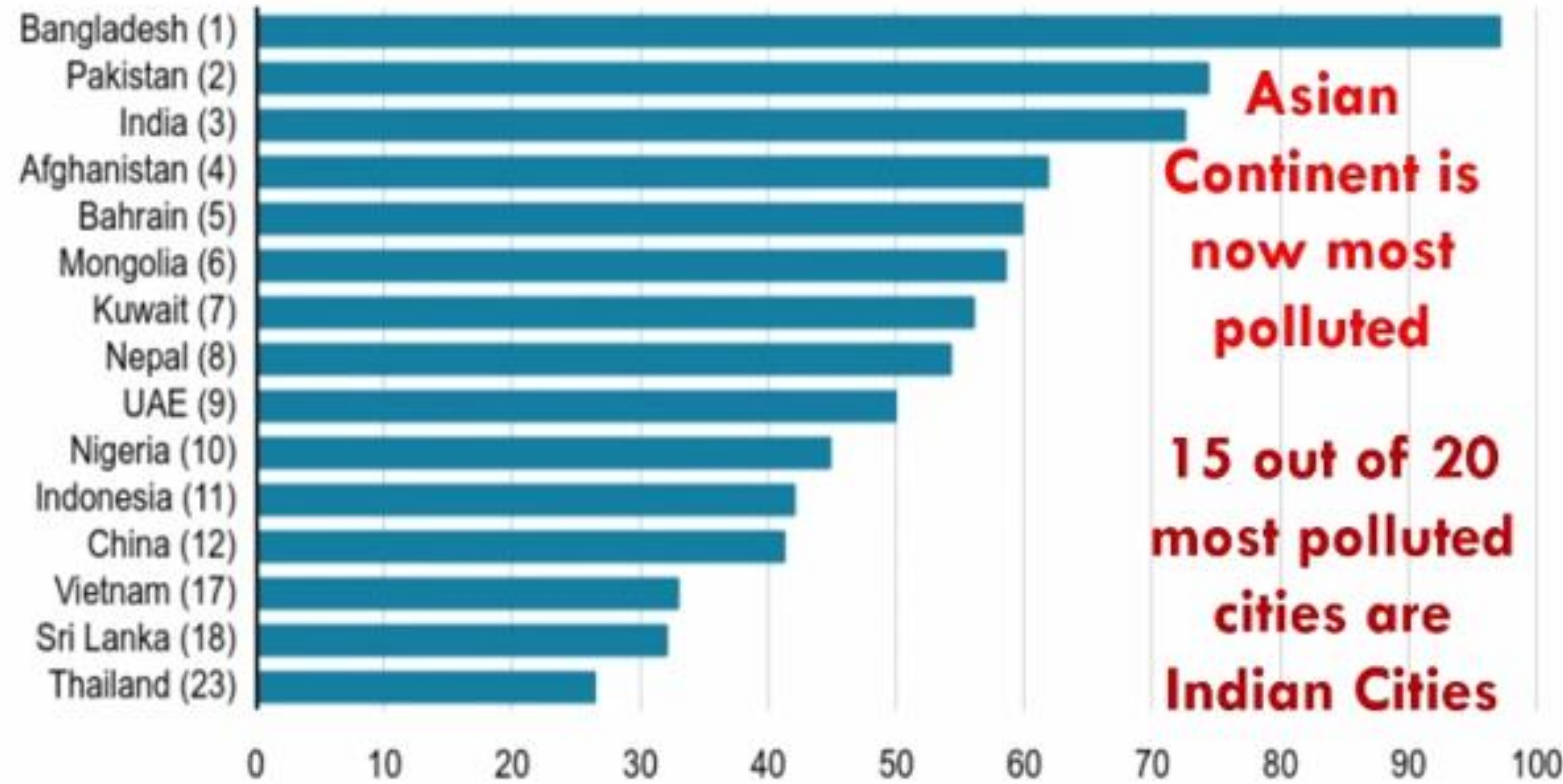


Glacier Burst & Flash Floods in Uttarakhand

India has some of the World's Most Polluted Cities

World's most polluted countries

Sorted by estimated average PM2.5



The Most Polluted Cities On Earth

Average level of particulate matter (PM 2.5) pollution in 2020



Source: IQAir AirVisual 2020 World Air Quality Report



Deloitte Report :India : \$11 Trillion Opportunity or \$35 Trillion Risk

Climate Change \$11-Trillion Opportunity and \$35-Trillion Risk for India: Deloitte

Country can add \$11 trillion if it properly handles the challenge, may lose \$35 trillion if it doesn't: Deloitte

Sachin.Dave@timesgroup.com

Mumbai: Climate change is both a momentous opportunity and significant threat for India – and New Delhi's choices will determine how the country fares.

A Deloitte report has said that around \$11 trillion – or more than three times the current size of gross domestic product – could be added to India's economy if it properly handles climate change. At the same time, India faces the biggest risk too – of losing \$35 trillion – if its crisis response falls short of what's required, said the report titled India's turning point: How climate action can drive our economic future.

That is the potential economic loss over the next half a century.

Deloitte researchers said that the country could end up gaining \$11 trillion in economic value over the same

period by limiting the rise in global temperatures and realising its potential to 'export decarbonisation' to the world.

"We have a narrow window of time – the next 10 years – to make the decisions needed to alter the trajectory of climate change," said Atul Dhawan, chairperson, Deloitte India.

If no action is taken on climate change, average global temperatures could rise by 3°C or more by the end of this century

tions with climate choices."

The report added that if no action is taken on climate change, the average global temperatures could rise by 3°C or more by the end of this

century.

"Deloitte's research also shows that if governments, businesses, and communities act boldly and rapidly in the next decade to address climate change, average global temperature rises can be limited to around 1.5°C by 2050 – a scenario that will minimise the impact of climate change for India and the rest of the world. At the same time, India can achieve significant economic growth by supplying the products, services, and financing the world will need to limit temperature increases," it said.

India could be at the vanguard of the global climate-change initiatives.

"We need to transform the world's economies toward new, low-emission pathways and India is well positioned to play a leading role in this process globally," said Viral Thakker, Partner and Sustainability Leader, Deloitte India.



Kids win against state violating right to Clean and Healthful environment

 **Zero Hour** ✓
@cebill_now Follow

In the first ruling of its kind in the USA, a [#Montana](#) state court has decided in favour of young people who alleged that the state violated their right to a “clean and healthful [#environment](#)” by promoting the use of [#fossilfuels](#). 🌞



Michael Gerrard and 9 others

 **Jamie Henn** @jamieclimate · 5h

WOW! The young people suing Montana over the right to a livable climate just won their case!!!!

This is absolutely HUGE and will open up th...

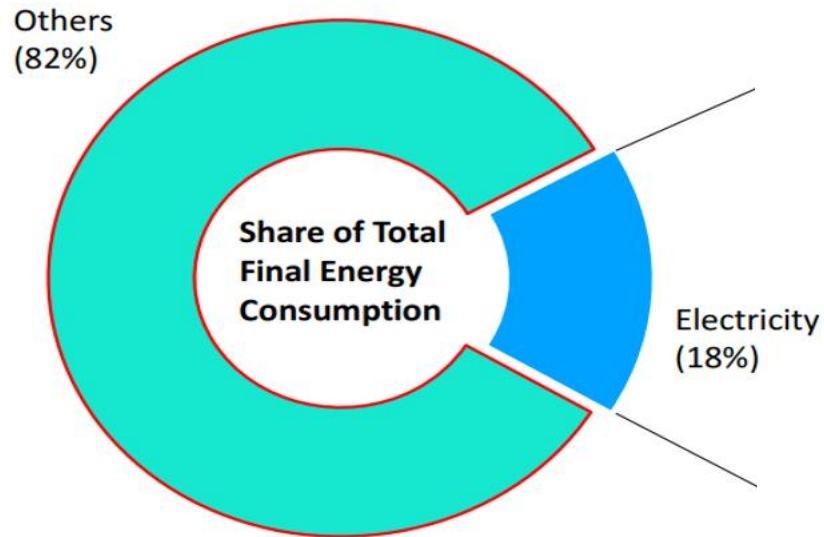


Urgency

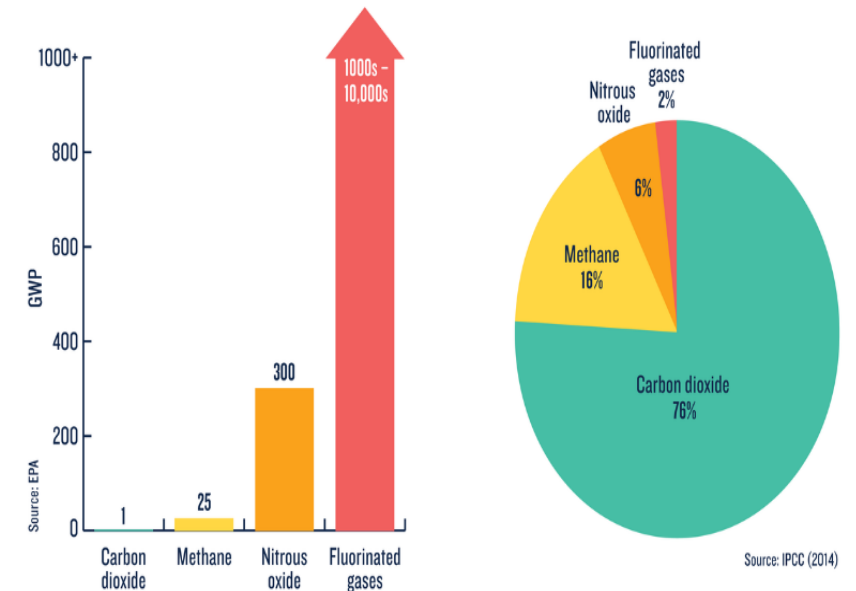
Urgent requirement of Decarbonization

- India is the third largest emitter of Green house gases.
- Country has pledged 50% reduction in emission intensity of its economy by 2030, compared to 2005 levels.

Electricity Contributes only 18% of Energy needs



Why CO₂ needs attention



The global warming potential (GWP) of human-generated greenhouse gases is a measure of how much heat each gas traps in the atmosphere, relative to carbon dioxide.

How much each human-caused greenhouse gas contributes to total emissions around the globe.



Global Waste to Hydrogen to Mobility Potential

2
Billion tons
of non-recycled waste globally
recycled into Hydrogen for local
direct or speed charging use
*No ash. Major elimination of
pollution to air, water and land*

31.5
Gigatons CO₂
of global energy related CO₂ emission
in 2020 – contributing to the highest
ever atmospheric CO₂ concentration
in industrial time
>20%
of Global Energy CO₂ Emissions
related to energy avoided.
More than global road transport and
landfill emissions combined (5+1.6)
-6.8
Gigatons CO₂
by running 500 million
zero-emission Hydrogen
or electric cars on energy
from nothing but that waste

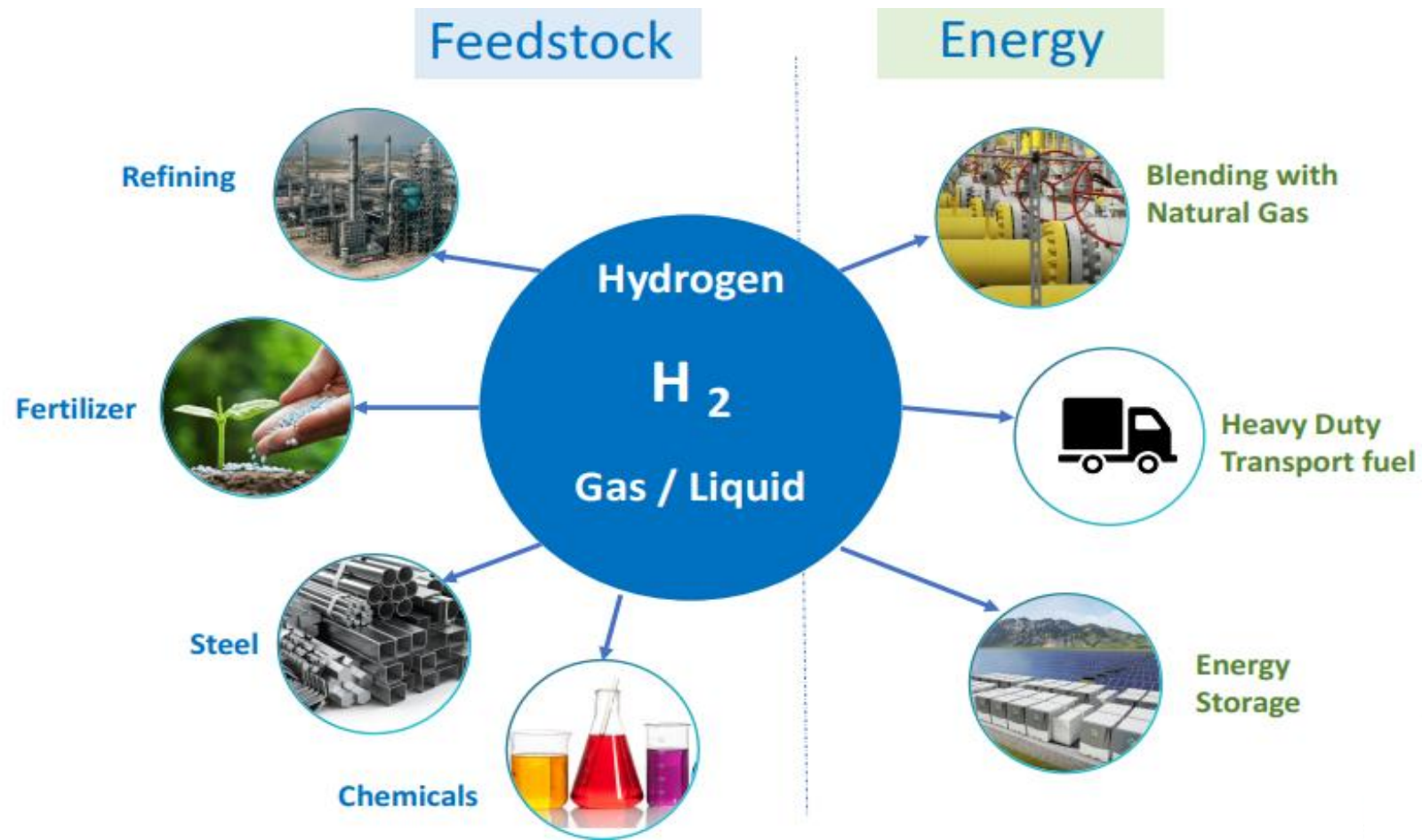
RADICALLY
LOWER
SYSTEM COST &
>90%
Reduction
of other emissions and
pollutants to air, water and so
(NO_x, Particulates, etc)

India has Lot of waste round the Year for Producing H2

MSW(62 MMT) + Agri-waste(150 MMT) + Animal Dung + Sludge +Poultry+Agro-forestry... Bioenergy Crops like Napier grass shown in Photos



H₂ is versatile energy Carrier interconnecting various sectors



Tokyo Olympics 2020(23Jul-04Aug 21) &
Paralympics(24 Aug - 05 Sep 21) &
China Winter Olympics (4 -22Feb 22)



- **Completely Hydrogen Based**
- **Hydrogen refueling stations**
- **Fuel cell vehicles and buses**
- **Power supply through fuel cells**
- **Stable hydrogen fuel supply**
- **Increased social acceptance**



Waste goes to Landfills or is burnt or left as it is

- Burning Plastics say by Incineration causes Air Pollution, Dioxins, Furans, Heavy Metals

<https://www.nationalgeographic.com/environment/article/should-we-burn-plastic-waste>

- Pyrolysis also concentrates these in the products and when used say as fuel on Combustion release these into air

<https://www.lowimpact.org/posts/pyrolysis-not-solution-plastics-problem>

- Harmful to Marine Life and Humans



Reimagine Waste and Produce H2 – Greener Solution

Criteria for Ideal Solution

- GHG Reduction
- Energy Security
- Clean Air, water, Soil
- **Waste Management**
- Cut Imports

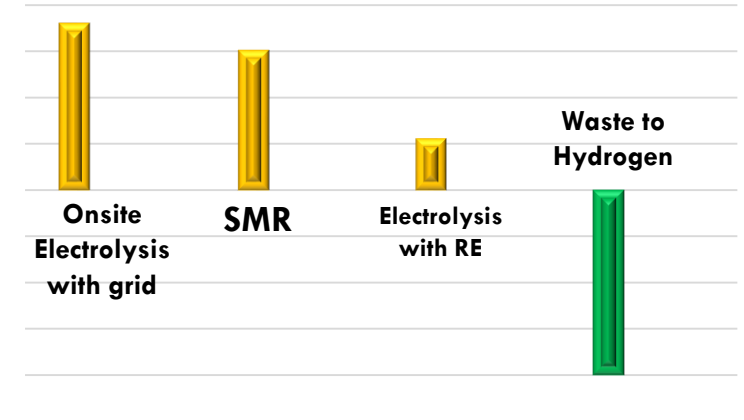
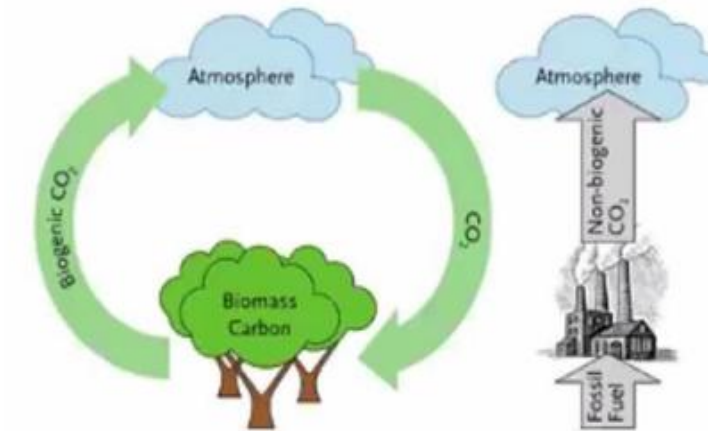
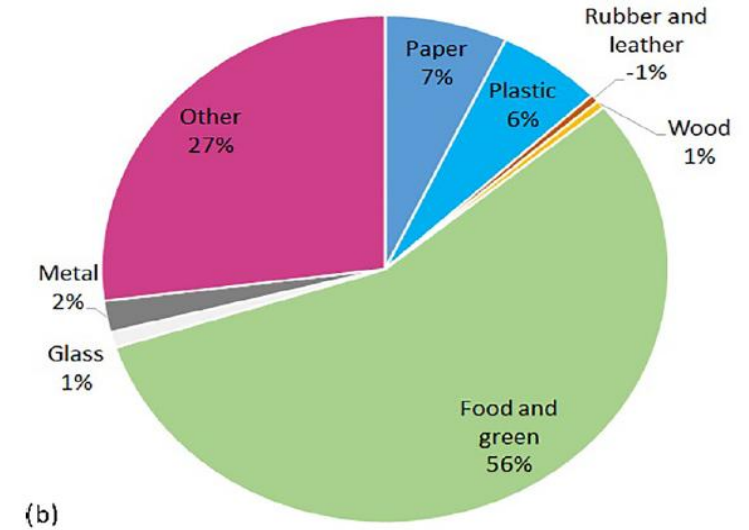
Hydrogen From Waste fits the bill

Waste Generation Profile

2019 – Over 2.0 Billion Tons

2050 – 3.4 Billion Tons

India Produces > 1.4 lakh tons of waste/Day



Some Companies in Waste to H2

- IPR has developed Plasma Gasification
- Pennsaco, US: Pennsaco technology heats biomass in absence of Oxygen and produces H2 and Biochar through its patented Process without any external electricity
- ThermoChem Recovery International Gasification of Waste to Syngas from which H2 and Biodiesel
- Standard Hydrogen (Waste+Sulphur: H2S to H2 and recirculating S)
- SGH2 (Gasification)
- [Ergostech](#) converts sewer-waste into bio-H2
- Shell : IH2: INTEGRATED HYDROLYSIS AND HYDROCONVERSION
- Revaluo
- Chinook Sciences' patented RODECS gasification and pyrolysis
- Polycrack (Catrogen Unit)
- CAC-H2 is also utilising its carbon-negative biomass-gasification technology to produce H2 and Biochar
- Mote: uses proprietary integration of proven equipment in a novel process: Biomass is heated in a limited-oxygen environment to above 815°C converting it to a mixture of gases which produce hydrogen & CO2 and the resultant Ash is used as additive for Fertiliser
- HOPE Resources using Vaccum reforming produces Hydrogen from Organic Carbon and Ash



Pennsaco: waste to BioChar + H2

- Carbon negative H2 & renewable electricity made from recycling biomass, agricultural, plastic, MSW, and other wastes avoids & offsets emissions of hundreds of thousands of MT CO2e from the atmosphere per facility per year.
- Tens of thousands of MT CO2 permanently removed from the atmosphere per facility per year through biochar. 3 MT of CO2 permanently removed per MT of biochar produced and sequestered.
- 6+ MT CO2e offset per MT of feedstock recycled.
- Carbon Intensity Score: -209 and higher
- Collaborating with complimentary blue carbon technologies to permanently remove all biogenic CO2 per MT of biomass recycled.
- Biochar is the solid carbon product of biomass pyrolysis & captures 3 MT CO2 per MT.
- When biochar is land applied in agriculture, incorporated as an additive in cementitious products, or otherwise permanently sequestered, this CO2 is permanently removed from the biogenic carbon cycle and the atmosphere



Pennsaco: Gasification and Pyrolysis in one Reactor

PENNSACO GREEN HYDROGEN

- Carbon negative
- 85 -110 kg of H₂ per MT of biomass waste = 3X thermal conversion competitors
- 4X yield of H₂ per MW of wind or solar at 8X less cost
- \$1.50/kg; Under \$1 by 2030
- Continuous baseload supply
- Ideally suited to supply H₂ for:
 - Mobility
 - Micro grids
 - Agricultural Decarbonization

PENNSACO CARBON REMOVAL

- 1 MT Biochar removes 3 MT CO₂
- 1 of 5 carbon removal pathways in the world
- Permanent & durable sequestration
- Low cost & scalable
- Most lucrative carbon credits in the market
- Multiple environmental co-benefits:
 - Soil health
 - Crop productivity
 - Water conservation

Search documents and file names for text

H2 Industries: Waste to H2 two Big Projects

Egypt: \$3bn Plant to convert

4MMT of organic waste and non-recyclable plastic into 300,000 tonnes of H2 per year — roughly the amount that would be produced by a 4GW renewable H2 electrolysis facility.

Oman: \$1.4bn plant to Convert

1 MMT MSW (fresh waste plus waste from Landfills) — into 67,000 tonnes of H2

It involves an “integrated thermolysis plant”. Thermolysis means chemical decomposition by heating.

The waste heat from the process can be used to generate power



SGH2 : Waste to H2 : 42000 ton waste pa to 3800 ton H2 pa

- **When energy is applied, matter changes its state: solid to liquid, liquid to gas. With more energy applied, gas becomes ionized and turns into an energy rich plasma state, the fourth state of matter. Using a plasma torch, combined with 95% oxygen enriched air, SGH2's SPEG **thermal catalytic conversion** process produces a high quality syngas without any of the toxic byproducts**
- **Plasma torches generate high temperatures (3500°-4000° C), the waste feedstock disintegrates into its molecular compounds, without combustion ash or toxic fly ash. The gases exit the catalyst-bed chamber as high quality hydrogen-rich biosyngas and it goes through a Pressure Swing Absorber system resulting in hydrogen at 99.9999% purity.**



Ways2H: Waste to H2
For every tonne of dry waste put into the system, roughly 40-50kg of hydrogen are produced — although this can vary between 30kg and 120kg depending on the contents of the waste stream.

--a mobile solution capable of processing one tonne of waste per day, which fits inside three shipping containers ---scaleable stationary solutions that can process between eight and 50 tonnes of feedstock a day.

The waste feedstock — from which inert materials such as metal and glass have been removed — is first processed to reduce the waste to particles of between 0.5 and 3cm. This is then fed by a screw conveyor into a gasification vessel, where it is mixed with ceramic beads that have been heated to around 1,000°C. At these temperatures, most of the organic waste and plastics are converted into a mixture of methane, hydrogen, carbon monoxide and CO₂. Solid carbon and minerals remain as char and is removed & burned in a separate vessel to provide the 1,000°C heat, which is used to heat the ceramic beads.

The gas mixture then enters the reforming vessel, where steam is added, which breaks down the methane into hydrogen, carbon monoxide and dioxide. The resultant syngas is cleaned and a separator recovers pure hydrogen. The char that was recovered from the gasification vessel is

Toyota, Iwatani and JGC : Plastics to H2 by 2025

The Japanese corporations plan to pulverize the collected plastic, then burn it in low-temperature and high-temperature gasification furnaces to produce a synthetic gas (syngas) containing carbon monoxide and hydrogen. Water vapour will then be added to the gas to increase the concentration of hydrogen, which will then be removed by an adsorber.





World's Largest Net-Negative CO₂ Biomass-To-Energy Facility

Babcock & Wilcox and Kiewit Industrial have teamed up to build a biomass power plant in the Port of Greater Baton Rouge in Louisiana. The 200-megawatt Project Cyclus power facility will be the largest of its kind.

The projected facility will create aviation fuel, green hydrogen, bio-plastic feedstock, and renewable diesel with no carbon emissions. Biomass fuels will be used in the Cyclus project, including wood waste, wood chips, and bagasse, etc., with carbon capture technology that will isolate the CO₂ emissions underground.

Babcock & Wilcox. (2022). *B&W, Kiewit partner to deliver 200 MW biomass plant in Louisiana*. [Online]. Available at: <https://biomassmagazine.com/articles/18852/bw-kiewit-partner-to-deliver-200-mw-biomass-plant-in-louisiana> (April 24 2022).

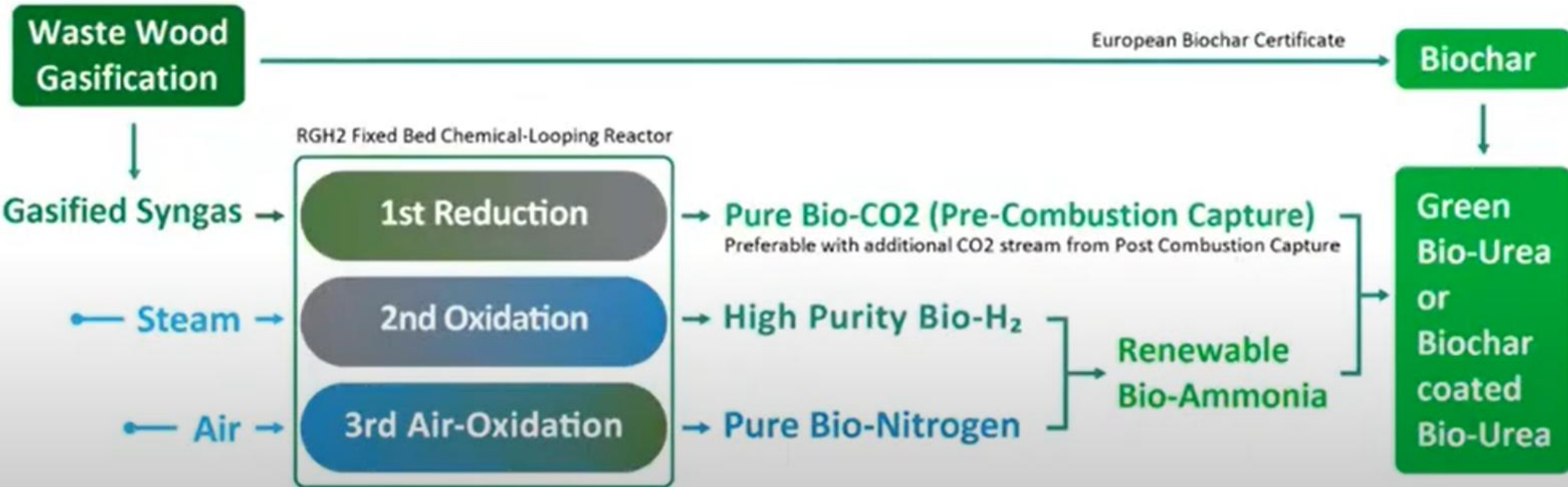
Ontario's Hydrogen Strategy

The Government of Ontario released its first Low-Carbon Hydrogen Strategy on April 7, 2022, outlining the province's vision and expectations for the developing hydrogen sector.



RGH2 Austria: Biogas to H2

Ongoing Projects: Renewable H2 from Wood Waste Gasification (BECCS, BECCU) in Italy, Germany, UK, Indonesia and Thailand



Methods for Hydrogen Production from Waste

Waste To H₂

Anaerobic Digestion + SMR or CH₄ Splitting

Gasification

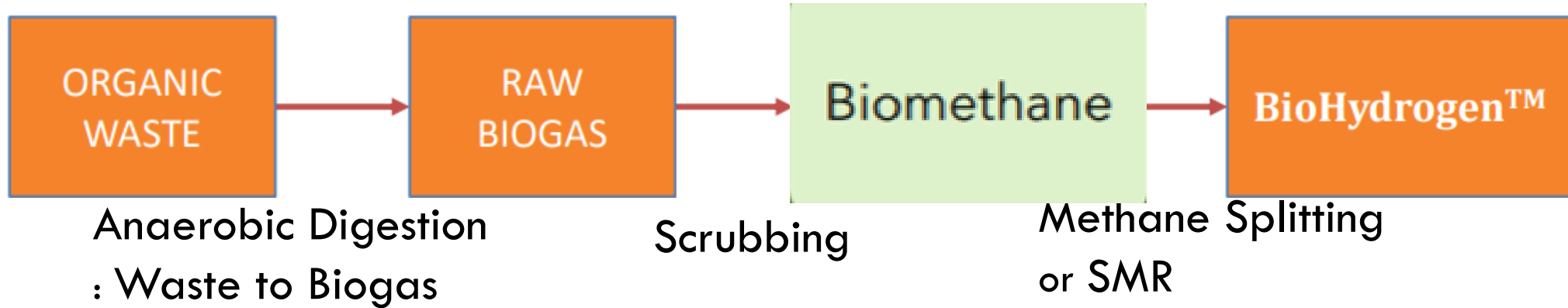
Plasma Gasification

Pyrolysis

Microbial ElectroChemical Cell MECC



Anaerobic Digestion + SMR/Methane Splitting

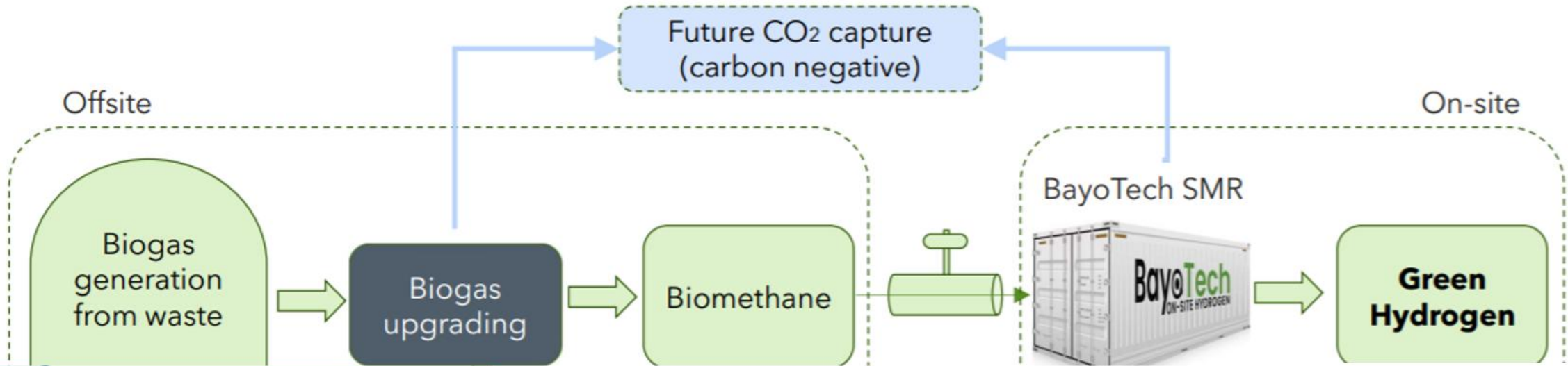


Decentralised H2 from Bio-Methane: for Remote off grid /Industry/ H2 Filling Station

- Many vendors supply SMRs for Conversion of Methane to H2. CO2 can be captured and can be used for various uses or mixed with H2 to make SAF, e-fuels etc.
- BayoTech USA offers Decentralised H2 at reqd site @\$2/kg (Biomethane, Water & Electricity to be provided by Customer) and authorized H2-Zest in India
- HyGear(Netherlands/Singapore) offers small scale H2 generation systems at the end user's site. On-site hydrogen supply by the HyGEN increases the reliability of supply and decreases the costs. Authorised Vendor in India: GPS renewables
- Ranging from 10 Nm³/h up to 1000 Nm³/h (20kg to 2000kg/day)
- Turnkey selling of equipment to full-service contracts or supply of gases “GaaS” or “Gas-as-a-Service”

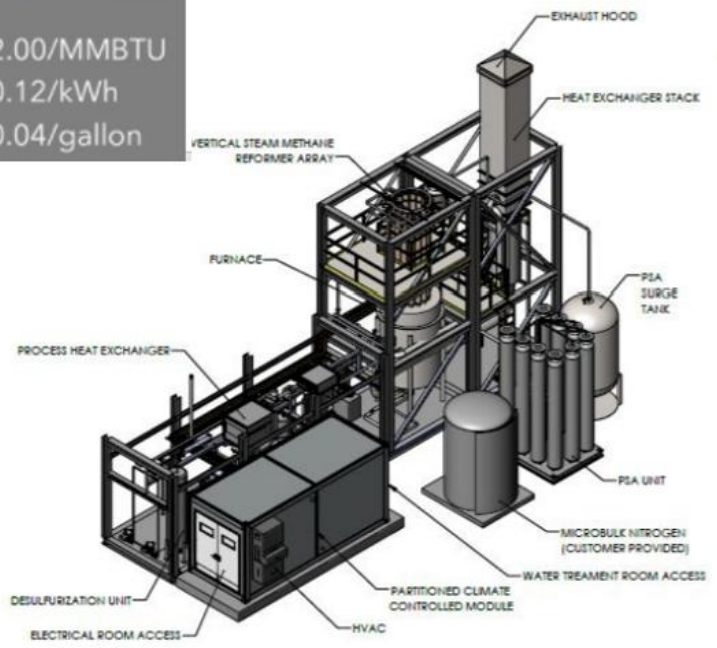


Onsite-H2 Production from Biogas



Hydrogen produced using BayoTech has the lowest cost of ownership - as low as \$1.69 per kilo

- Assumed utility costs
- Natural Gas Cost: \$2.00/MMBTU
 - Electricity Cost: \$0.12/kWh
 - Potable Water Cost: \$0.04/gallon



Carbon Capture Technologies

	Amine Separation 2 TPD CO ₂ \$TBD/MT	Gaseous CO ₂ Purity TBD
	Solvent Separation 1 & 10 TPD CO ₂ \$TBD/MT	Gaseous CO ₂ Purity TBD
	Mineralization 1-10 TPD CO ₂ \$TBD/MT	Limestone CaCO ₃

Some SMRs

- Hy.GEN Steam Methane Reformers
- Natural gas or BioCNG at a pressure of 11 bar(g) is the inlet requirement which allows
- the system produces high purity hydrogen gas suitable for the Fuel Cell industry
- Hy.GEN 50 can produce a maximum hydrogen flow of 42 Nm³/h based on a 5.0 (99.999%) purity
- Fits into 20 ft container
- 100kg/day : Rs 7 crore

- 200Nm³/h NG-SMR HYDROGEN PLANT
- 500kg/day H₂
- US\$1,000,000 FOB China Port
- or Rs 8 Crore

**Chengdu TCWY
New Energy Technology Co., Ltd.**



SMR Designed by NANOSOL India (H₂:10kg/day)

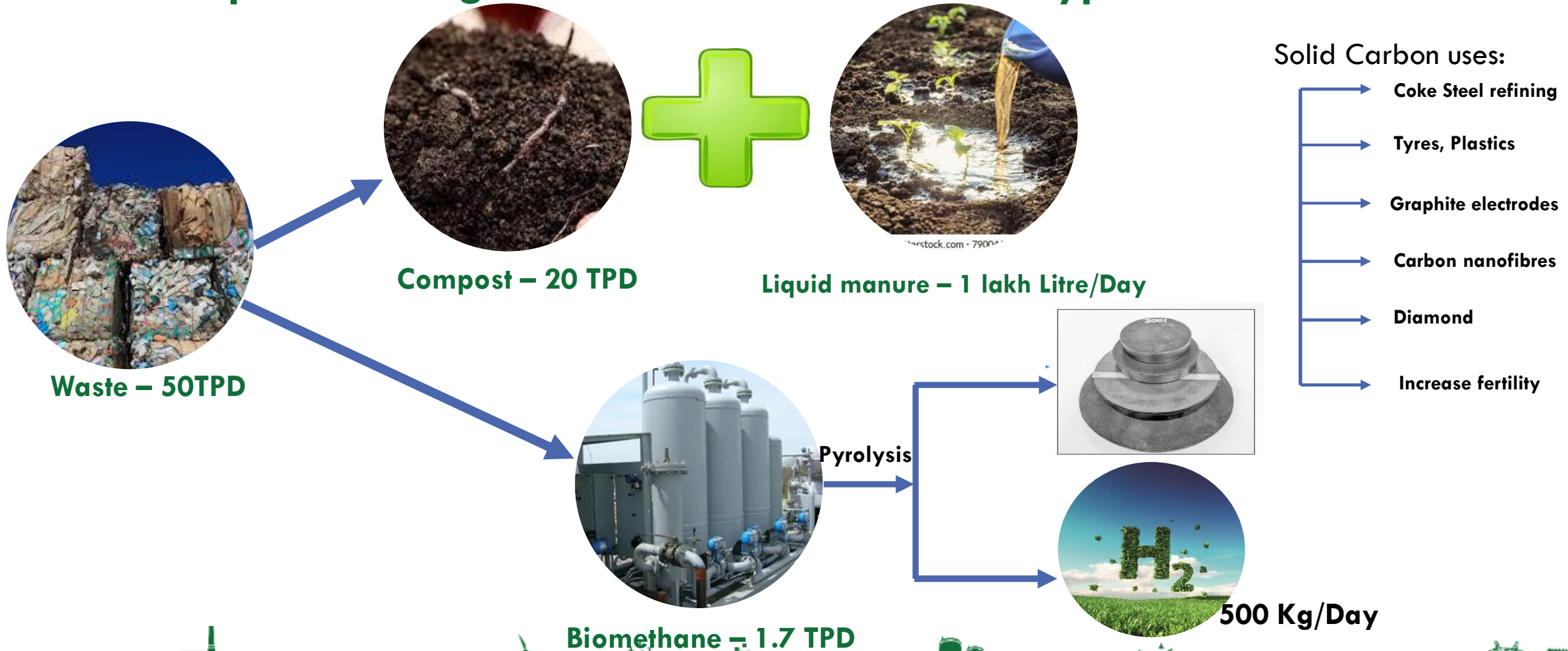
A. Summary

A1	Project Title	Development of SMR reactor for hydrogen production capacity of 10 kg per day for commercial applications
A2	Project Cost <i>(Amount in INR)</i>	₹. 25,00,000.00 (Rupees Twenty-Five Lakhs Only)
A3	Duration	12 months
		Dr K. Naqa Mahesh, CEO / Director



H2 from Waste – Biomethane Splitting

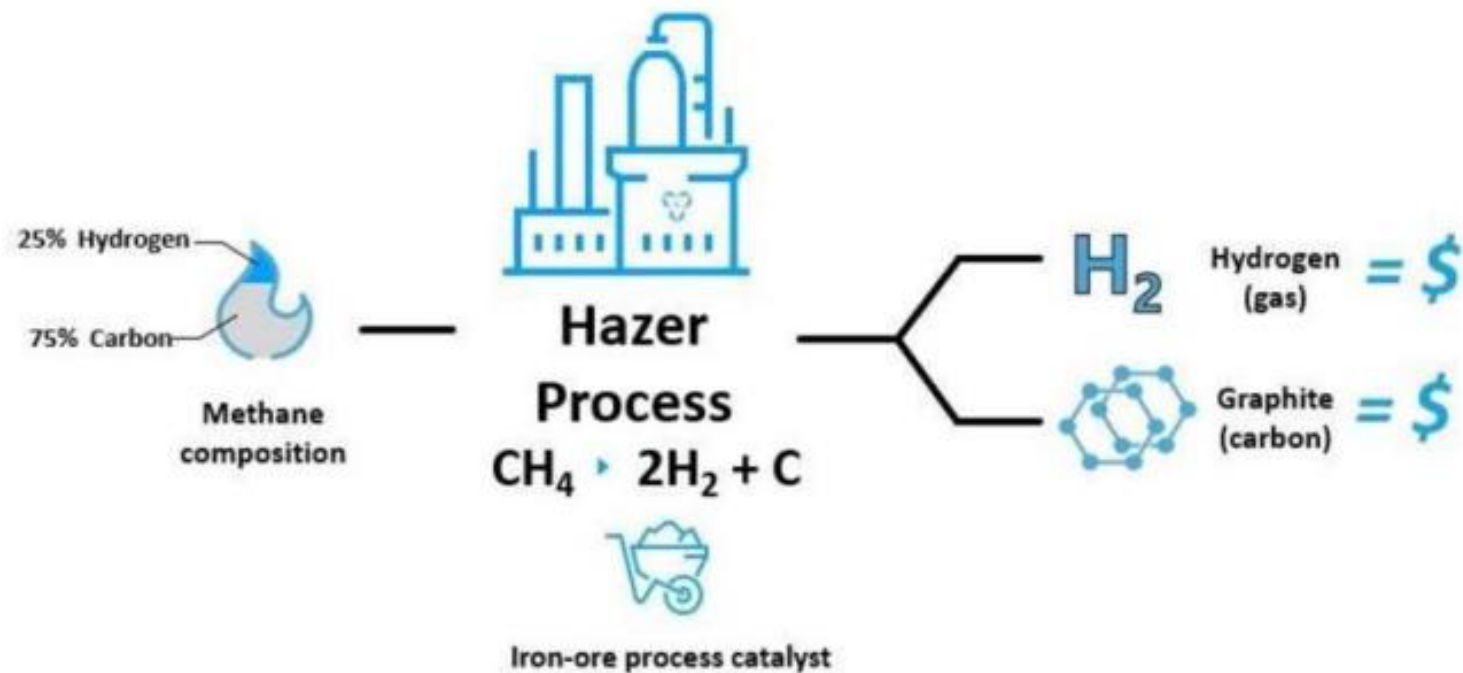
Conversion of waste to Bio-methane and subsequently to Hydrogen production generates various valuable byproducts



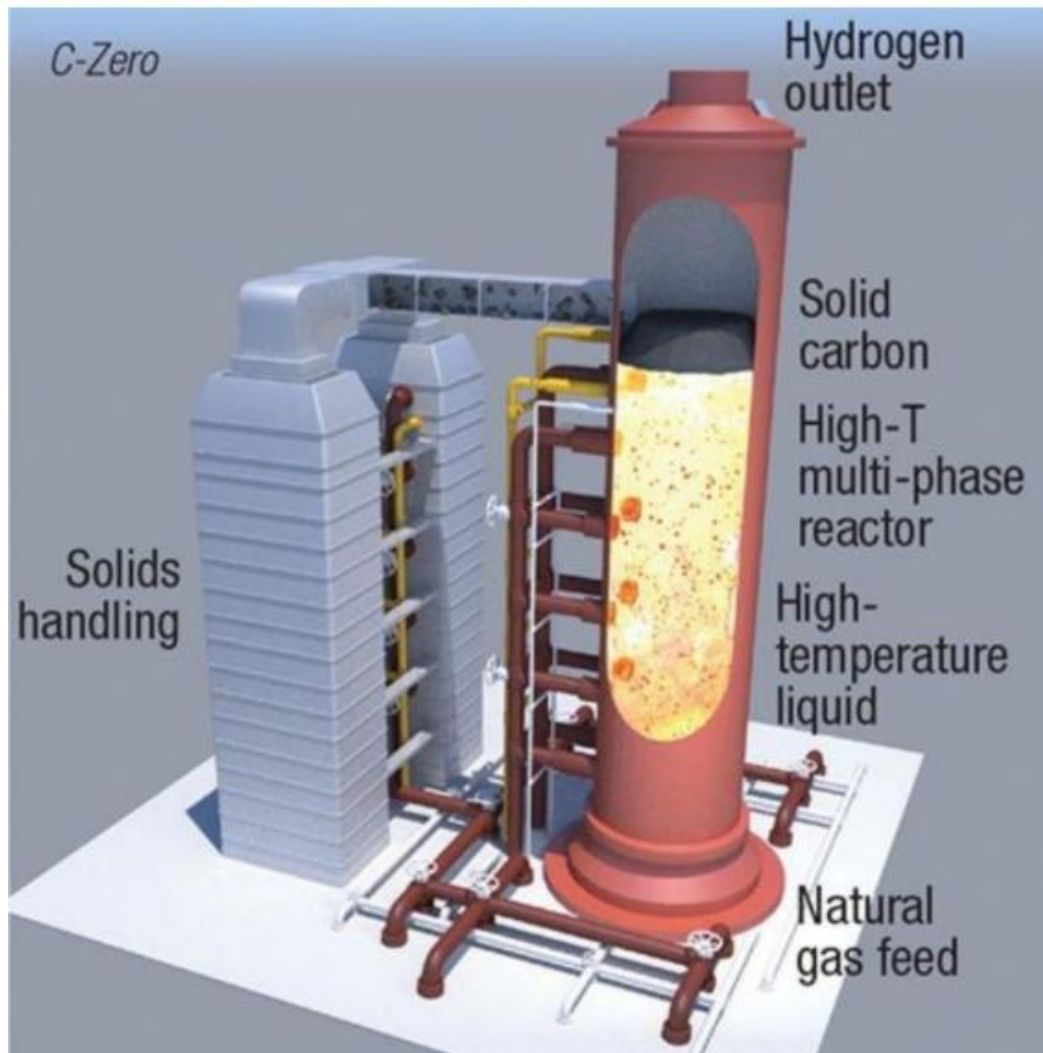
PLASMA METHANE PYROLYSIS: Monolith USA



FeO Catalysed Methane Pyrolysis: Hazer, Australia

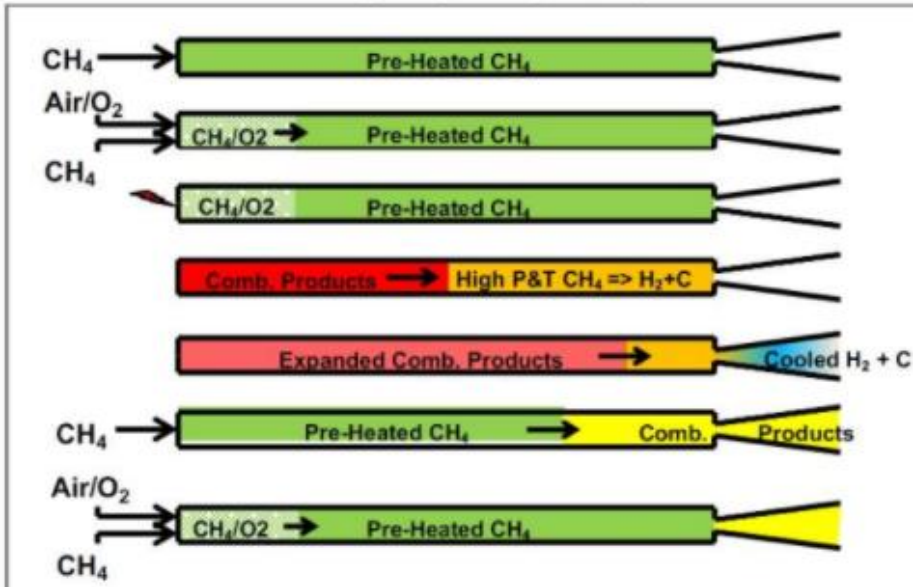


Molten Salt Methane Pyrolysis, C-Zero, USA



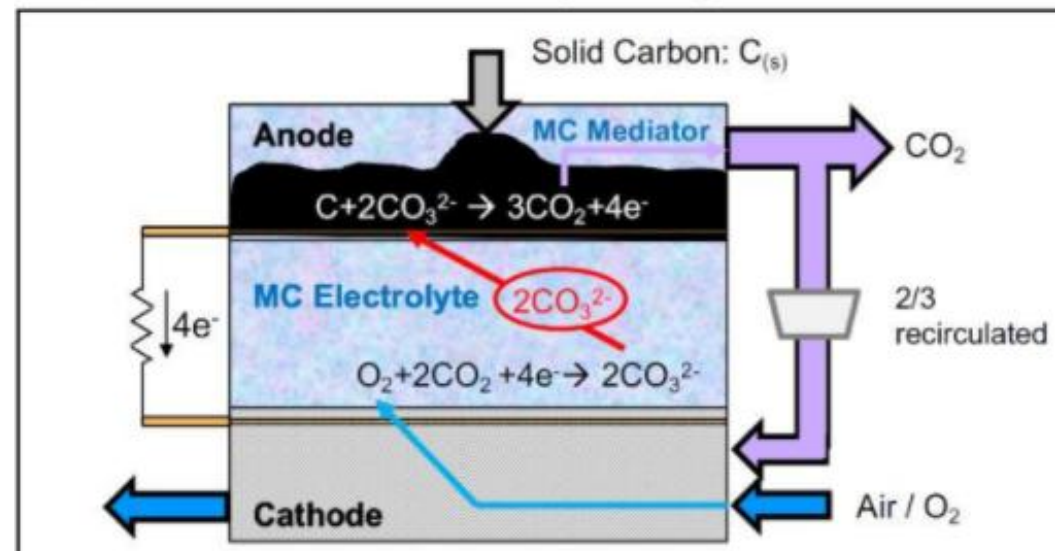
Pulse Methane Pyrolysis : Ekona Power, Canada

Pulse Methane Pyrolysis (PMP)



- Pulsed injection of thermal & mechanical energy
- Automatic removal of C-buildup due to unsteady flow
- Fast kinetics quenching via unsteady expansion
- Prototype [reactor](#) presently being assembled & tested
- PI Partners: [Geminus Technologies](#), [U of W](#), [NRC](#)

Direct Carbon Fuel Cell (DCFC)



- Fuel: solid carbon in a MC mediator
- Advantages: high efficiency + pure CO₂ byproduct
- Challenges: carbon delivery to anode
- Prototype [button cell](#) is presently being assembled & tested
- PI Partners: [NRCan-Canmet Energy](#), [NRC](#)



Levidian Loop50 Shipping container: CH₄ Pyrolysis

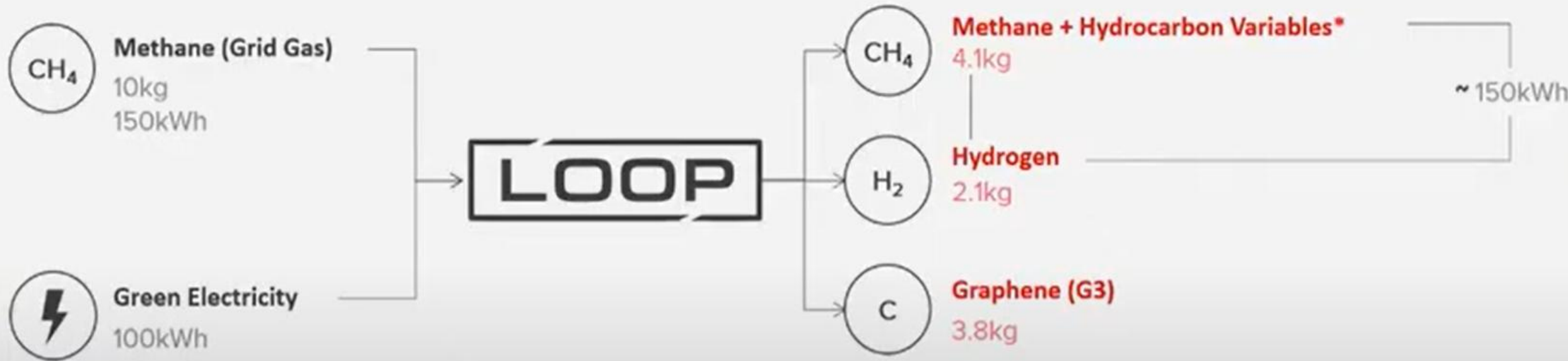
- LOOPs can be deployed in standard shipping containers or into permanent infrastructure as single units or larger arrays. Levidian is currently scaling up LOOP technology to deploy LOOP1000+.
- The device uses a patented low temperature, low pressure process to crack methane into its constituent atoms, hydrogen and carbon, without the need for catalysts or additives. (Microwave Electromagnetic waves and Cold Plasma).
- The carbon is locked into high-quality graphene and the hydrogen can either be used as a hydrogen-rich blend or separated and stored for use pure form.
- A single LOOP50 device utilising Bio-CH₄ reduces CO₂ equivalent (CO₂e) by 100 tonnes per year.



Levidian : LOOP-100

LOOP100 Industrial Development Module

Potential initial size configuration for a demonstration unit

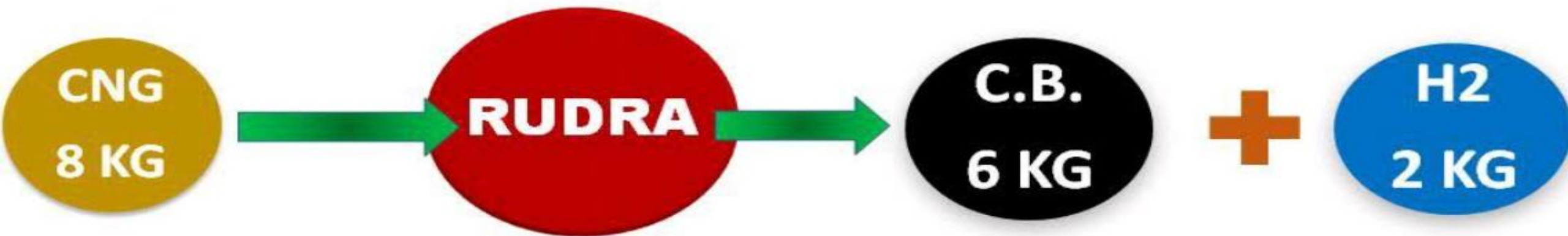


This mass balance represents the base operating case before system optimization. Higher hydrogen and graphene yields are expected during development throughout 2022.

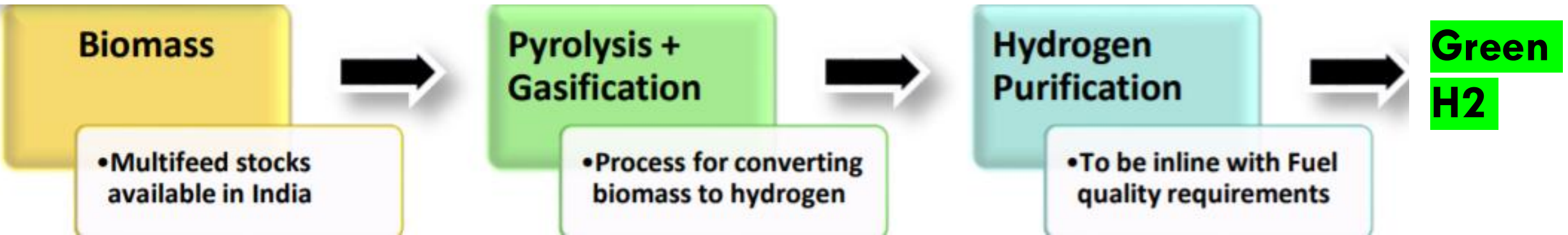
* Additional Hydrocarbon variables include Acetylene (c20%) Ethylene (c5%) Ethane (c2%) [mass percentage in total exhaust]

METHANE PYROLYSIS

RUDRA IS READY TO ROCK



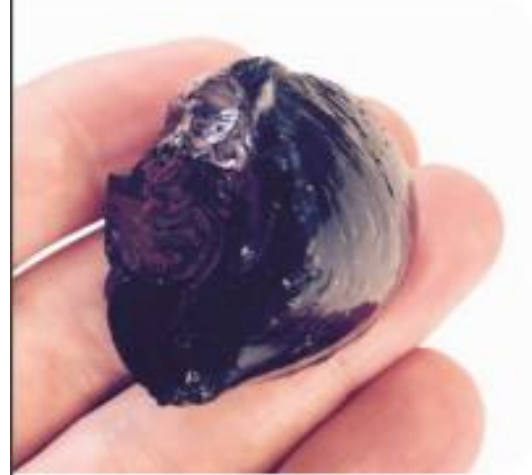
Biomass/Waste to H₂ by Gasification



- IOC and IISc. working to Scale up the Tech
- Sentient Labs(KPIT Research) is also working on it
- “Inst. For Plasma Research”(IPR) has developed Gasification Technology



Waste To H2 by Boson Energy



A waste pile and the corresponding inert glass aggregate after treatment (close-up above)

BOSON ENERGY

- ✓ Core technology proven at full commercial scale
- ✓ Complete elimination of wide range of wastes
- ✓ Net CO_{2e} negative. Zero toxic ash. Zero emissions.
- ✓ High energy efficiency and Hydrogen output
- ✓ High execution capacity through global partners
- ✓ Turn-key 'as-a-Service' business model



Lot of Energy and resources reqd for H₂ by Electrolysis using RE

Energy

- ~ 50 – 60 BU/ MT Green Hydrogen
- ~ 30 – 40 GW of Installed Capacity

Land

- ~ 4-5 acre / MW for RE
- ~ 10 acre / GW for Electrolyzer

Water

- ~ 9-10 litre/Kg of Hydrogen
- ~Raw water – 3 to 4 times

Material

- Nickle
- Platinum, Iridium
- Zirconium, Yttrium

Min. Cost of Green H₂ using
Electrolysis by RE ~ Rs 300/Kg



MECC (Microbial ElectroChemical Cell)

Advantages of MECC

1. Increased rate of degradation
2. No predigestion or pretreatment
3. No harmful gas as in incineration or pyrolysis

Waste to wealth by Microbial Electrochemical cells (MECC)

Plastic Recycling
By environmentally available wastes and microbes employing Bioelectrochemistry

waste Recycling
Into value added products such as H₂, Methane, ethylene glycol, TPA, nanoparticles, Carbonates, bicarbonates, phosphates and sulphates

Plastic waste alone
15342 tonnes /day
generated in India



MECC thru Microbes

waste eating Microbes!!!
Gram negative, non pathogenic

Hydrolyse ester bonds with enantiospecificity

Releases enzymes such as PETase and MHETase

Degrade waste into desired product based on the rate of release of chemicals by bacterium electrochemically

No control over the metabolic rate as it is a natural process

Takes millennium to degrade the tonnes of plastic waste generated every day



Novel Concept to Convert waste into H₂,EG & TPA

In MECC as biofilms to degrade unsegregated waste including plastic

Hydrolyse ester bonds with enhanced enantiospecificity

Release rate of enzymes such as PETase and MHETase increases

Enhanced degradation of waste including plastic into desired products (H₂, Methane, methanol, ethanol, carbonates, bicarbonates, sulphates, nanoparticles etc)

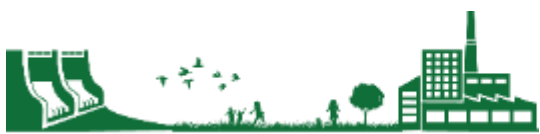
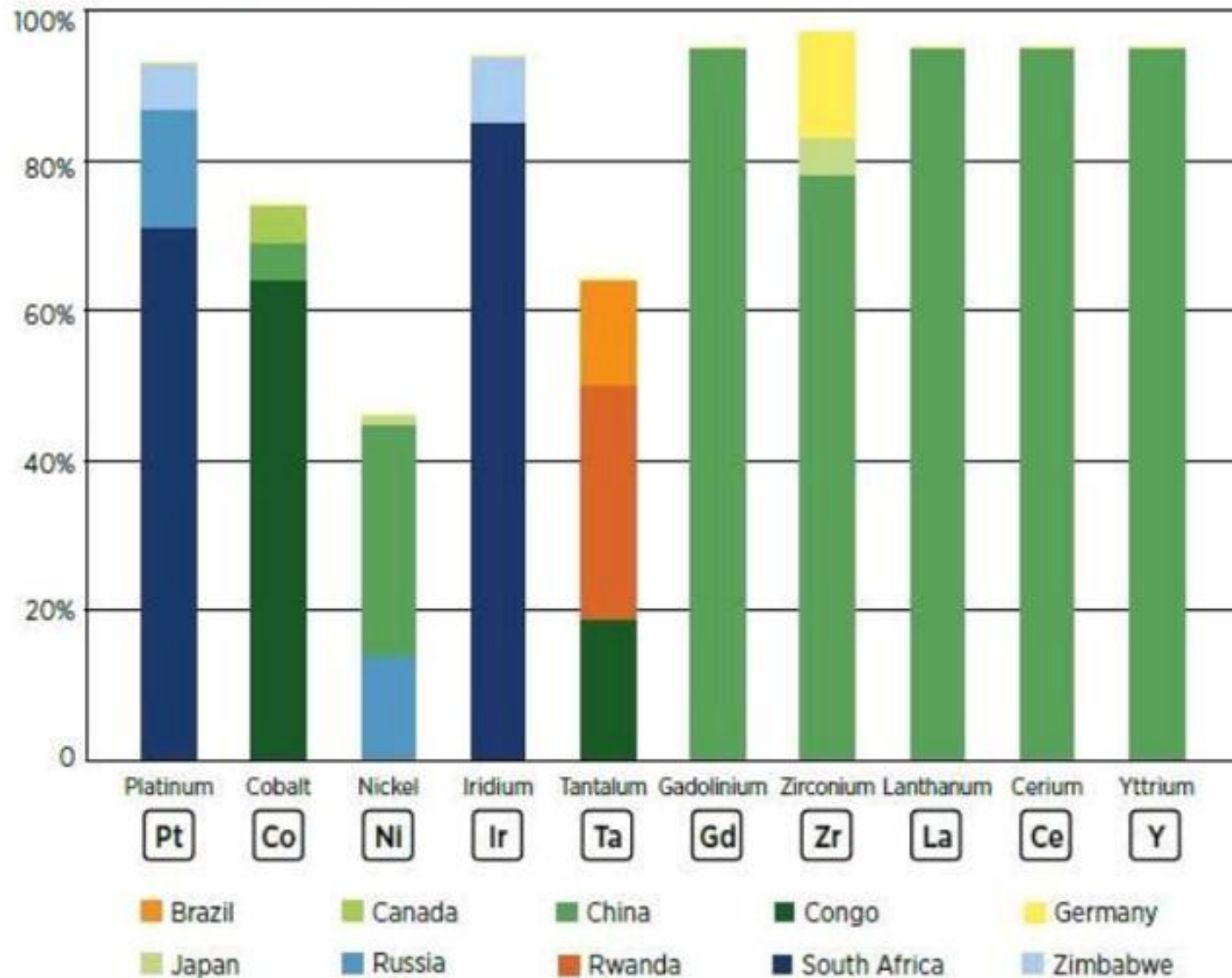
Advantages of MECC over natural/biotechnology/pyrolysis or incineration of plastic

- ❖ Simulating bacterium to release the enzyme at higher rate via electrochemical perturbations
- ❖ Control over the experimental conditions such as current density, potential, pH, partial pressure of oxygen to control formation of Ethylene glycol and Terephthalic acid
- ❖ Inhibit the absorption of ethylene glycol and TPA by the outer membrane and stops further metabolism by bacteria via electrical impulses on the electrode
- ❖ Takes hours to days to degrade the tonnes of plastic waste generated every day
- ❖ Environmental friendly, no harmful pollutants, complete conversion of plastics to value added products



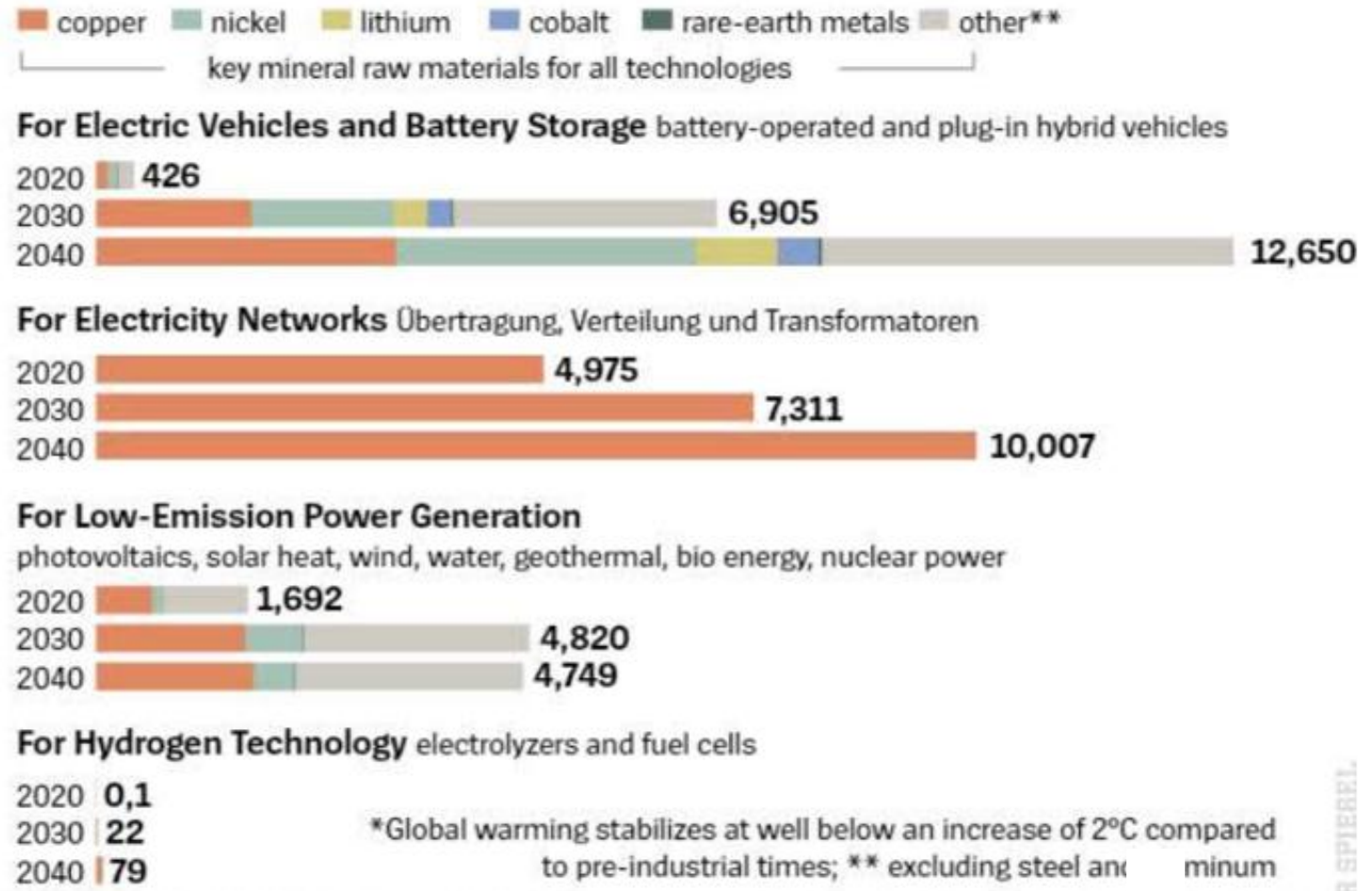
Top Producers of Critical Materials

Fraction of global mining supply (%)



Global demand of materials for Clean Energy Tech

It is clear that H2 has minimal Imported MATERIAL Requirement and so least dependence of Imports for India



*Global warming stabilizes at well below an increase of 2°C compared to pre-industrial times; ** excluding steel and aluminum

Sources: IEA (2021) World Energy Outlook Special Report, IEA data (2021, compiled by SPIEGEL)

DER SPIEGEL



New Toyota Mirai

H2 in CNG pipeline: Economical

Championed notifications:

HCNG 585(E) dtd25/09/20 &

FCEVs safety & Type approval

Requirements GSR 579E

180HPM

Range 650 km or 400Miles

Cost:\$50,000 to \$70,000



H2 Mirai Launched on 16th March 2022



Office Of Nitin... @Office... · 22h
Union Minister Shri @nitin_gadkari Ji's public schedule for 16th March 2022.

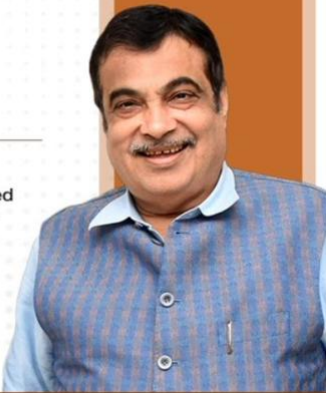
Union Minister Shri Nitin Gadkari Ji's PUBLIC SCHEDULE

16th March 2022

Event 1
Question Hour
(Rajya Sabha)
Time- 12:00 PM
Venue- Rajya Sabha, New Delhi

Event 2
To launch Hydrogen based advanced Fuel Cell Electric Vehicle (FCEV) - Toyota Mirai
Time- 02:00 PM
Venue- 2 Motilal Nehru Place, New Delhi

LIVE



Launched today on 16th of March 2022 at New Delh
[#hydrogen](#) [#fcev](#) [#fuelcell](#) [#greenenergy](#)
[Source : <https://lnkd.in/dew8b4UC>]

Nitin Gadkari @nitin_gadkari

Delighted to launch the world's most advanced technology - developed Green Hydrogen Fuel Cell Electric Vehicle (FCEV) Toyota Mirai along with Union Minister Shri @HardeepSPuri ji, Union Minister Shri @RajKSinghIndia ji,...



Gadkari launches India's first green hydrogen fuel EV

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NEW DELHI: Union Minister for Road, Transport and Highways, Nitin Gadkari, launched the world's most advanced technology - developed green hydrogen Fuel Cell Electric Vehicle (FCEV), Toyota Mirai in New Delhi on Wednesday.

Toyota Kirloskar Motor Pvt Ltd and International Center for Automotive Technology (ICAT) are conducting a Pilot Project to study and evaluate the world's most advanced Fuel Cell Electric Vehicle (FCEV) Toyota Mirai which runs on hydrogen, on Indian roads and climatic conditions.

This is a first of its kind project in India which aims to create a Green Hydrogen based ecosystem in the country by creating awareness about the unique utility of Green Hydrogen and FCEV technology.

It is an important initiative which will promote clean energy and environmental protection by reducing dependence on fossil fuels and thereby make India 'Energy Self-reliant' by 2047.

Fuel Cell Electric Vehicle (FCEV), powered by Hydrogen, is one of the best Zero Emission solutions. It is completely environmentally friendly with no tailpipe emissions other than water.

Green Hydrogen can be generated from renewable energy and abundantly available biomass.

Introduction and adoption of technology to tap into the green hydrogen's potential will play a key role in securing a clean and affordable energy future for India.

THE FUEL CELL ELECTRIC VEHICLE (FCEV), POWERED BY HYDROGEN, IS HAILED AS ONE OF THE BEST ZERO EMISSION FIX



HCNG Buses : DTC: 70% reduction in Emissions

Mass Emission Results – Certifying Lab

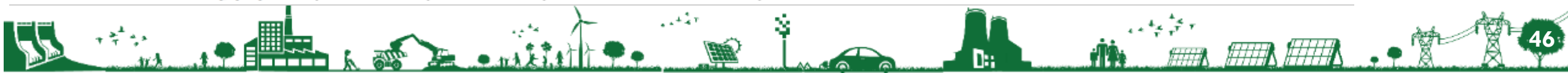
Emission species	% benefit achieved with HCNG over CNG	% reduction claimed in Hon'ble Supreme Court
CO	-77.97	70
THC	-68.15	15

Raw Emission Results

Idle Emission Species	Idle Emissions		
	CNG	HCNG	% reduction achieved
CO (%)	0.13	0.07	-50.63
NMHC (ppm)	96.16	40.08	-58.32
NOx (ppm)	112.45	85.71	-23.78
O ₂ (%)	6.64	6.75	+1.68
CO ₂ (%)	7.12	6.69	-6.15

Fuel Economy Benefits

Fuel	Avg. FE (Km/Kg)	% Fuel saving with HCNG
HCNG	3.07	+4.77 (against 4-5% claimed)
CNG	2.93	



Repowering Coal Fired Plants with Gas/H2

Shift from Coal to Gas-fired reduces 50% of the CO2 emissions, and also lowers other pollutants like Hg, NOx, SOx and PM

Blending with H2 reduces pollution drastically

- China: **GE**(using GE 9HA.01 Turbine) **commercial operations started Junliangcheng 661 MW plant in Tianjin City, : 50% H2** by volume blended with natural gas
- Capital Power a **Canadian utility has ordered two Mitsubishi Power natural gas-fired turbines(M501JAC) to repower its combined cycle plants in Alberta**, as it converts from coal-fired generation Expected repowering completion of Unit 1 in 2023 and Unit 2 in 2024.
- The repowered plant will provide 1,360MW of electricity capacity.



Co-firing Coal with H₂/NH₃

<https://www.ammoniaenergy.org/articles/ihl-first-to-reach-20-ammonia-coal-co-firing-milestone/>

- The Japanese manufacturer IHI Corporation **announced** on March 28, 2018 **successfully demonstrated 20% NH₃ co-firing with coal** (% energy content)

<https://www.powermag.com/jera-planning-to-shift-coal-power-fleet-to-100-ammonia/>

- **Japan:** JERA plans to **shutter** its entire 2.2 GW supercritical **coal plant** by 2030, and then gradually **co-fire coal with ammonia and hydrogen**



Utah Power Plant :H2 adoption/transition from Coal

- CA Delta(Utah): **Coal** power plant (1 900MW) is transitioning to **840 MW Hybrid (30% H2/NG fuel) in 2025 and later in 2045 to switch to 100% H2**

<https://www.greenbiz.com/article/you-say-old-coal-plant-i-say-new-green-hydrogen-facility>

- 1000 Electrolysers (Siemens Energy's Silyzer technology) and H2 storage
- The scope also includes hydrogen compression, storage and intelligent plant controls.



SWOT Analysis Biomass to H2

Strengths

Decentralized; **Strengthens self-reliance**,
Environmentally sound;
Locally available fuel, ability to meet the fossil fuel
applications/replacement

- **Indigenous technology**
 - **Directly from biomass to hydrogen**
- **Hybridization with other renewables for firm power**
 - **To support other renewable hydrogen**
- **Employment potential**

Opportunities

- **ATMA Nirbar**
- Potential very high
- Distributed concept
- Gestation period nearly zero;
- Hydrogen generation costs are comparable to that of fossil fuel system;
- Supports Gol's initiative on Green NH3 and Urea

Weakness

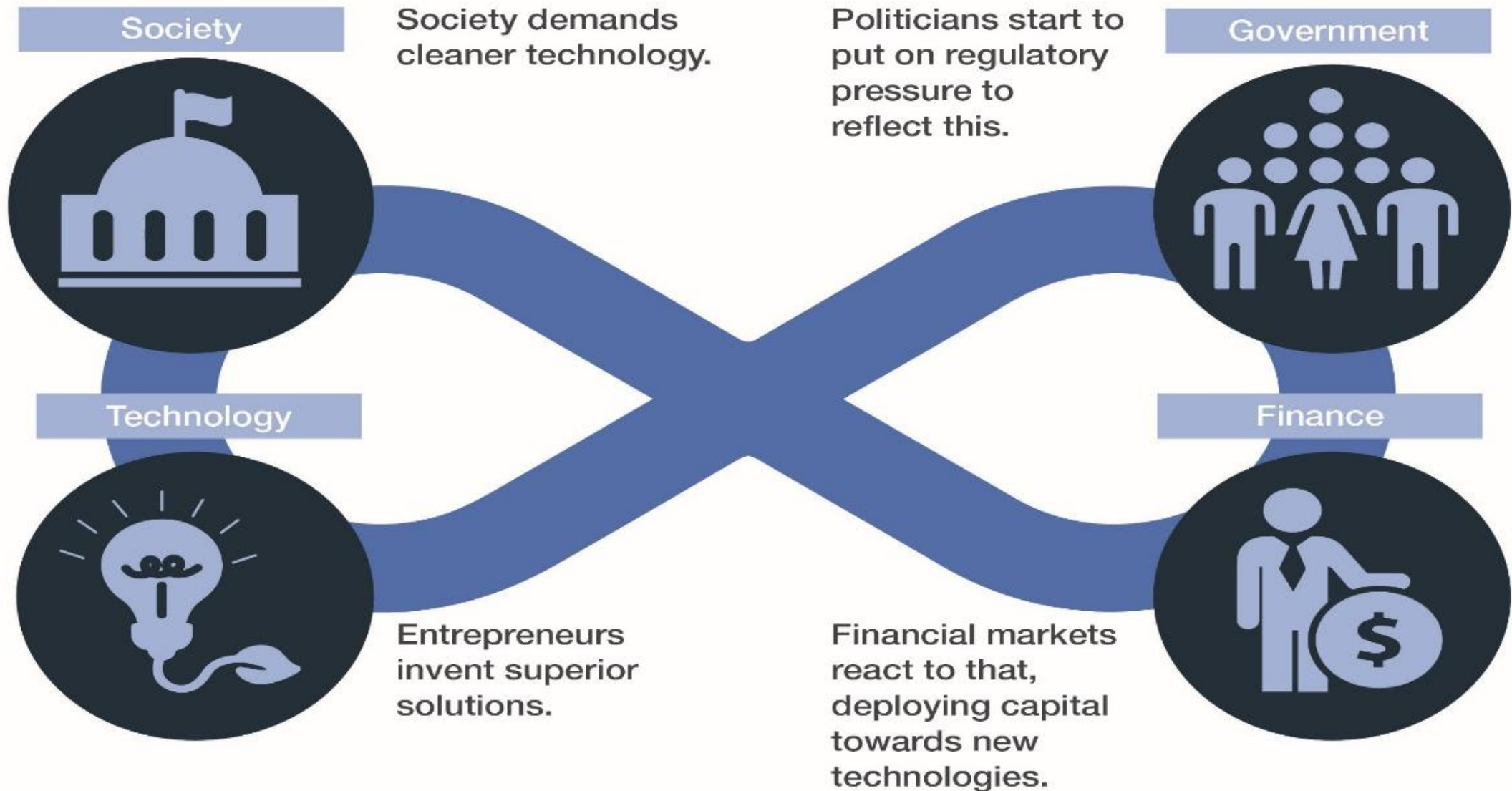
- No level playing field
- **Fuel dispersed;**
- Not many players in the sector
- Low visibility
- **Completely indigenous technology**

Threats

- **Reforms under-emphasize biomass-based systems;**
- **No access towards level playing field,**



Stakeholder's engagement



Policy Recommendations

- Carbon intensity should be measured instead of color and Certified
- Funding for Pilots: If pilot/ demo plants are set up by govt/ PSU, the success will create change and more entrepreneurs will come in.
- Derisked and Long term Finance by Banks / Institutions/ Agencies
- Carbon mkt regulator/ regulations/ trading established ASAP. Carbon credits will help financing green economy
- Policies supporting decentralised waste to H2 : reducing transportation of waste/H2 and the waste.
- Just like RE: Banking of Bio-Methane
- Allowing Different Points of Injection and withdrawal should be permitted for Bio-H2 and for Bio-CH4



Policy Recommendations

- Stable and Bold Policies with tax incentives
- Demand Creation by Target Setting for using Green H2 across various sectors
- Dollar Linked Contracts for Green H2, Green NH3
- PLI incentives for SMRs and Methane Splitting
- Ecosystem development with better co-ordination between Academia, Start-ups, Research, Industry and Finance
- Researchers should get Credits for industrial participation and supporting Ecosystem and events for eco-system building
- Credit worthy aggregators like SECI for Demand Aggregation



Hydrogen from Waste – Advantages

Can be stored
and used when
needed

Major Components
manufactured in
India

Lower Capital
Investment

Decentralized
Hydrogen
Production

Rural Microgrids
Rural Electrification

**24/7 Supply of Clean Local Hydrogen from Waste
– reduce Infrastructure Stress and build Hydrogen Ecosystems**



Summing up

- Hydrogen from Waste would be a key driver in the triad of energy, economy and environment.
- Meeting the requirements for Grid Stability, Energy storage Transport and utilization in Micro-grids.
- @ Rs 80/Kg as against Rs 313/Kg of Hydrogen from Electrolysis it is economic and sustainable.
- Hydrogen from waste is greener than the green because it prevents contamination of soil, water and air, mitigates GHG and returns carbon to the soil improving fertility, preventing soil erosion and land slide.



All SDG Goals can be addressed Direct and Indirect Impacts

No Poverty

Zero Hunger

Good Health & Well Being

Quality Education

Gender Equality

Clean Water & Sanitation

Affordable & Clean Energy

Decent Work & Economic Growth

Industry, Innovation & Infrastructure

Reduced Inequalities

Sustainable Cities & Communities

Sustainable Consumption & Production

Climate Action

Life Below Water

Life on Land

Peace, Justice and Strong Institutions

Partnerships for the Goals



Conclusion

- **Waste to H2 is Greener than green**
- **Green H2 is Multi-Decade opportunity**
- **Green H2** can integrate RE sustainably and thus Provide Energy across Sectors
- Additional benefits being :
 - Cleaner Environment, Avoid Methane Flaring, Waste Treatment, Clean Energy, Free Prime Lands being locked by Landfills
 - More Jobs/Lesser Migration
 - Lesser imports
 - Higher Exports (Lo Carbon produce like Steel, Green NH3)
- **PPP (Planet, People & Prosperity) [100]**
- **Win-win for all**





Thank You,
Questions ?

