Sustainable Future Fuels for Global Green Climate

4th World Future Fuel Summit

New Delhi, 16 February 2023

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CSIR-Indian Institute of Petroleum

Creating Future Fuels

An Overview of the Sustainable Development Goals

Rules of Thumb for Sustainability

- ***INPUT RULE***

RENEWABLES: Harvest rates of resources must be within the regenerative capacity of systems that produce them.

NON-RENEWABLES: Rates of depletion must not exceed the rate at which ecologically sound, long-term resource substitutes are developed.

- ***OUTPUT RULE***

Waste and pollution from a community must not exceed the assimilative capacity of its bioregion and must not degrade future absorptive capacity or any other important ecological services. (Note: residuals exported beyond the bioregion must be accounted for)

Source: Ismail Serageldin, 1993

250 Years of “Progress”

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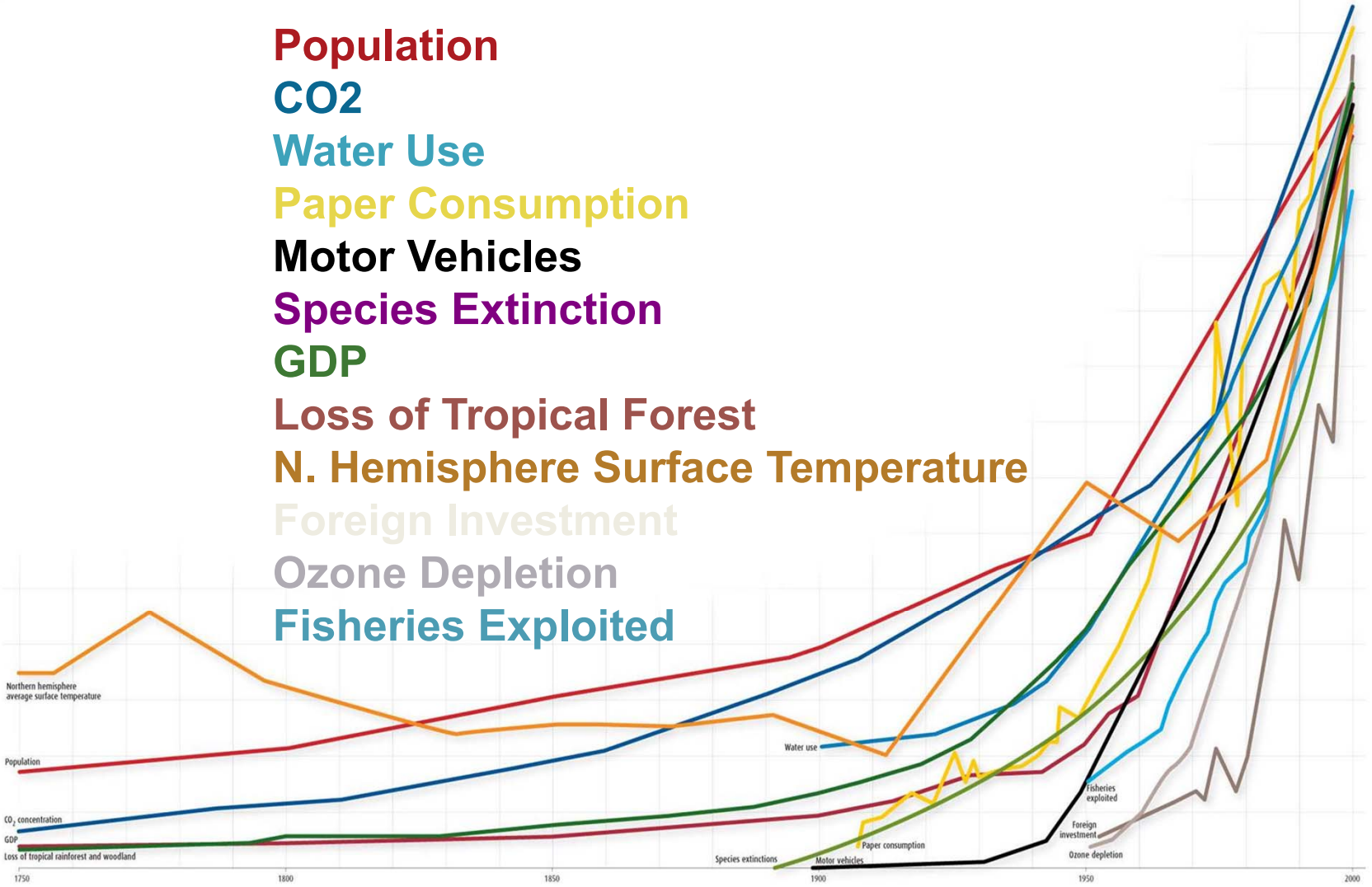
Population
CO2
Water Use
Paper Consumption
Motor Vehicles
Species Extinction
GDP
Loss of Tropical Forest
N. Hemisphere Surface Temperature
Foreign Investment
Ozone Depletion
Fisheries Exploited



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Sustainability and Us

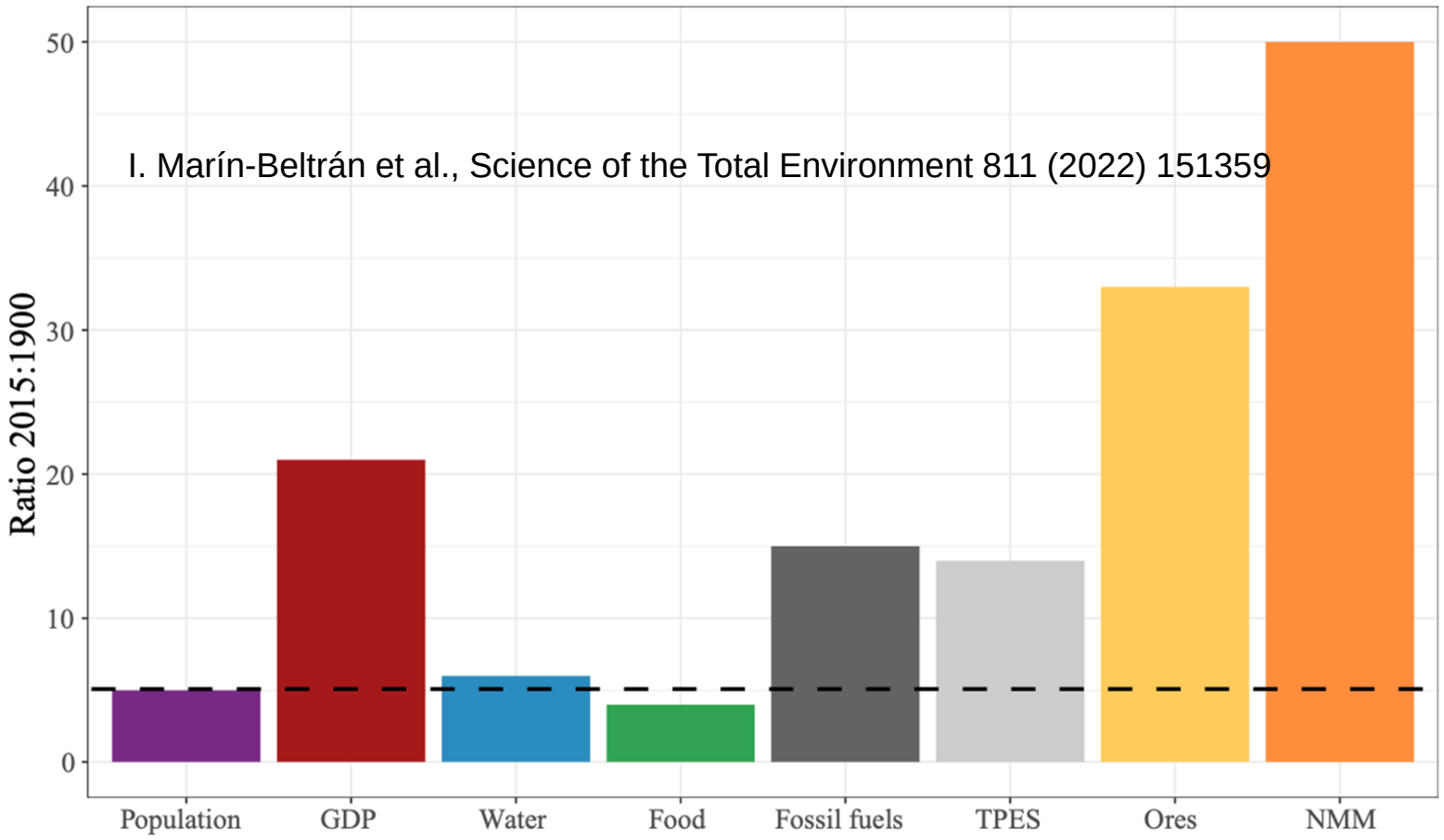
- "Sustainability requires alleviation of poverty, a decline in fertility, the substitution of human capital for natural resources, effective demand for environmental quality and a responsive supply."
  - » T. Panayotou, Green Markets: The Economics of Sustainable Development, Institute for Contemporary Studies, 1993

- "The range of products and processes that now exist –and the environmentally unfriendly approaches to production and consumption that underpin them- are the result of companies' choices over product and process innovations made during the past 20, 50 and in some cases 100 years."
  - » K. Green, A. McKeekin and A. Irwin, "Technological Trajectories and R&D for Environmental Innovations.", *Futures*, Vol 26:1036-52

- "The root cause of all our environmental (and many of our social) problems is overconsumption and population increase. Limit the amount of goods you buy. Do you really need twelve sweaters, twenty-three dresses, nine pairs of jeans and six pairs of boots?"
  - » E. Sartzetakis: The Economic Dimension of Sustainable Lifestyles, University of Macedonia, 2004

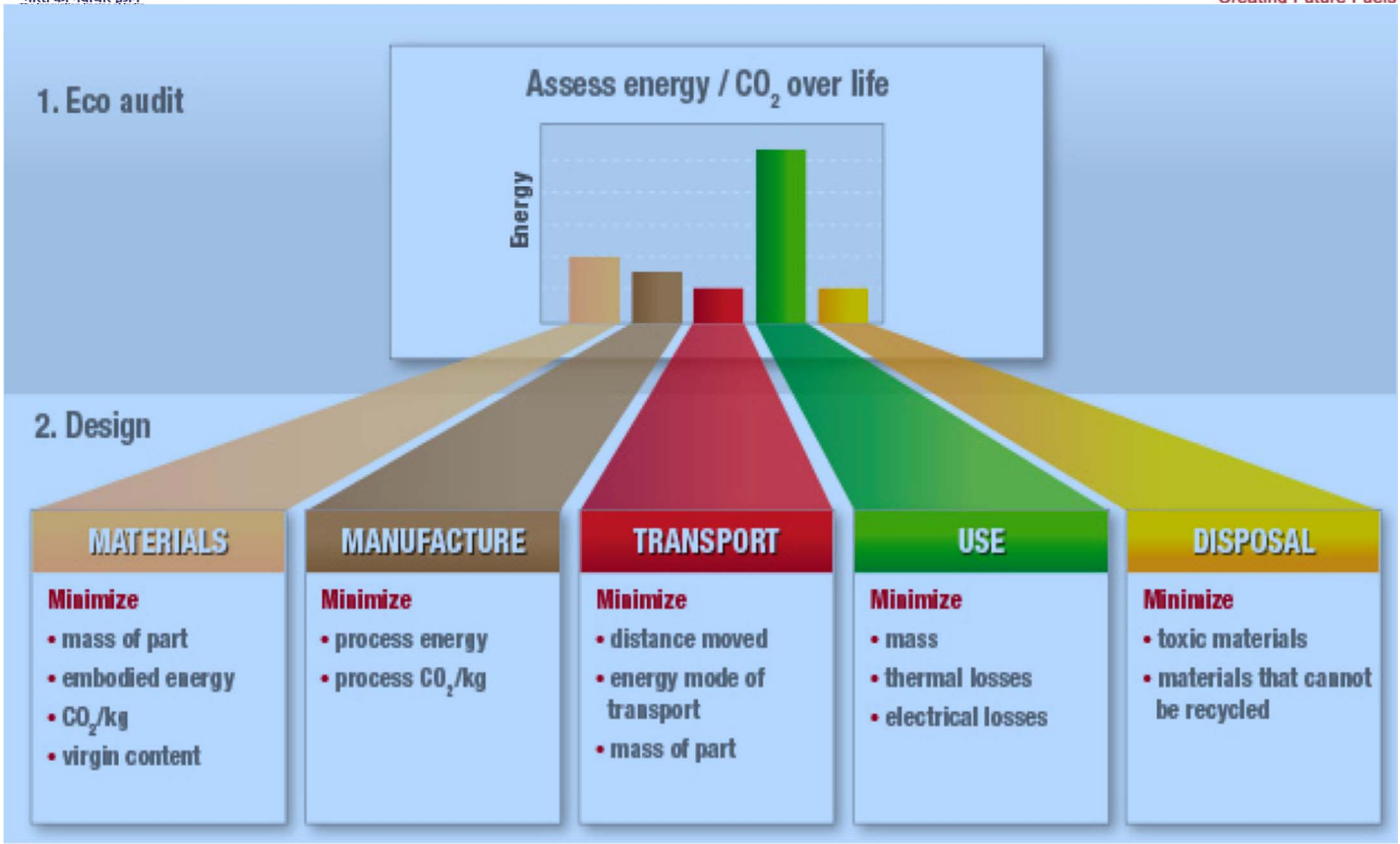
Overconsumption

Global Annual Extraction of Natural Resources, 1900-2015



Increase in human population growth, Gross Domestic Product (GDP) and the extraction of natural resources in 2015, relative to values reported in 1900. The black dashed line delimits the level above which the increase in production of a given material is above the increase in human population growth. Non-metallic minerals (NMM), Total primary energy supply (TPES)

Energy, Emissions, Environment - Manufactured Goods



A.A. Morini et al. / Materials and Design 178 (2019) 107861

India – Carbon Atom Imports

Commodity	Import MMT, 2022	% C	Imported C atoms, MMT/yr
Crude Oil	212	85%	180
Coal / Pet. Coke	180	75%	135
Natural Gas	20	77%	15

Demand Side Response

- Reduce energy requirement (enhance efficiency)
- Reduce carbon requirement (non-carbon energy e.g. solar, wind, geothermal)

Supply Side Response

Find and reuse about 230 MMT of domestic carbon (on current basis) to replace our fuel carbon imports

Need energy security solutions within our control

Domestic Carbon Sources (estimates)

- India – Most populous nation ~18% of World population
- Limited availability of landfill space; high cost of urban land
- Carbon atoms discarded by each of us add up!

Carbon Source	Scope, MMT/yr	% C, approx.	Potential C, MT/yr
Agri-residue (surplus)	120	40%	48
Forest residue	150	42%	63
Sewage / dairy / distillery (via biogas)	400	45%	180
MSW	60	25%	15
UCO	5	85%	4
Industrial/Urban C1 gaseous emissions	500+	25-70%	150

> 460 MMT of carbon excluding coal, under-utilized land

All the carbon we need is available within our borders

But Repurposing Carbon needs Water, Energy, Catalysts, Equipment, Labour

Supply-Side Solutions

(Domestic Carbon Sources)

CSIR- IIP Drop-in Liquid Sustainable Aviation and Automotive Fuel (DILSAAF™ Process, Centralized)

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Civilian Flight
Bombardier Q400
Operated by SpiceJet
Dehradun-Delhi
27 August 2018

Military Flights
Antonov-32
Indian Air Force
Republic Day Parade
26 January 2019

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In a first, IAF uses blended bio-jet fuel to fly aircraft

TNN | Dec 17, 2018, 08.15 PM IST

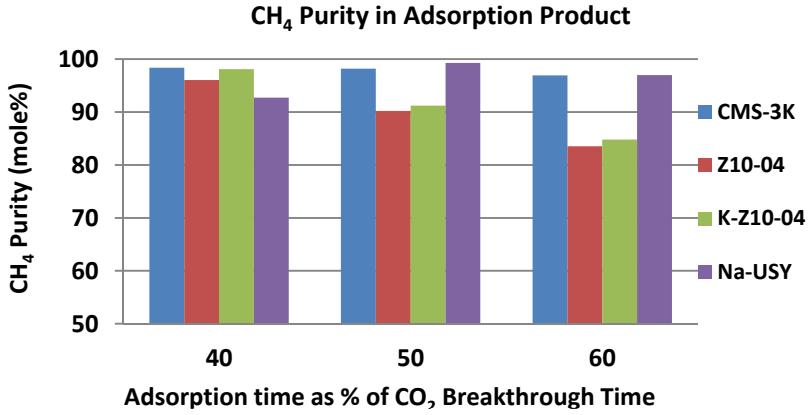
NEW DELHI: The IAF flew a military aircraft with blended bio-jet fuel for the very first time in India on Monday morning. A Russian-origin AN-32 transport plane was flight-tested, with the 10 per cent bio-jet blended ATF (aviation turbine fuel) made from Jatropha oil, in a sortie flown from the Chandigarh airbase.

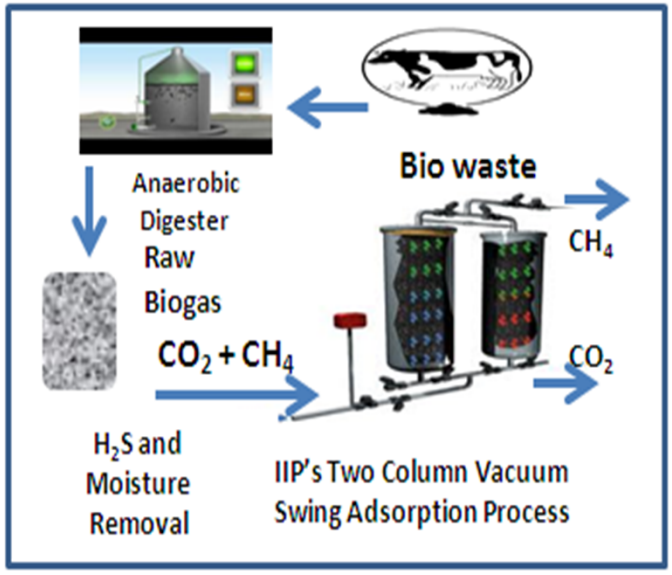
"The project to flight-test the bio-jet fuel, with experimental test pilots and engineers from IAF's premier testing establishment ASTE, is a combined effort of IAF, DRDO, directorate general aeronautical quality assurance (DGAQA) and CSIR-Indian institute of petroleum," said IAF spokesperson Wing Commander Anupam Banerjee.

15000 L/day plant by 2023 – feedstock supply chain is a key success factor

Biomethane (CBG/Bio-PNG)

- Production of bio-methane (CH_4) with pipeline-quality purity and recovery >90 mol%
- Simpler VSA cycle based on low cost commercial adsorbent
- Low energy required, high productivity
- Product biogas suitable for
  - Combined heat and power generation
  - Transportation fuel
  - Industrial and domestic usage





Demo Bio-PNG Plant of 500 Nm^3/Day operated at Pune 2018-22; now relocated to Rudrapur; ties into SATAT Scheme of Indian Government

CSIR-IIP- GAIL Technology: Waste polyolefins to fuel and aromatics

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Petrochemicals (500 ml)
(Benzene,Toluene, Xylenes) +

Gasoline (700 ml)
+ LPG

Option-1

Option-2

Option-3

Diesel (850 ml)
+ LPG

1 Kg waste (PE+PP)

- Exclusive production of either ***gasoline or diesel or aromatics*** along with ***LPG*** from polyolefinic wastes (e.g. HDPE, LDPE, PP etc)
- Liquid fuel meeting Euro IV/VI specifications, Aromatics rich in BTX

Waste Plastic to Diesel
1000 kg/day demonstration unit at CSIR-IIP

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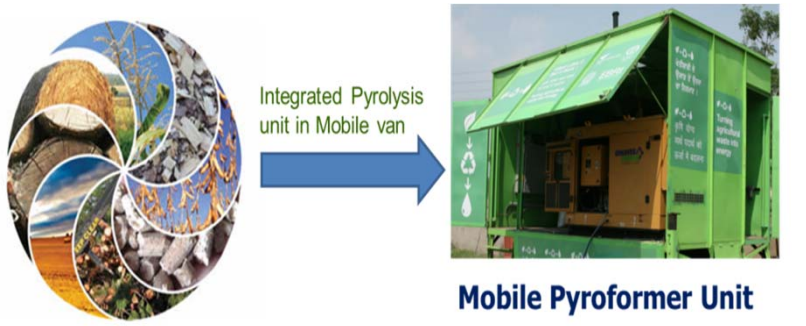
1 TPD plant at Dehradun, India

- *A one ton per day demo unit for converting waste plastics to diesel set up at CSIR-IIP to facilitate commercialization of the technology*
  - *With pre-treatment facility*
  - ***Feedstock collected through 20 "Plastic Banks"***
  - *Plant inaugurated on 27 August, 2019*
  - *Technology demonstration available to potential external partners by April 2023*

Plants of capacity 10 tons or higher likely to be economically viable

Mobile Pyroformer: Under Implementation at Nabarangpur District, Odisha

- Effective utilization of residual biomass for production of energy products and fertilizer
- Avoid stubble burning
- Provide electricity/heat to rural households from their **own agricultural biomass residues/waste**
- Raise awareness of alternatives to stubble burning with **decentralized pyrolysis process**



Less than 1 year payback at 5 tons per day

INPUT: 100 kg rice straw			
OUTPUT	Kg	Utility	Remarks
Pellets	80-85	(a) Co-fire with coal OR (b) Feed to Pyrofomer	Denser than biomass, easier to transport
Pyro-char	30-35	Water treatment, soil conditioning/fertilizer	Can be upgraded for high value uses like catalysis
Bio-oil	30-35	Use in furnaces / kilns	Low sulfur (<0.1%) compared to Fuel Oil (~3%)
Gas	20-25	Pyroformer process heat	Can also be used for power

Demand Side Solutions

(Reduced Carbon Usage)

Appliances: CSIR-IIP / PCRA PNG Burner

Energy Efficiency offers higher national value than additional Energy Generation

- Fuel carbon not converted to CO2 results in CH4, CO, and/or VOC emissions and is due to incomplete combustion
- Combustion efficiency of our burner compares with dedicated LPG Stove (> 65%)
- Energy Saving Potential of 20-25% compared to in-use retrofitted PNG stoves
- Patented innovation, modelled using state-of-the-art CFD, claims verified by actual users
- Enhances safety of users by eliminating the chance of **Flame Lift, Flame Flashback and Flame Extinguishment**

Domestic PNG Connections in India	1.0 Cr (2022)
Average Consumption of PNG (4 member family)	0.50 SCM / Day
25% Saving through PNG Burner	0.125 SCM / Day
Per connection savings (PNG @ Rs. 52/SCM)	Rs. 6.5 / Day
Yearly saving potential on existing connections	~ Rs. 2200 Crore

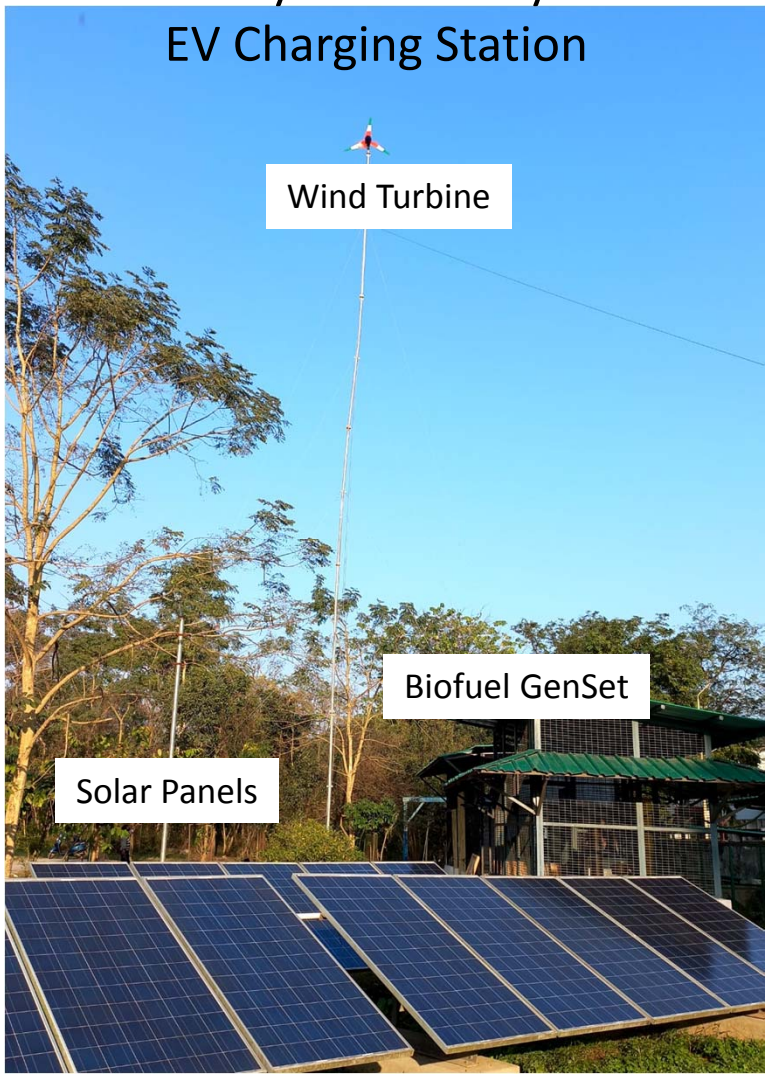
>50% lower net operating cost compared to LPG stoves

Demand-Side Solutions

- Energy Efficiency
  - Industry: Lubricants (including bio-lubricants), Process Energy Optimization, Waste Heat utilization
  - Buildings: Natural lighting and ventilation, insulation, appliances/fittings (BEE Star Ratings)
  - Transportation: Vehicle-level design innovation, Hybrids, Regenerative braking

- Non-carbon energy
  - Industry: Solar PV / Solar Thermal / RE Grid
  - Buildings: Integrated Geothermal, Solar Water Heaters, Solar Cookstoves
  - Transportation: EV (battery/fuel cell) with RE charging infra (including pumped hydro)

15kW Hybrid Battery-free EV Charging Station



Old cars as a resource:
Retrofit Kit for conversion of IC Engine Vehicles **into EVs**

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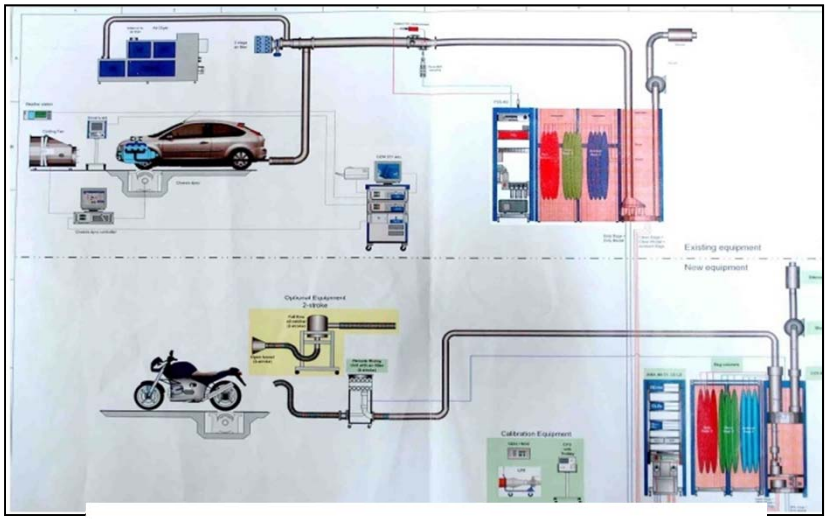
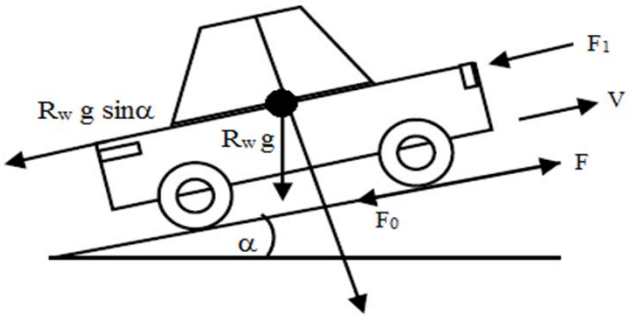
- **Development, Selection, System Integration** of Electric Powertrain Sub-systems
- **Rigorous component testing**
- **Real-World Performance Testing Pre- and Post-Conversion**





Pre-conversion IC Vehicle Performance Test

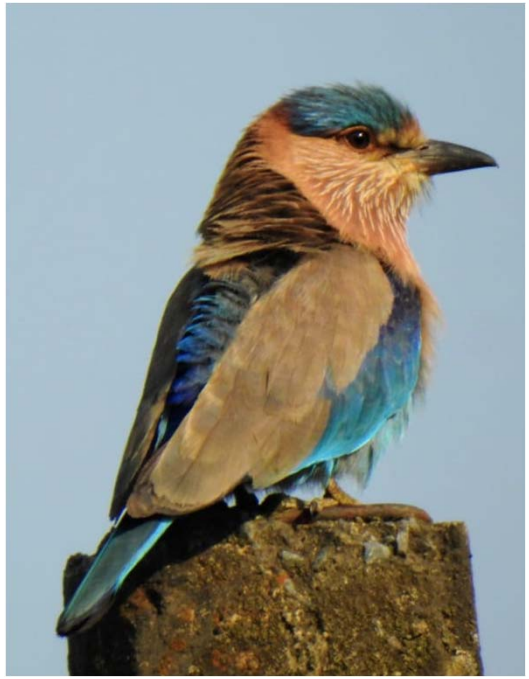
Post-conversion EV Performance Test

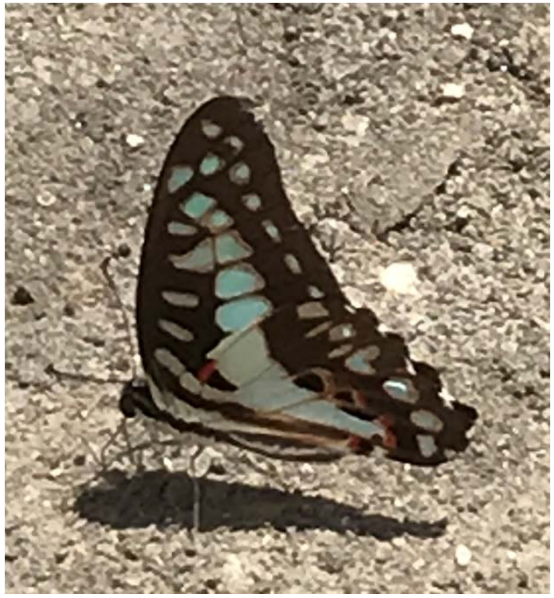
In Summary

- Sustainability is not just fashionable, it is an imperative
- Decarbonization and Resource Effiiciency are essential components of Sustainability
- Locally available resources – from used cooking oils to agri-waste end-of-life assets – should be recycled within local areas to the extent practicable; “economies of scale” thinking can distort GHG emission outcomes
- R&D in emission control and decarbonization can unlock significant value for India – but effective collaboration and interdisciplinary thinking is needed

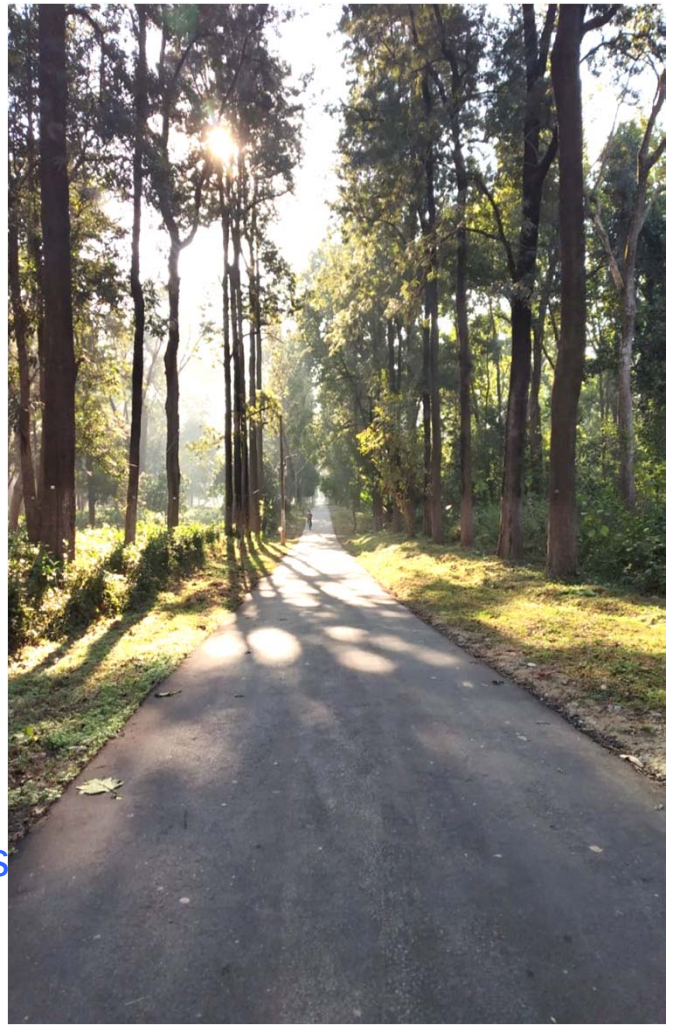
Sustainability in Action

Cornell eBird Database, 2022
212 bird species





World Environment Day, 2017
90+ butterfly and moth species



Thank You