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Unfolding the Net Zero Conundrum for the Indian Transport Sector

Dr. Avinash Kumar Agarwal FAAS, FSAE, FASME, FRSC, FNAE, FNASc, FCI, FISEES, FWSSET
Director, Indian Institute of Technology Jodhpur
J C Bose National Fellow and SBI Endowed Chair Professor,
Engine Research Laboratory, Department of Mechanical Engineering

IIT Kanpur

Commitments by India

PM MAKES FIVE PLEDGES

1. India will increase its non-fossil energy capacity to 500GW by 2030
2. India will meet 50% of its energy requirements from renewable energy by 2030
3. India will reduce the total projected carbon emissions by one billion tonnes from now to 2030
4. By 2030, India will reduce the carbon intensity of its economy by 45% (from a previous target of 35%)
5. By 2070, India will achieve the target of net zero

WHAT IS NET ZERO?

Net zero refers to a balance where emission of greenhouse gases are offset by the absorption of an equivalent amount from the atmosphere. Experts see net zero targets as a critical measure to successfully tackle climate change and its devastating consequences

PLEDGES BY TOP THREE EMITTERS

CHINA: Beijing announced no new pledges on Monday. It previously pledged net zero by 2060.

UNITED STATES: The US touted domestic legislation to spend $555bn to boost renewable power and electric vehicles. It has pledged net zero by 2050.

INDIA: The country's economy will become carbon neutral by the year 2070

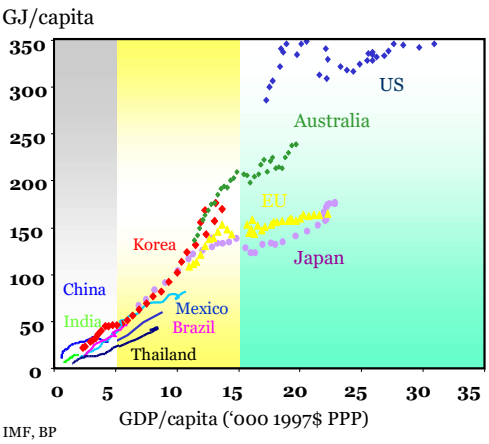
1. Global Sustainability Challenges

1.5°C Scenario and Net Zero

Three Serious Global Concerns

Depletion of natural resources	
Acceleration of global warming	
Effects of exhaust emissions	

Energy Use Vs GDP/ Capita



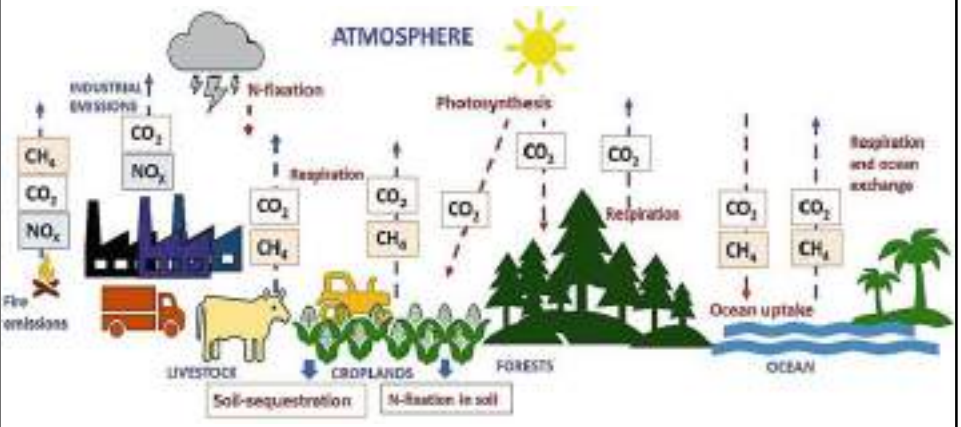
Source: IMF, BP

- **+$25k/capita**: little extra energy needed.
- **+$15k/capita**: services start to dominate growth.
- **+$10k/capita**: industrialisation near complete.
- **+$5k/capita**: industrialisation and mobility take off.

Shell International Ltd.

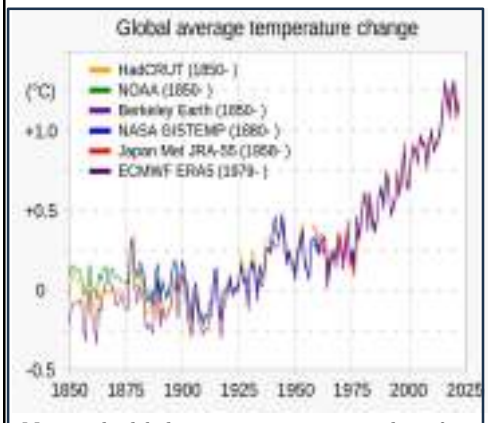
- 2050, world population: 8-10 billion
- 80% people: urban areas
- Average income: US $ 15-25,000 per annum
- Per capita energy demand (2050): 2-3 times that of present

GHG Emissions & Uptakes: A Delicate Balance!!



https://link.springer.com/chapter/10.1007/978-981-16-4482-5_3

GHG Emissions – Global Warming Challenge



Measured global average temperature data from several scientific organizations is highly correlated. ("0" value is the average temperature from 1850–1900, which is considered the "pre-industrial" temperature level.)

https://en.wikipedia.org/wiki/File:20200324_Global_average_temperature_-_NASA-GISS_HadCrut_NOAA_Japan_BerkeleyE.svg

- Climate change" and "global warming" are often used interchangeably but have distinct meanings.
- Global warming is only one aspect of climate change. Climate change in a broader sense also includes previous long-term changes to Earth's climate.
- Human-induced warming reached approximately 1°C (likely between 0.8°C and 1.2°C) above pre-industrial levels in 2017, increasing at 0.2°C (likely between 0.1°C and 0.3°C) per decade.
- The current rise in global average temperature is more rapid than previous changes and is primarily caused by GHG produced by burning fossil fuels.

Global Energy & GHG Emissions Scenario

Global Per Capita Energy Consumption

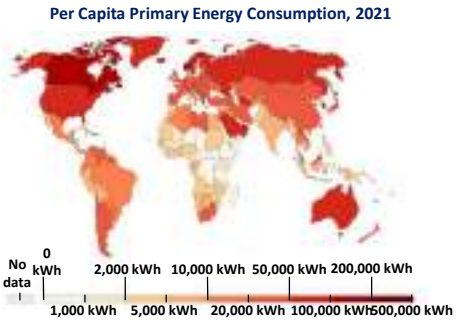
- **20,902 kWh** (2021)

Global per capita GHG emissions:

- **6.3 tCO_2e** (2020)

G20 Nations Account for

- 85% of global GDP
- 75% of global trade
- 65% of the world's population
- 75% of World GHG emissions in 2020

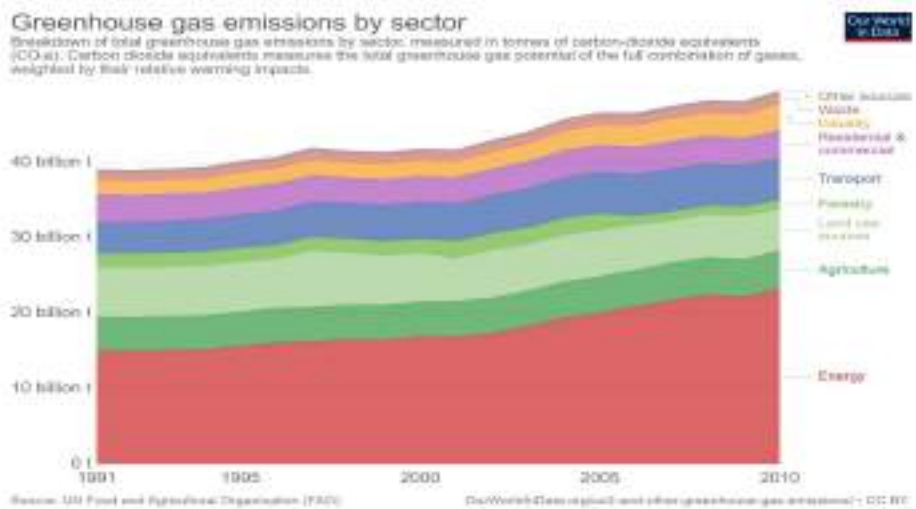


Indian Scenario:

- **6992 kWh/p** (2021)
- **2.4 tCO_2e** (2020): **less than 40%** of the world average GHG emission.
- Contribution to cumulative carbon emissions between 1850 and 2021: **less than 4%.**

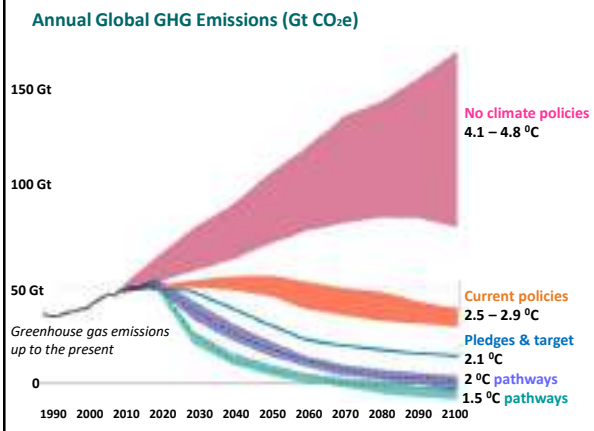
Source: ourworldindata.org

Many people believe that most of the world's GHG emissions come from cars and trucks: A misconception that is grossly incorrect.



Pathways To Net Zero

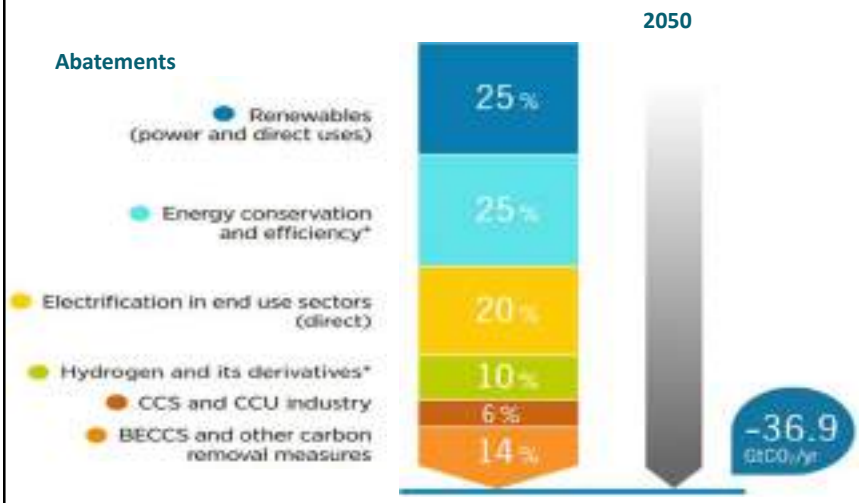
According to International Energy Agency (IEA), to reach Net Zero, over 10 Billion Tons of CO_2 will need to be captured per year by 2070.



Source: Ourworldindata.org
Source: McKinsey India IEA

- BAU trends of post-industrial revolution projects GHG emission rise to 150 $GtCO_2e$, by 2100, with no climate policies implemented, resulting in global average temperature rise 4.1 - 4.8^{0}C
- Under Current Climate Policies, by 2050, GHG emission will peak above 50 Gt, limiting the global temperature within 2.5 – 2.9^{0}C
- Implementation of 2^{0}C and 1.5^{0}C pathways to limit GHG emission peak by 2025 and reach Net Zero Emission (NZE) goals by 2070.

Carbon emissions abatement under 1.5°C Scenario



Sustainable Energy

- **Non-Renewable Energy Sources**

Coal, Natural Gas, Petroleum, Nuclear Energy

- **Renewable Energy**

Wind, Solar, Oceanic (Wave, Tidal, Ocean Thermal)

Hydro, Geothermal, Biomass, MSW

Hydrogen and Fuel Cells???

Nuclear Fusion???

Sustainability Energy: From HELL or HEAVEN?

India: Glasgow-COP 26

To counter climate change issue, Government of India, at COP26 Glasgow committed – Roadmap to *Panchamrit*

- **India will reach its non-fossil energy capacity to 500 GW by 2030**
- **India will meet 50 percent of its energy requirements from Renewable energy by 2030**
- **India will reduce the total projected carbon emissions by one billion tons from now onwards till 2030**
- **By 2030, India will reduce the carbon intensity of its economy by 45 percent**
- **By the year 2070, India will achieve the target of Net Zero**

India's Clean Energy Transition Strategies


CCT


CCUS


Methanol


Hydrogen
(Blue to Green)

India's Clean Energy Transition Strategies


Small Modular Reactors


Renewables

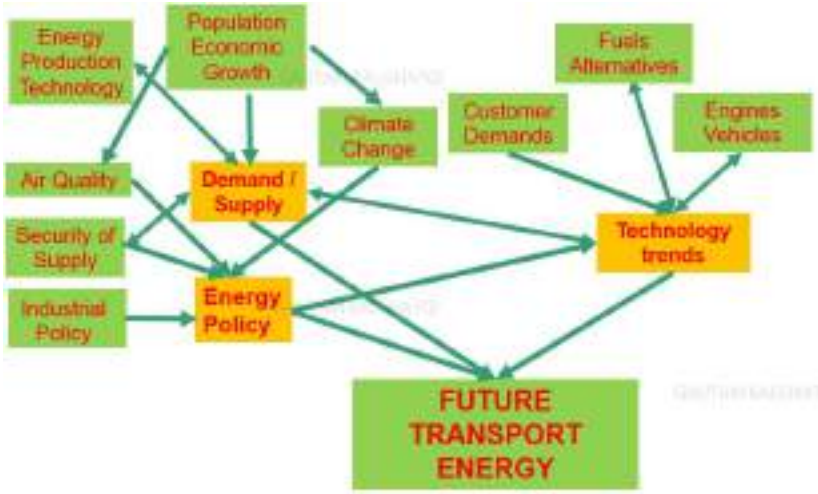

Sustainable Mobility


Water Battery - PSPP


Energy Storage

2. Transport Energy Needs and Sustainability

Future Transport Energy: Many Drivers for Change. Differences between different countries



Transport is Central to Modern Society and Demand for Transport Energy is Gigantic

Globally, TRANSPORT sector accounts for

- 14% of global GHG (CO_2, methane and nitrous oxide) emissions, 20% of total energy use, 23% of CO_2 emissions
- Currently over 1.2 billion light duty vehicles (LDVs); over 350 million commercial vehicles
- LDVs account for ~44% of global transport energy demand.
- Transport is essentially driven by liquid fuels – high energy density, ease of transport and storage, extensive infrastructure
- Over 4.9 billion liters each of gasoline and diesel and 1.2 billion liters of jet fuel each day. **105 TWh** of fuel energy needed each day (India's total electric power installed capacity is 365 GW).

Global demand for transport energy is growing at an average annual rate of ~1 %

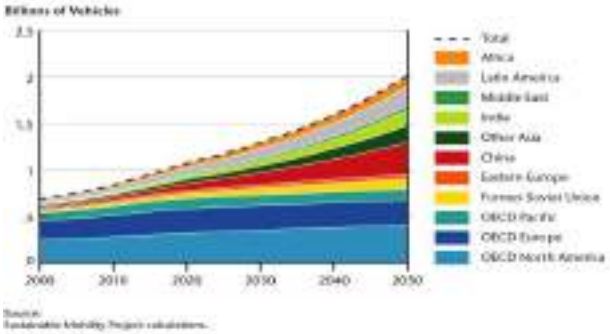
Petroleum and transport closely linked

- 95% of transport energy from petroleum
- 60% of petroleum goes to transport fuels

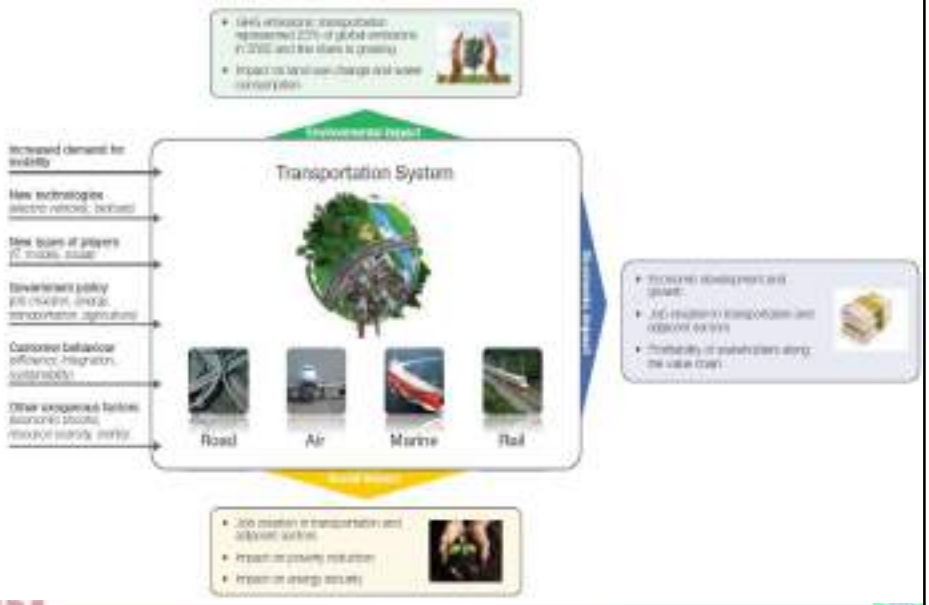
Outlook for Transport Fuels

- Primarily liquid fuels, with scope for sustainable gaseous fuels.
- Made from crude oil and coal/ biomass.
- Why liquid fuels ?
  - High energy density – Gasoline ~ 32 MJ/lit., Diesel ~36 MJ/lit.
  - Easy transport, storage and handling
  - Extensive distribution network

The 21st Century: Projected Growth in Motorization



Sustainable Transport: Noisy Space



Sustainable Biofuel Options ?

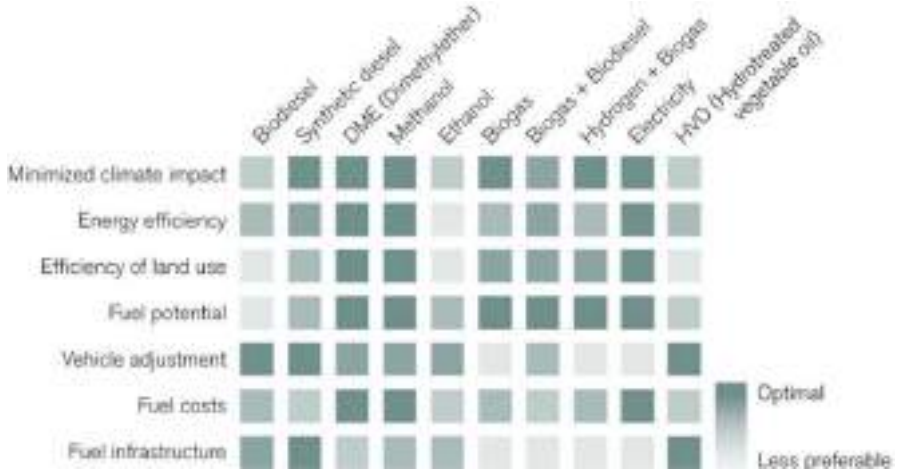
- Renewable fuels from bio-sources
- Include **Ethanol, Methanol, Biodiesel, Bio-Hydrogen, and Biogas (CBG)**

CO2 Free Fuels for the Future…. Busy Space….

Seven Criterions for New Fuel Adaptation

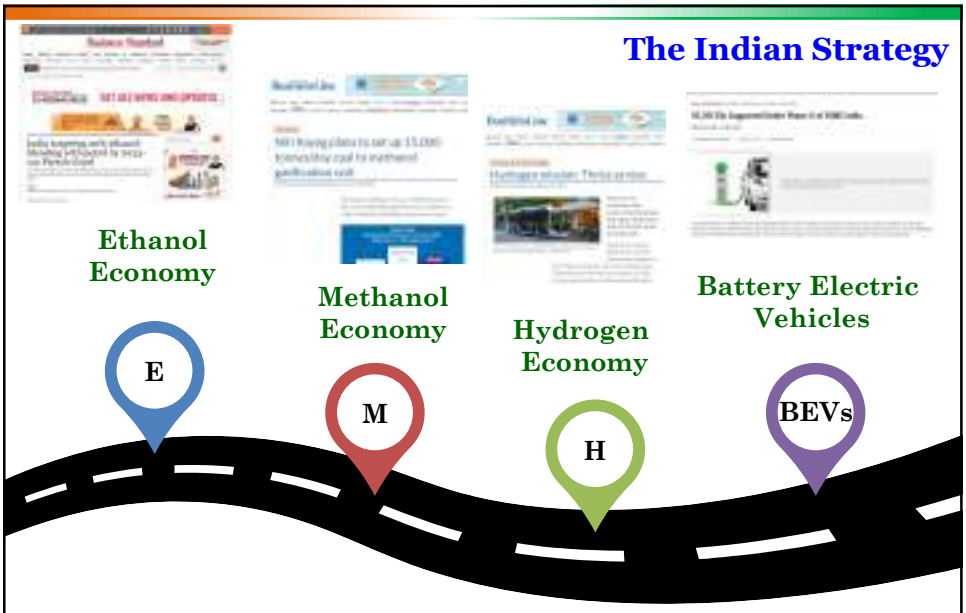
1. Climate impact
2. Energy efficiency
3. Land use efficiency
4. Fuel potential
5. Vehicle adaptation
6. Fuel cost
7. Fuel infrastructure

Evaluation of Fuel Pathways



Reference https://www.wlpga.org/wp-content/uploads/2016/05/4.-Rohan-Cook_Alternative-fuels-for-commercial-vehicles.pdf

The Indian Strategy



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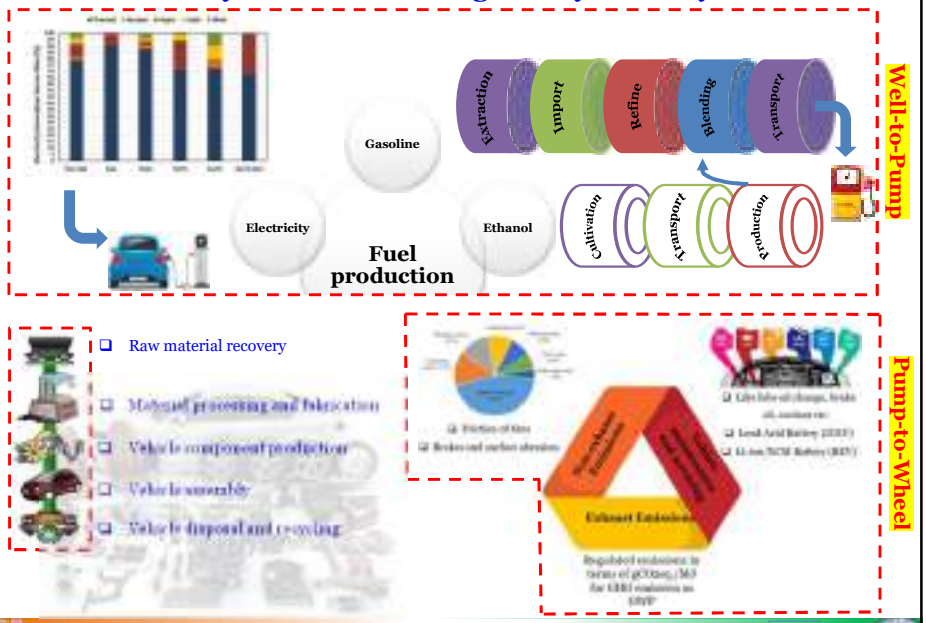
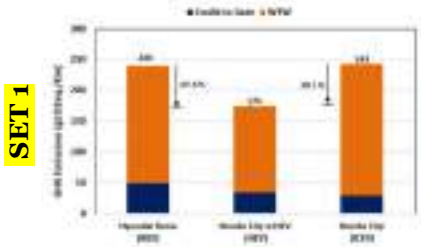
https://www.thehindubusinessline.com/business-tech/hydrogen-mission-thrice-as-nice/article33834355.ece

3. Assessing Sustainability of Transport Fuels

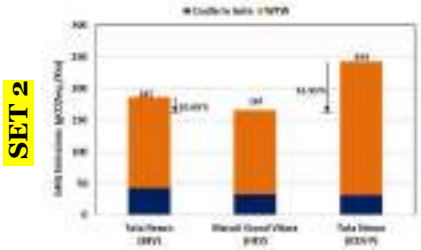
Sustainability Assessment using Life Cycle Analysis (LCA)



LCA Results : For Vehicle Life Cycle (200,000 km)



- Life cycle GHG emissions for HEV was 27.5% lower than BEV and 28.1 % lower than ICEV.
- Life cycle GHG emissions for ICEV and BEV were almost similar.

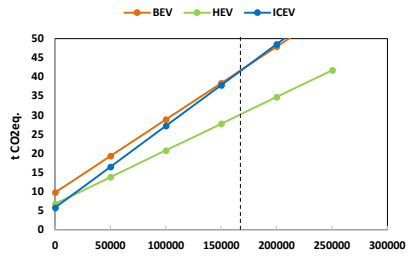


- GHG emissions for HEV were 10.69% lower than BEV and 31.55% lower than ICEV.
- GHG emissions during manufacturing of vehicles was the highest for BEV. For BEV, it was 35.3% higher than HEV and for the ICEV-P, it was 3% lower than HEV.

Cradle to Gate: Manufacturing Stage GHG
WTW: Usage stage GHG

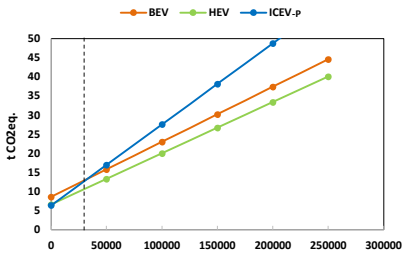
LCA Results: Sensitivity Analysis with annual distance travelled

SET 1: Japanese/ Korean Vehicles



Life Cycle GHG Emissions for Japanese/Korean Vehicles for Distance Travelled

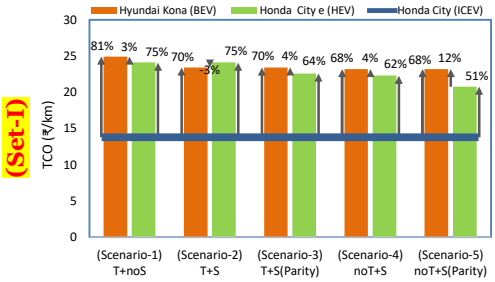
SET 2: Indian Vehicles

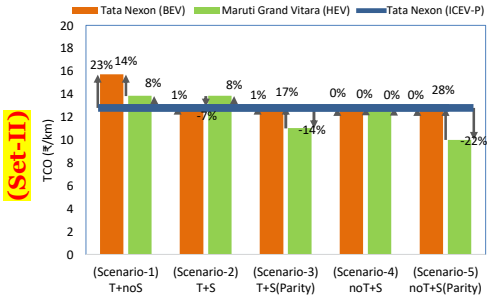


Life Cycle GHG Emissions for Indian Vehicles for Distance Travelled

- SET-I: The total GHG emissions from BEV over the vehicle lifetime were lower than ICEV, only in cases where a minimum distance travelled was more than 165K km.
- SET-II: The total GHG emissions from BEV over the vehicle lifetime were lower than ICEV-P, only in cases where a minimum distance travelled was more than 33 K km.
- In both sets, HEVs emerged to be most environment friendly powertrain technology option.

TCO Results: Different Scenarios (200,000 km)





- **For all scenarios, the TCO of Honda City (ICEV) was the lowest from set-1, showing ICEV to be the most economically viable.**
- **This indicated that if HEV and BEV were given similar subsidies, HEVs would be far more economically viable.**

Overarching Conclusions of LCA Analysis

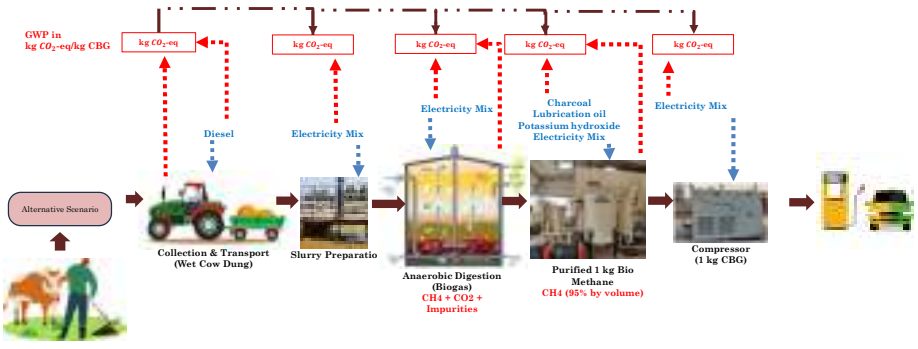
- HEVs turn out to be emitting much lower GHG emissions compared to BEVs and ICEVs, for both Indian and Japanese set of vehicles.
- The sensitivity analysis also does not change this conclusion.
- HEVs have much lower environmental impact compared to BEV and ICEV counterparts and India should promote use of HEVs to move towards the sustainable transport in future to meet its international commitment for net-zero by 2070.
- In both sets, HEVs emerged to be most environment friendly powertrain technology option.
- HEVs operating with E-fuels would be the most sustainable way forward for India.

4. Compressed Biogas (CBG)

CBG Production & Manure Management

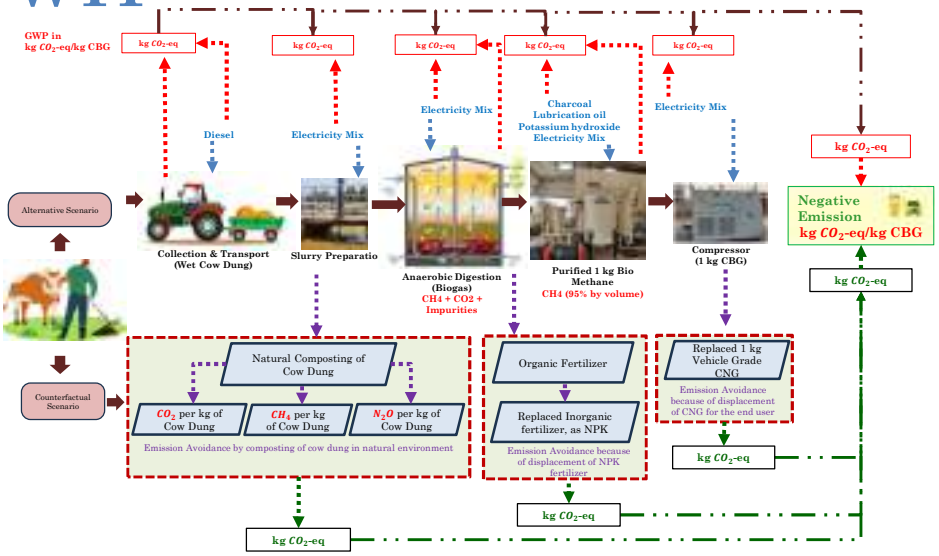
LCA of CBG Production including Avoidance

WTP



LCA of CBG Production including Avoidance

WTP



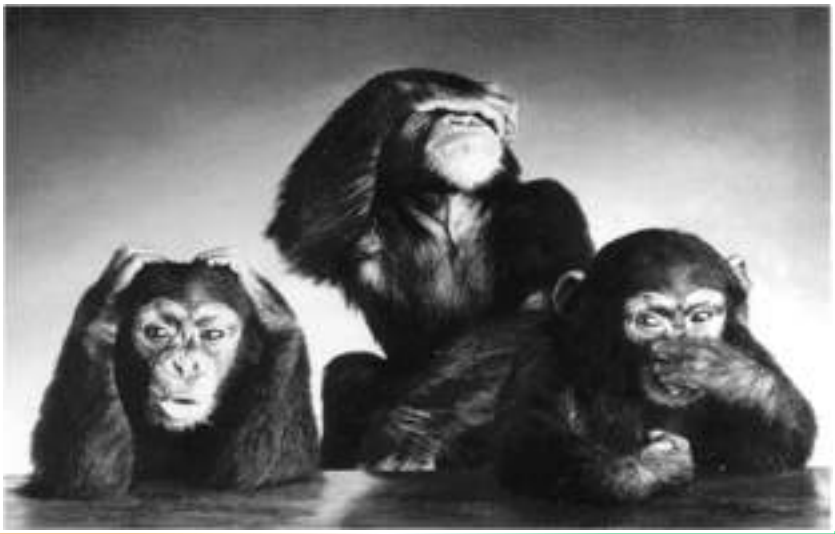
5. Summary

Roadmap for Sustainable Energy Transition

- Higher Penetration of Renewables (Solar, Wind, Hydro, Biomass).
- Setting up CCUS to lower the carbon footprint.
- Access to sustainable, competitive capital to accelerate energy transformation journey.
- Embrace emerging and cleaner fuels such as Hydrogen, Ammonia, DME, Methanol and CBG.
- Utilizing captured CO_2 for green methanol/ DME production.
- Global transport energy demand is large and increasing. There are differant motivations for change in different places.
- Alternatives start from a very low-base, are costly/ inconvenient and cannot grow without constraints, hence need nurturing.
- Up to 2040, most (~ 90%) of transport energy will come from petroleum-fuelled ICEs and then Fuels will start becoming Greener.

- Alternatives need to be assessed on a life cycle emissions basis.
- GHG and other impacts of transport can be reduced only by improving ICEs.
- More diesel and jet fuel needed compared to gasoline.
- Great scope for developing highly efficient engines running on Low Octane fuels on new and unconventional engine technologies.
- Gasoline Compression Ignition (GCI) or Octane on Demand (OOD) engines offer such a prospect.
- All stakeholders need to work together to bring such optimized fuel/ engine systems to the market rather than only developing engines for existing market fuels.
- There will be increasing electrification – mostly hybridization, which will help IC Engines to improve.
- There is no single solution for future fuels. No Silver Bullet.
- There is no perceptible threat to IC Engines for next 30-40 years, however they should become cleaner, greener, meaner, and more efficient.
- Next 30-40 years will see a wider range of vehicle technologies and fuels in developed markets and developing economies.

and finally…. Sustainable world should be hearing no engine sound, seeing no visible emissions, and no smell from emissions …. And it is possible by advancing the engine and fuel technologies. Let's DO IT….



It is all in our hands

Thanks

Jai Hind!
Jai Bharat!

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