April 14th 2021

International Transport Forum Workshop on Decarbonizing Transport in India

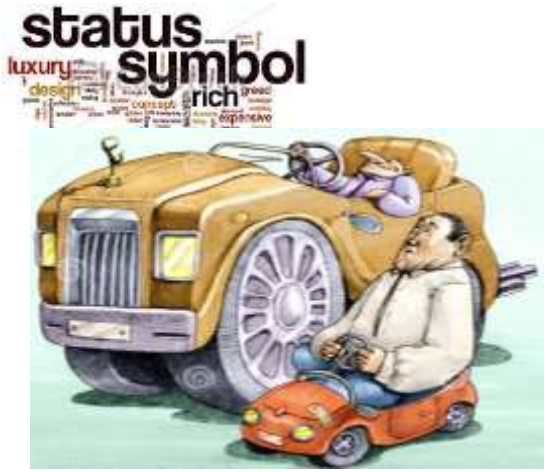
LCA of Lightweighted ICEs and BEVs: An India Perspective

Krishna Upadhyayula

Associate Professor, Chemistry Dept. Umea University, and

Researcher, System Analysis Platform, Bio4Energy Program, SLU, Sweden

The Rise of Automotive Industry in India



From Product of Elite Class

⇨

Affordable by Middle Class

Before 1990's

Now

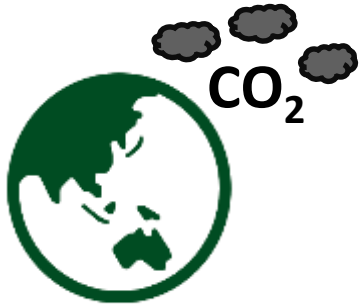
- ✓ **7.1% Contribution to India's GDP in 2017. Increases to 12% by 2026**
- ✓ **Sustained Growth Rate of 7.5% per Year**
- ✓ **Sales Volumes Reaching 10 million units by 2030**

Part of The Big Three

SIAM, 2017

Bigger Benefits Come with Bigger Risks

Three Major Sustainability Challenges for Automotive Industry in India



- ✓ Globally Third Largest Offender in terms of GHG Emissons
- ✓ Transport Sector Responsible for 12% Impact

- ✓ 14 out of 20 World's Most Polluted Cities in India
  WHO Report 2017
- ✓ Passenger Cars: 11% PM and 7% NO_x Emissions

- ✓ $101 billion USD of Crude Oil Imports in 2020
- ✓ Threefold Increase in Oil Demand -280 Mtoe by 2040
  Trading Economics 2020

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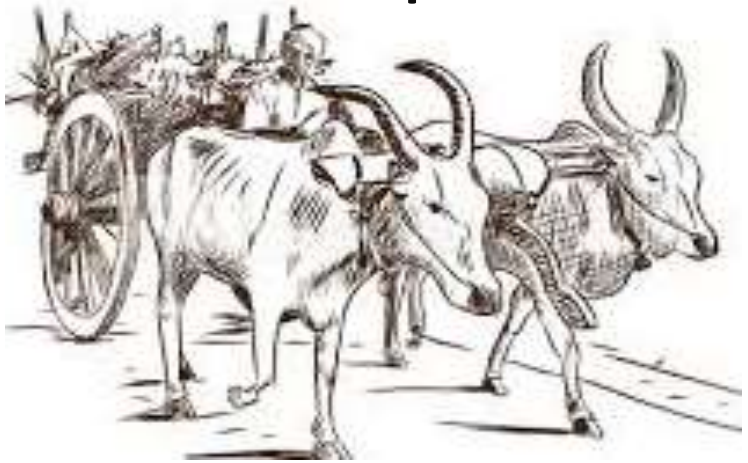
And We Cannot Forget Traffic Congestion Problems

5 kmph



Driving in Urban Areas

Fuel Loss: 1625 Kilo Liters/Year
GHG Emissions: 3899 tons/year
PM_{10}: 9.75 tons/year

Sarath, sim-air.org Study, 2009

Electric Cars Touted as a Cleaner Alternative

EXPRESS DRIVES

CARS BIKES REVIEWS PHOTOS VIDEOS

Auto / Car News

Government finally wakes up: Sets a realistic goal of 30% electric vehicles by 2030 from existing 100% target

EESL had procured 10,000 e-vehicles last year and is likely to issue a new tender in March 2018 for 10,000 more e-vehicles to cater to the growing demand. With these 20,000 electric cars, India is expected to save over 5 crore litres of fuel every year leading to a reduction of over 5.6 lakh tonnes of annual CO2 emission claims Indian Government.

TRENDING

New 2018 Hyundai Santro Review: Can the new Santro bring back the old magic?

Mahindra Marazzo Video review: Why this Mahindra MPV is the best value for money 7/8 seater vehicle

New 2018 Ford Aspire facelift India Review with prices: Should Maruti Dzire, Honda Amaze be worried?

Electric vehicles in India: Govt gets realistic, plans to develop ecosystem first

First came the ambitious target of having all new cars electric by 2030. Then, the about-turn of not needing any policy on electric vehicles. And now, toning down the hyperbole.

BusinessToday.In Last Updated: March 9, 2018 | 08:59 IST

The Indian EXPRESS

Sunday, November 11, 2018

Home India World Cities Opinion Sports Entertainment Lifestyle Technology Viral Parenting Photos Videos Audio ePaper

Home › India › All electric cars by 2030? Nitin Gadkari inaugurates EV charging points at Niti Aayog

All electric cars by 2030? Nitin Gadkari inaugurates EV charging points at Niti Aayog

In a bid to go green, the government is targeting the year 2030 by which it plans to go all-electric in terms on new car sales across India. In a step towards its mission, Union Minister Nitin Gadkari inaugurated Electronic Vehicle (EV) charging points today.

Long road for Tesla in India with infrastructure, supply chain woes

It's also difficult to see how Tesla's sought-after and expensive autonomous driving features will work on India's congested roads

Reuters • January 22, 2021, 16:11 IST

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Business News › Industry › Auto › Auto News › View: Indians will plug into electric vehicles—if these barriers are knocked down first

View: Indians will plug into electric vehicles—if these barriers are knocked down first

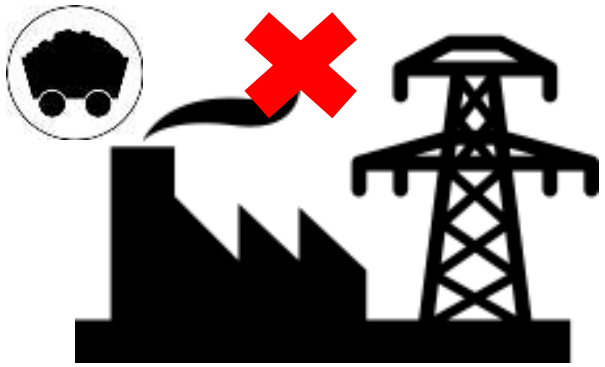
By Akash Gupta, ET CONTRIBUTORS • Last Updated: Mar 16, 2021, 06:40 PM IST

Synopsis

It's clear that the Indian automotive industry is experiencing a disruption. Electrification is leading the way and could have a huge impact on auto OEMs and auto component manufacturers. India is paving the way for EVs and their technologies by announcing its plans for the decade ahead. The country is focused on reaching a high level of EV adoption by 2030.

For India, Is Electro Mobility a Sustainable Solution?

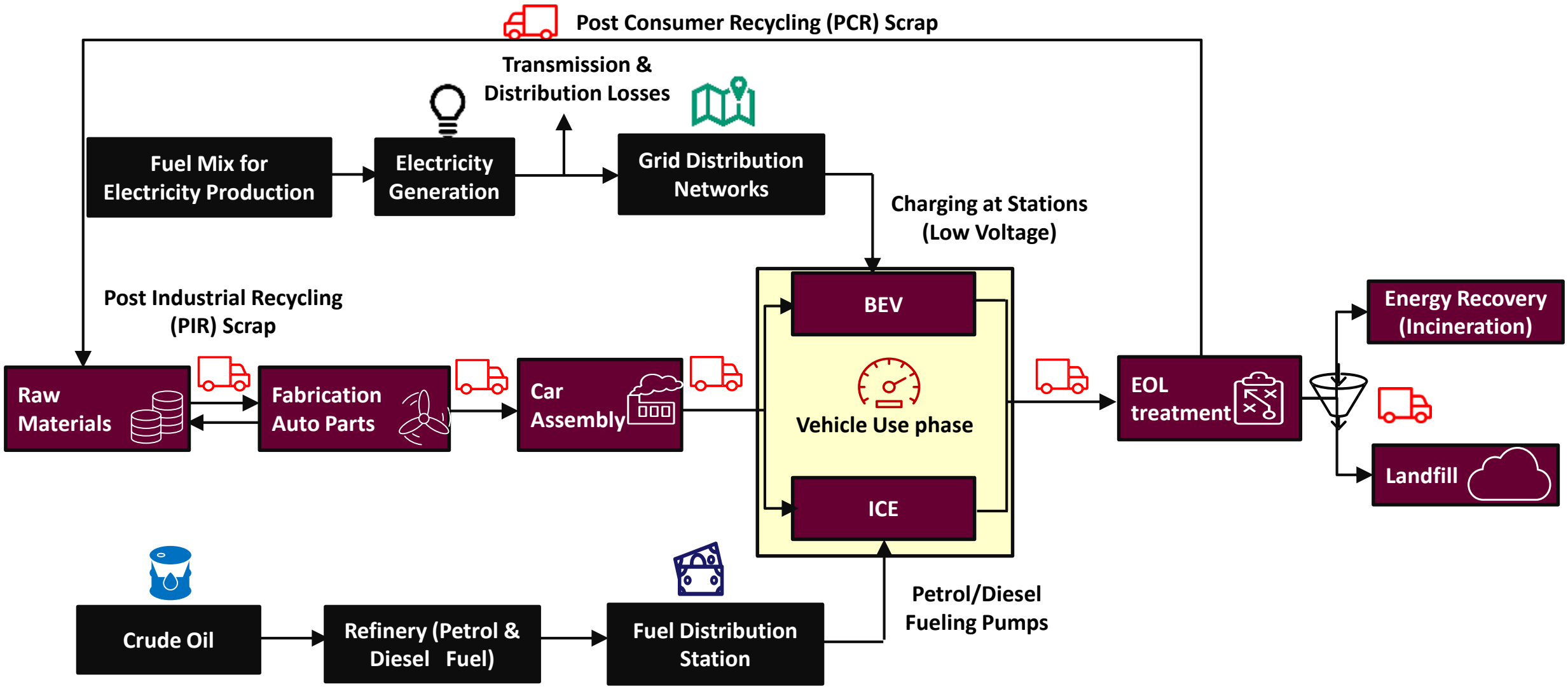
Coal Intensive Electric Grid
Increase GHG Emissions



Reduced Foriegn Oil Dependency

Improved Urban Air Quality

LCA of Lightweighted ICEs and BEVs



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Env. Performance of a Passenger Car Driven for a Lifetime Distance of 150,000 km in 15 Years

Key Modeling Parameters

Material	Regular ICE		Lightweight ICE		Compact BEV		Sub Compact BEV	
	Wt. kgs	Wt.%	Wt. kgs	Wt.%	Wt. kgs	Wt.%	Wt. kgs	Wt.%
Steel	770	66%	57	7%	781	53%	660	59
HSS	80	7%	244	30%	81	6%	70	6
Plastic	75	6%	162	20%	76	5%	75	5
Aluminum	55	5%	187	23%	56	4%	55	7
Battery	0	0	0	0	294	20%	120	11
Others	180	16%	162	20%	183	12%	140	12
Total	1160	100%	812	100%	1471	100%	1120	100%
Others include: Fluids, Glass, Copper, Elastomers and not included in the model								

Fuel Economy for ICEs	
Petrol Cars	16 km/lit (based on avg of 12 variants)
Diesel Cars	22 km/lit (based on avg of 16 variants)

IEA Report 2015

EV Charging Mix	
Current (2018)	71% Fossil (**60% Coal**) and 29% Renewables
2030	56% Fossil (**44% Coal**) and 44% Renewables

Key Modeling Parameters: Fleet Level Impact Estimation for 2030

$$FEI_{C2030} = N_{V2030} \times \left[\frac{VKT_{2030}}{Car} \left(\frac{EID_{C-2030}}{km} + \frac{EIEA_{C-2030}}{km} \right) \right]$$

FEI_{C2030} = Fleet Level Env. Impact for Year 2030 for impact category "C" (GWP in tons CO_2 eq; Fossil Depletion in Million Barrels of Oil; and Air Pollution in tons PM_{10} eq.)

N_{V2030} = No.Vehicles on Road (in 2030) = 69 million units (7.4% growth rate & 10 years retirement age)

$\frac{VKT_{2030}}{Car}$ = Vehicle kilometers travelled per car in 2030 (Avg. 10,000 km/year)

$\frac{EID_{C-2030}}{km}$ = Env. Impact of Driving a Car per km. (GWP or Oil Consumption or PM_{10})

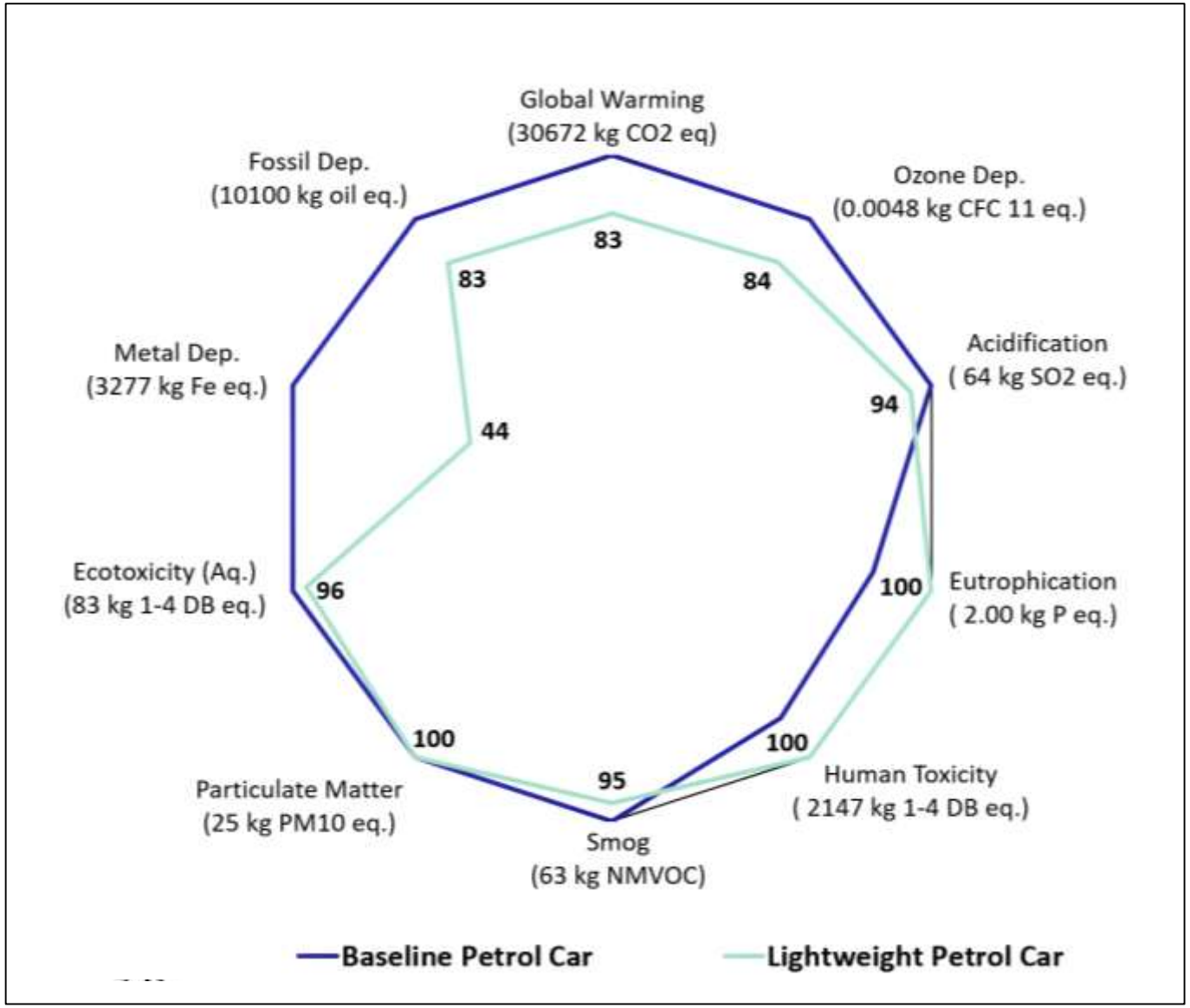
$\frac{EIEA_{C-2030}}{km}$ = Env. Impact of Attributed to Ageing (Only for GWP @ 10 $\frac{g}{km}$ for every year aged)

Key Modeling Parameters: Vehicle Fleet in 2030

Total Projected Vehicles on Road in 2030				
Scenario Type	**Petrol (P)**	**Diesel (D)**	**EV**	**Scenario Description**
Business Usual	41366257	27577504	0	60% P + 40% D
Conservative EV	41366257	13788752	13788752	60% P+20% D+ 20% EV
Moderate EV	34471880	10341564	24130316	50% P+15% D+35% EV
Agressive EV	34471880	0	34471880	50% P+50% EV

Scenarios are Proposed Based on Gradual Phaseout of Diesel Cars Plus Gradual Introduction of BEVs

LCA Results of Regular *Versus* Lightweighted Petrol Car



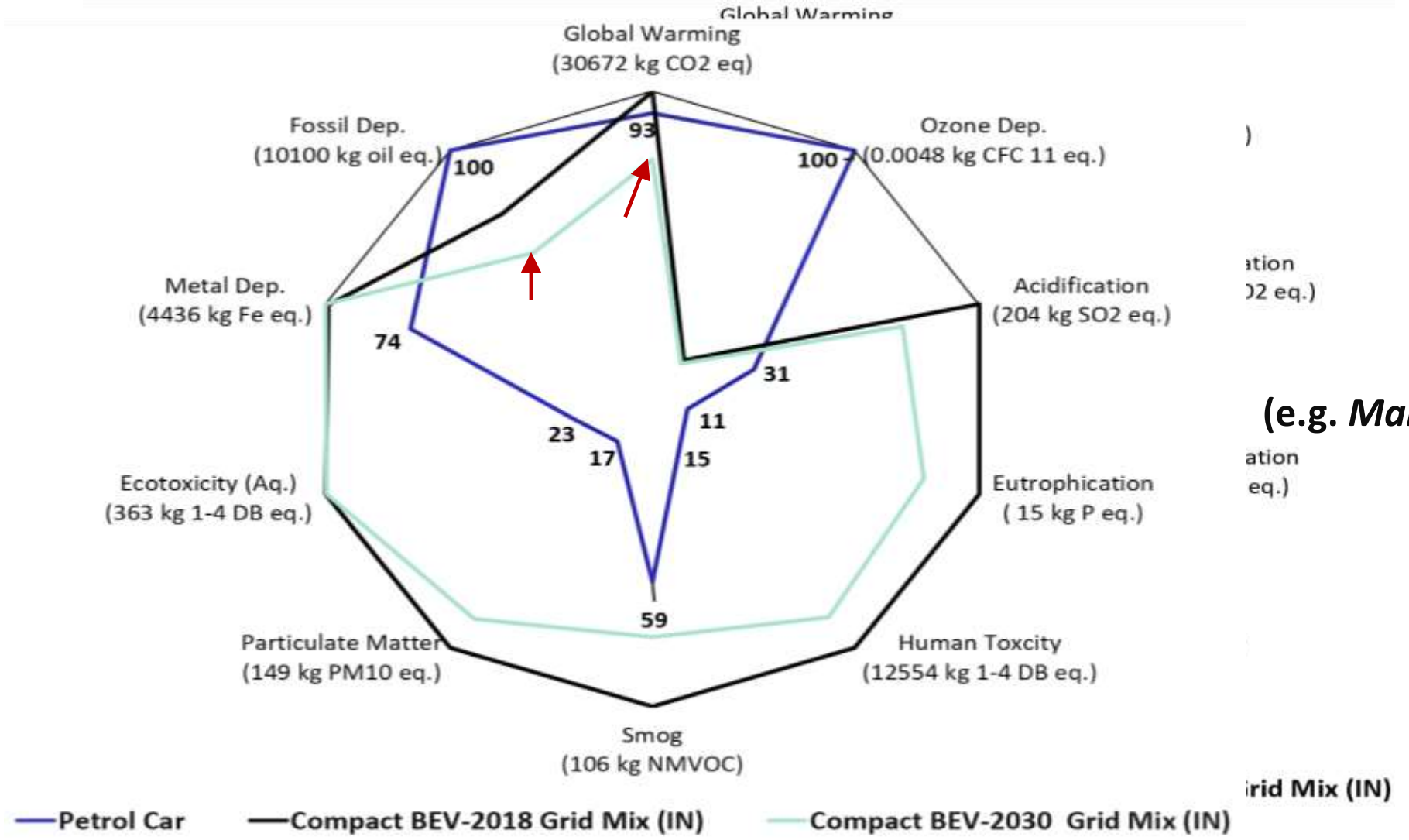
Lightweight ICEs (Major Benefits)

- 17% reduction in GWP, Ozone Depletion and Fossil Depletion Impacts
- 54% reduction of Metal Depletion Impact

Lightweight ICEs (Tradeoffs)

- 5-10% Higher Eutrophication and Human Toxicity Impacts

LCA Results of Petrol Driven *Versus* Electric Operated Car in India



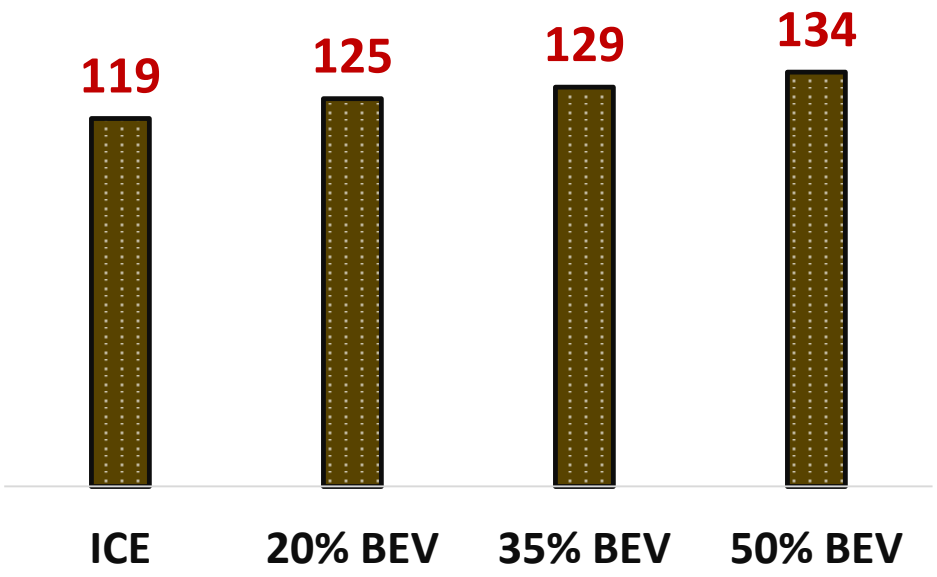
Compact BEVs
BEVs (e.g. *Nissan Leaf*)
(e.g. *Mahindra e2O, Mitsubishi iMiEV*))

- ✓ Except for Ozone Dep, Petrol Car Performs Better than BEVs in Other Impact Categories
- ✓ GWP and Fossil Dep. Lower than Petrol Car with 2030 Grid Mix
- ✓ Fossil Dep of BEVs Lowered with 2030 Grid Mix Poor Overall Env. Performance
- ✓ Other Impacts Lower than Regular BEVs but Still Lower than Petrol Car

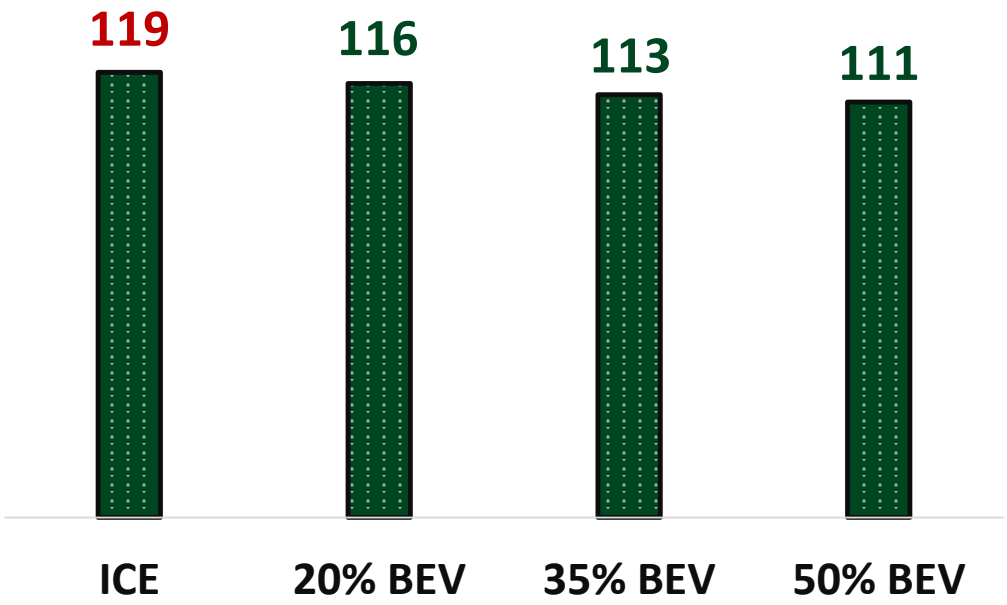
2030 Fleet Level Assessment Results

Fleet GHG Emissions (MMT CO_2 eq.)

Regular BEV Penetration



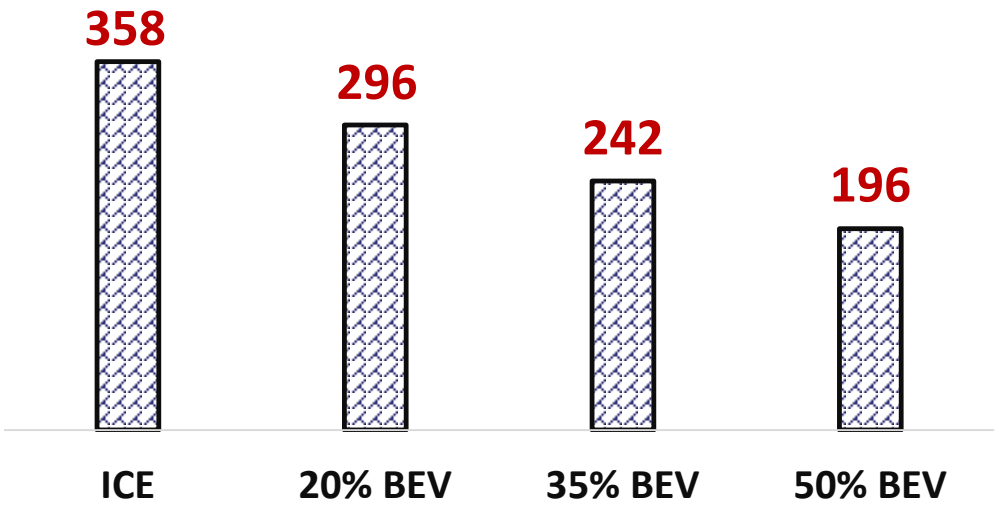
Compact BEV Penetration



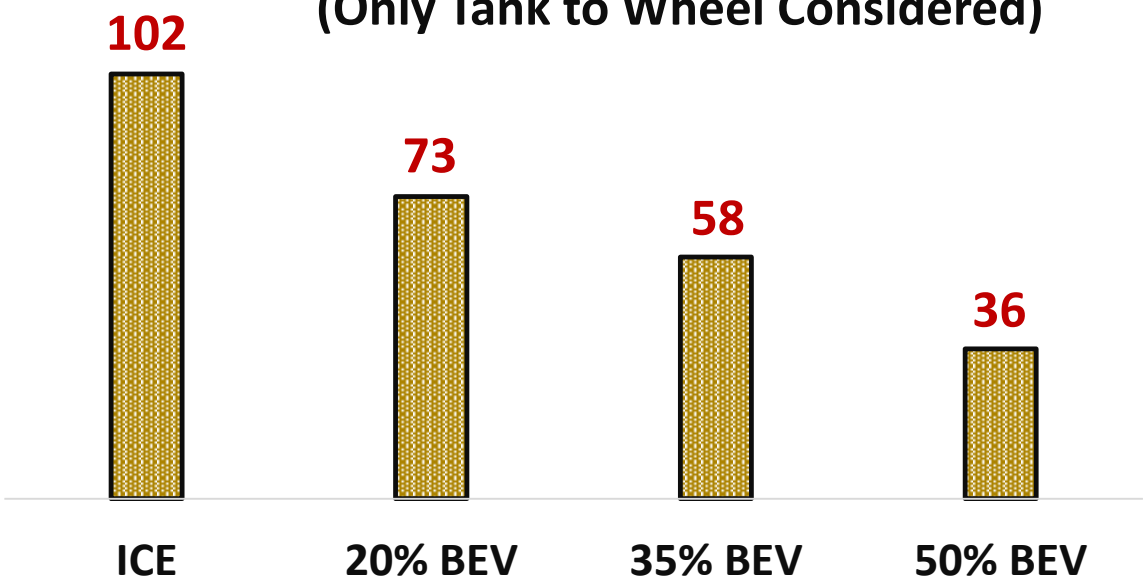
Compact BEV Option: GHG Friendly for India

2030 Fleet Level Assessment Results

Fleet Oil Consumption (Million Barrels)



Fleet Particulate Matter (kilo tons PM_{10} eq.) (Only Tank to Wheel Considered)



Conclusions

- ✓ Lightweighting ICEs is a Short Term and Compact BEVs a Long Term Sustainable Solution
- ✓ BEVs Reduce India’s Oil Dependency and Air Pollution in Urban Areas.

Some Future Insights: Talk to Industry In Terms of Total Costs

AHSS BIW (235 kg)

MS BIW (280 kg)

CFRP BIW (140 kg)

Business As Usual

Mfg. Costs (Private Cost)

Lifetime Operation of 200,000 km

Mfg. Costs (Private Cost)

Fuel Cost to Consumer

Fuel Cost to Consumer

Environmental Impacts (LCA)

Unit Externality (€/Impact)

SROI

Total Externality Cost of BIW (€)

SROI

Some Future LCA Insights for India: Talk to Industry In Terms of Total Costs

$$\text{SROI} = \frac{\text{Reduction in Fuel Consumption \& Env. Externality Costs from Baseline}}{\text{Body in White (BIW) Manufacturing Cost}}$$

MS BIW Replaced with	Fuel Used for Operation	Mfg. Cost to OEM (€)	Social Costs (€)	SROI (€/€)
None (Baseline)	Gasoline	882	3663	0
AHSS BIW	Gasoline	941	3167	0.52
AHSS BIW	E-85-Wood	941	1828	1.94
AHSS BIW	E-85-Corn	941	2426	1.31
AHSS BIW	Electricity-RER	941	908	2.92
CFRP BIW	Gasoline	1464	1863	1.22
CFRP BIW	E-85-Wood	1464	1147	1.71
CFRP BIW	E-85-Corn	1464	1454	1.50
CFRP BIW	Electricity-RER	1464	797	1.95

- **High SROI for AHSS BIW with Wood Biofuel and Electric Cars**
- **High SROI for CFRP BIW with Gasoline and Corn Biofuel Driven Cars**

Shanmugam et al., ACS Sust Chem. Engg. 2019, 7, 4951-4963

Some Future LCA Insights for India: Account for Regionalization

Particulate Matter Impact Assessment

- ✓ **Current Methods (e.g. ReCiPe)**
  - No Differentiation Between Emissions of Mobile and Stationery Sources (PM < 10 µm = 0.228; PM < 2.5 = 1)

- ✓ **Fractional Intake Approach**
- ✓ Differentiates Emissions from Mobile and Stationery Sources
- ✓ Differentiates Stationery Source Emissions Based on Stack Height
- ✓ Scope for Inclusion of Regionalized Factors.

Humbert et al, ES&T. 2011, 45, 4808-4816

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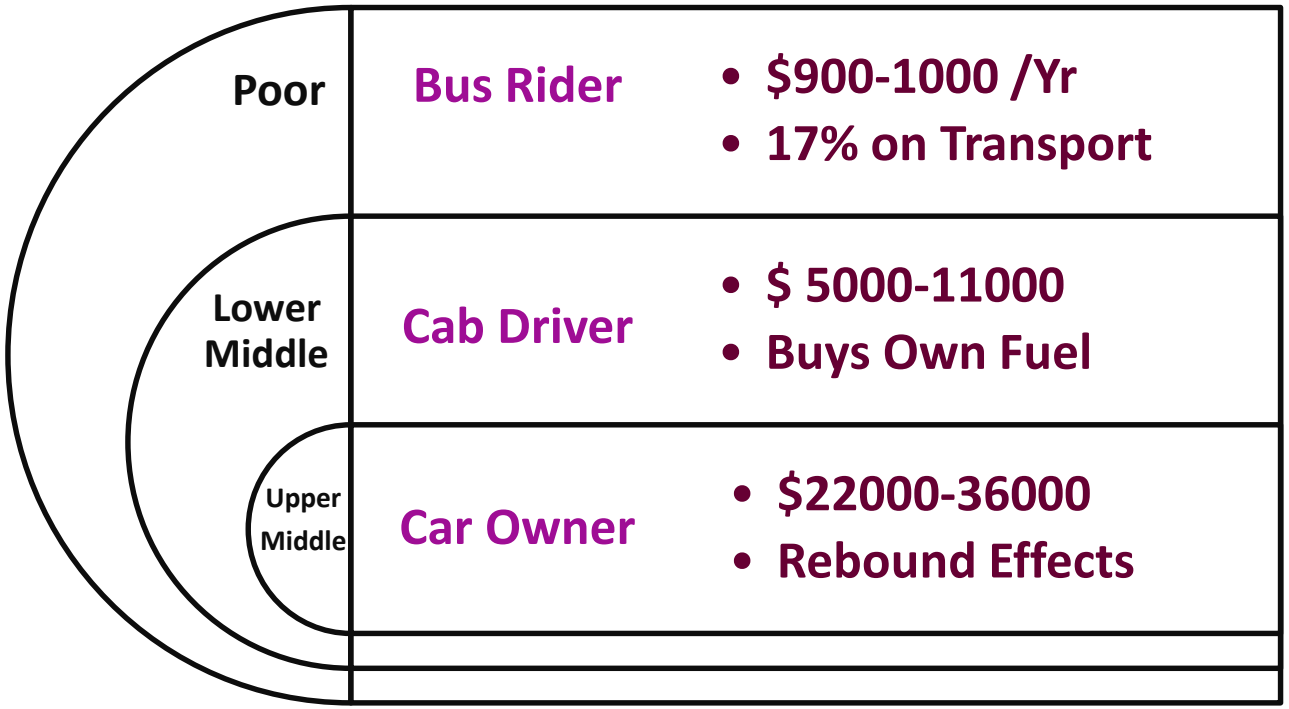
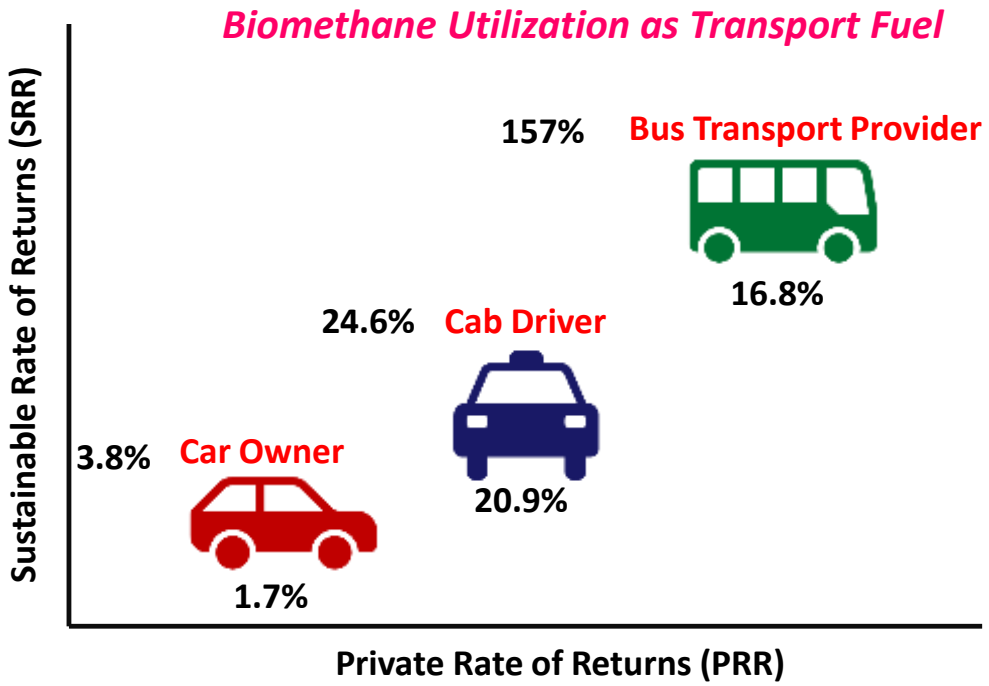
Some Future LCA Insights : Sustainability Goals Also Should Target Social Welfare





$$Private\ Returns\ Ratio\ (PRR) = \frac{Fuel\ Savings}{Annual\ Income_{Person}}$$

$$Sustainable\ Returns\ Ratio\ (SRR) = \frac{Fuel\ Savings + Savings\ on\ Env.Ext.\ Costs}{GDP_{PPP}}$$

Shanmugam et al., *Sustainability*. 2019, 11, 4190.

Questions?

Krishna.Upadhyayula@umu.se ;
krishna.Upadhyayula@slu.se

Acknowledgements to All Co Authors & Collaborators

- Abhijeet G. Parvatker, Sphera, USA
- Anju Baroth, Wildlife Inst of India, Dehradun, India
- Sachin Nande, Tata Motors (Now Eaton)
- Kavitha Shanmugam, Umea University, Sweden