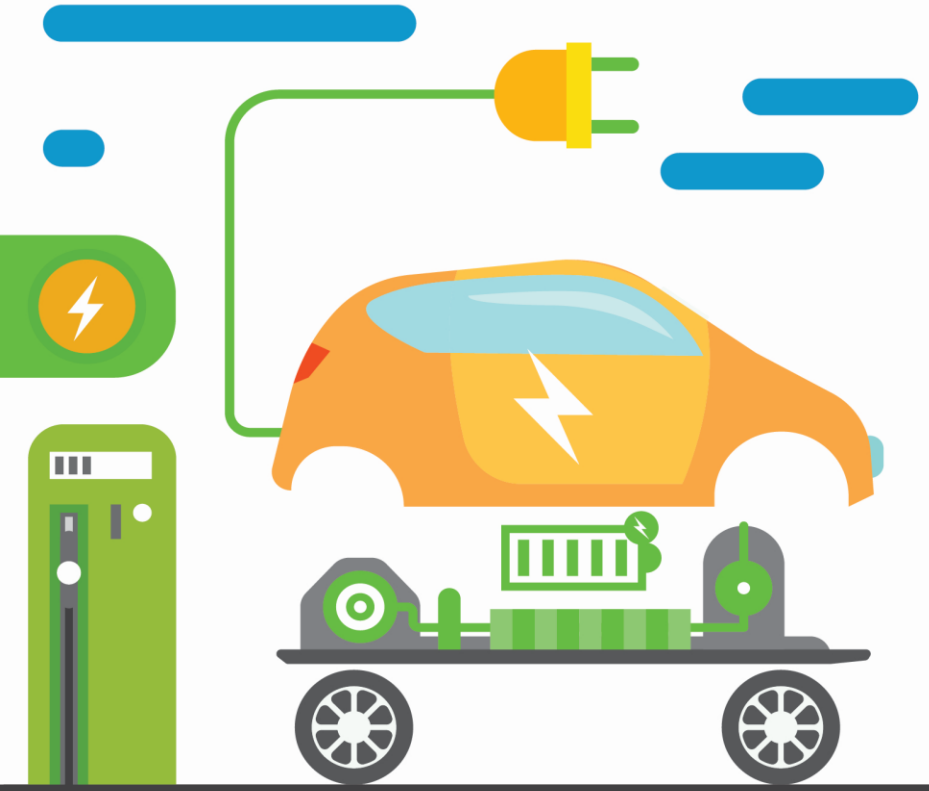

ELECTRIC MOBILITY FORUM

ENGAGE
Connecting Big Ideas To Action

RETROFITTING FOR ELECTRIC VEHICLES

Status, Potentials and Challenges

WRI INDIA — ROSS CENTER

SHAKTI SUSTAINABLE ENERGY FOUNDATION

Speakers:

Nakul Kukar
CEO & Co-founder
Cell Propulsion

Shalendra Gupta
CFO & Co-founder
Altigreen Propulsion Labs

Moderators:

Dr Parveen Kumar
Senior Manager
WRI India

Shravani Sharma
Project Associate-
Electric Vehicles, Policy and Infrastructure, WRI India

ALTIGREEN
DRIVE ELECTRIC

EV Retrofits

A Webinar

July 29, 2019

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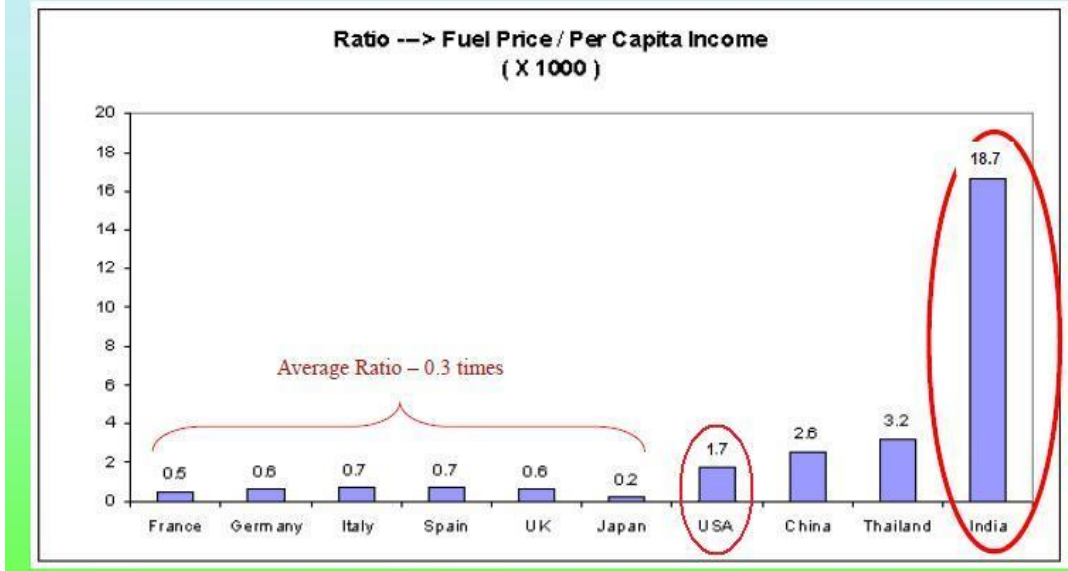
Customer's Needs
- Financial goals
- Sustainability goals
- Vehicle end-of-life

Society's Needs
- Public health
- Climate change

Government's Needs
- GDP growth
- Crude oil consumption
- ForEx conservation
- Carbon intensity of development

Industry's Needs
- Leadership position
- Inevitability

Fuel Price / Capita Income



- In India Fuel price as a Pocket Pinching factor is highest.
- Hence , it is already a strong competitive development parameter

SOURCE : Fuel Price - Internal SIAM Data

Fuel is Expensive

"Rising fuel costs have forced us to make major design changes. Like the in-dash ATM, in case you run out of gas money."

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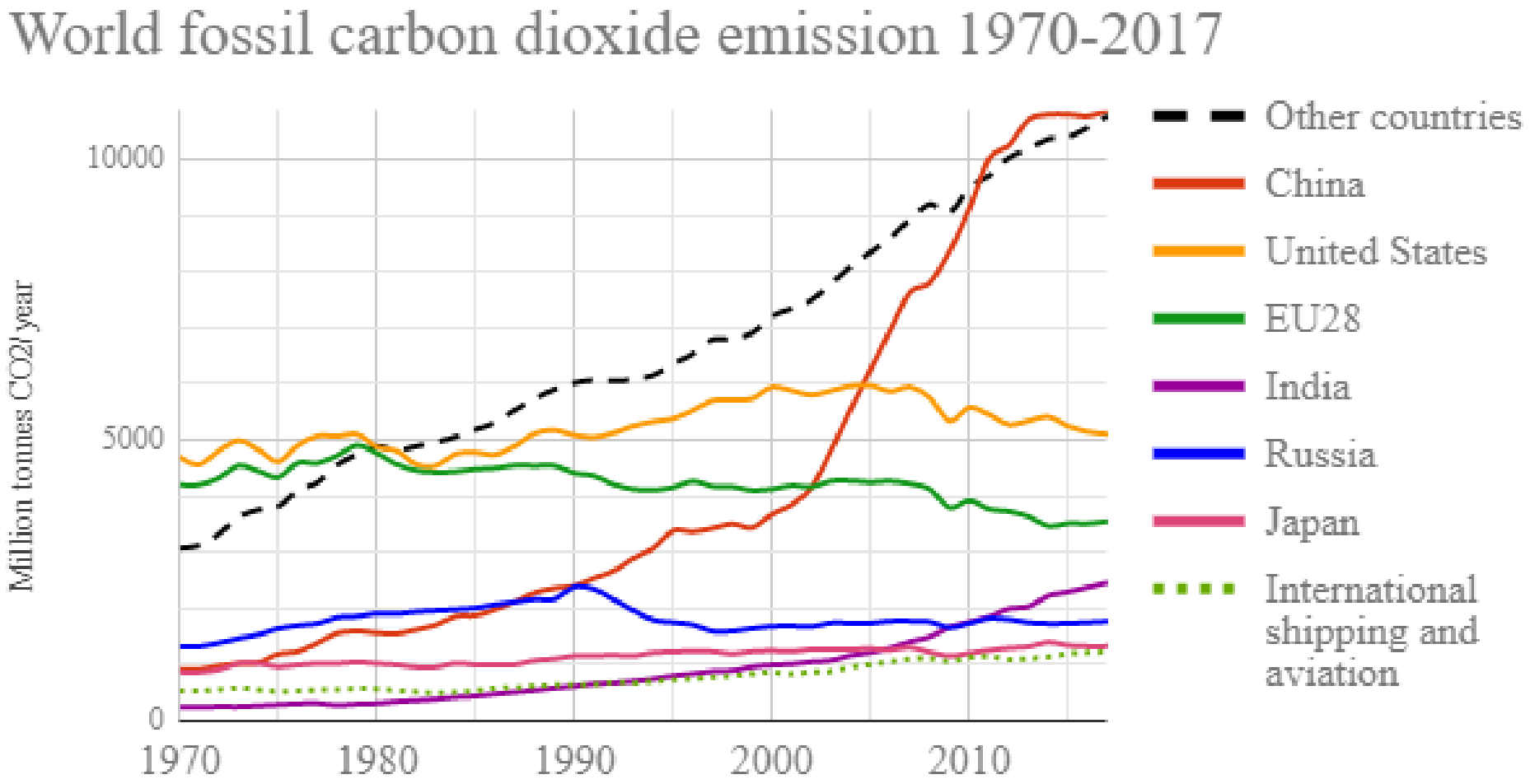
Contributions to Global Warming



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Hard Facts

- 1,200,000 – Premature deaths in India due to outdoor air pollution, each year
- 25% – Share of road transport in air pollution, including GHGs
- 14 of Top 20 Worst Polluted Cities of the World are in India
- Millions – Others suffering from severe to mild ill-health due to air pollution
- 5% – GDP impact of air pollution
- 85% – India's crude oil imports as percentage of consumption
- 2x to 5x – Amount of emissions from older vehicles, compared to new vehicles

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Types of Retrofit

Hybrid Electric: In which the electric drivetrain is added to an existing vehicle and supplements the internal combustion engine to create a (P)HEV.

- Regulated by AIS-123 Parts 1 and 2
- This is usually a ‘torque-assist’ system

Full Electric: In which the electric drivetrain replaces the internal combustion drivetrain in an existing vehicle to create a BEV.

- Regulated by AIS-123 Part 3

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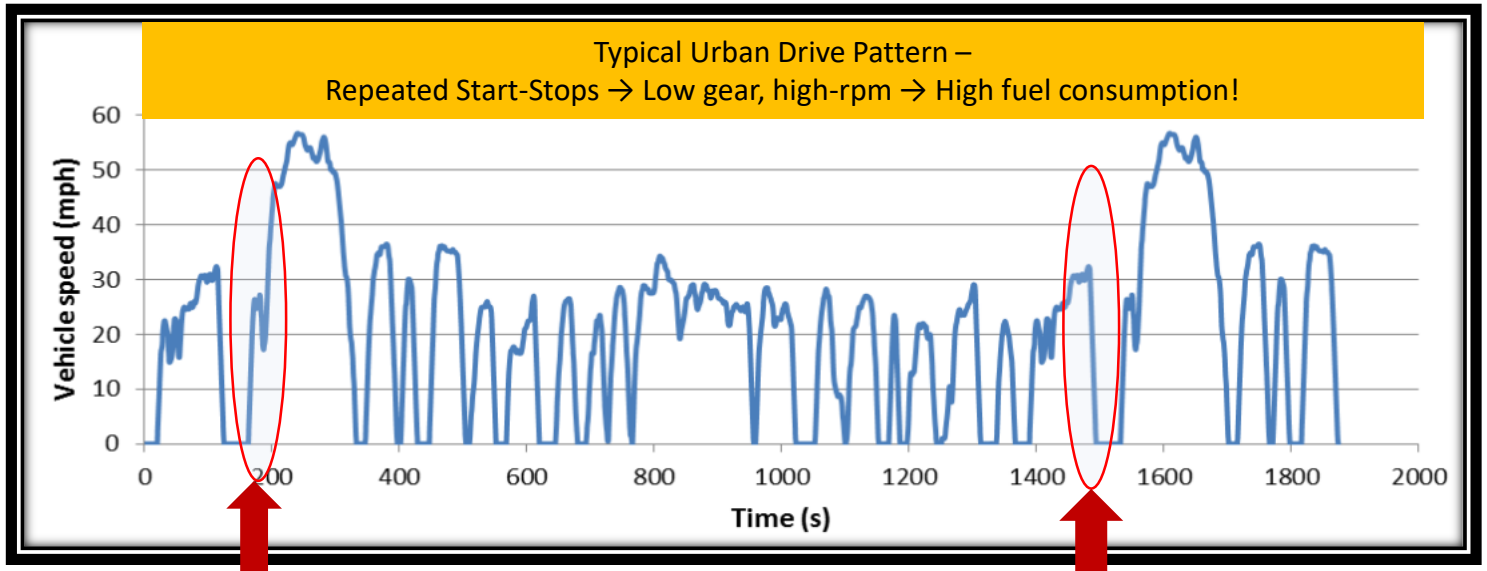
How It Works



During acceleration:

Altigreen's motor intelligently assists engine at just the right moments -

- Engine needs to generate less torque
- Lowers engine RPM → **saves fuel**!

During braking:

Altigreen's motor becomes an electrical generator (regeneration) -

- Converts waste energy to electricity,
- **Saves energy in battery system**.

1. Saved battery energy drives motor.
2. No need for external charging infrastructure!

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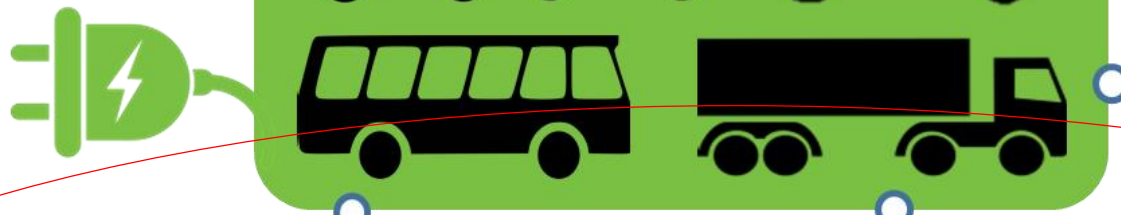
Retrofit Components

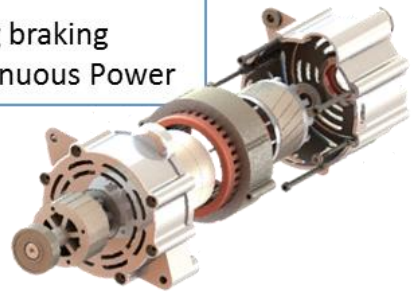
Real-Time Monitor
- Driver & Fleet aid
- USB, SD Card & OBD
- GPS/GPRS
- Mobile App

Battery Pack (48V – 450V)
- Li-ion, UCaps, or Lead Acid

EV Gearbox
- Single & 2 Speed

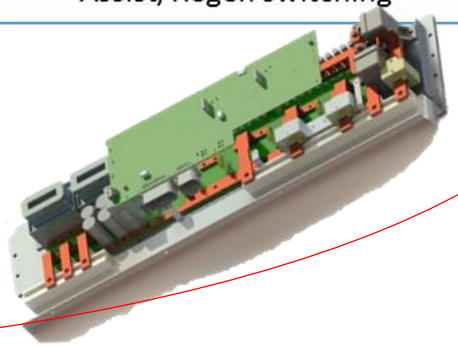


Integrated Motor/Generator
- High RPM, Torque
- Regeneration during braking
- Wide Band for Continuous Power



Robust Wire Harness
- Protected against high temp and environment
- Separation between signal and power lines

Drive Controller
- AC/DC & DC/DC Converters
- BMS with active balancing
- 48V & 12V SOC monitor
- Assist/Regen switching



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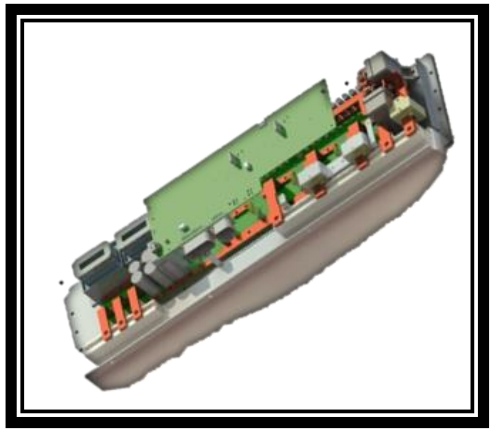
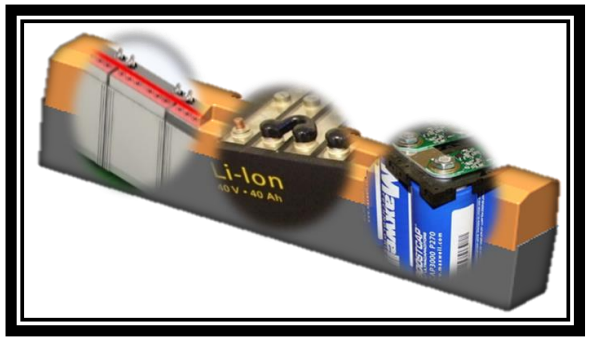
Key Components





Motor-generator:

- Replaces the existing alternator in the vehicle.
- Motor to assist engine
- Powers aux 12 V loads
- Charges battery during braking via regeneration.

Controller:

- The ‘brain’ of the system.
- Ensures motoring and regeneration occur at precise moments.
- Manages battery charging / discharging

Battery pack:

- Saves energy during braking.
- Delivers energy to motor during acceleration.
- Ultra-caps / Lead Acid / Li-ion

2W, 3W, 4W, …

Global recognition

- HyPixi^{TM} awarded 19 global patents
- Patented in 60 countries including USA, Europe, Africa, SE Asia, Australia.
- Recognized as a unique retro-fitment solution globally.

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Challenges of Retrofits

Technical
- Adequate power
- Marriage of 2 drives
- Regenerative braking
- Storage tech

Financial
- Cost of product
- Cost of fuel as proportion of total cost of operations

Regulatory / Policy
- Homologation – by model, variant and year
- State-level approvals
- Government support

2W, 3W, 4W, …

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Challenges of Retrofits (contd)

Customer acceptance

- Certainty of benefit
- Peace of mind
- Cost
- Reversibility

Safety

- Vehicle balance / structure
- Fire
- Explosion
- Catastrophic failure

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Examples from Altigreen Retrofits

Maruti Suzuki Swift Dzire	
OEM Mileage (km per litre)	17.4
Hybrid Distance Covered (km)	71,386
Hybrid Mileage (km per litre)	21.7
% Improvement in Mileage	**25%**

Toyota Etios	
OEM Mileage (km per litre)	10.5
Hybrid Distance Covered (km)	30,000
Hybrid Mileage (km per litre)	13.7
% Improvement in Mileage	**24%**

Tata ACE Facelift BSIV	
OEM Mileage (km per litre)	8.64
Hybrid Distance Covered (km)	6,334
Hybrid Mileage (km per litre)	10.49
% Improvement in Mileage	**21%**

Tata ACE BSIII	
OEM Mileage (km per litre)	11.3
Hybrid Distance Covered (km)	11,112
Hybrid Mileage (km per litre)	13.8
% Improvement in Mileage	**22%**

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Status and Future

Possibilities: Enormous – a market size of millions of vehicles

Status: Embryonic – less than 500 retrofits so far

Future: To be determined

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Thank You!