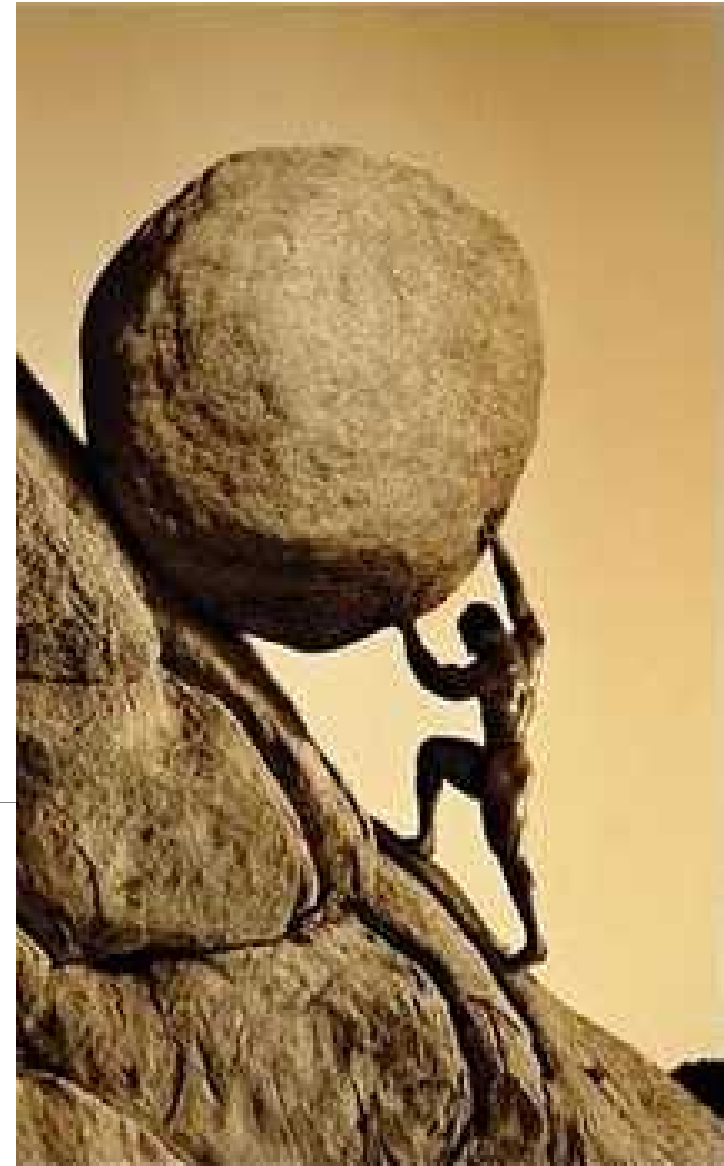


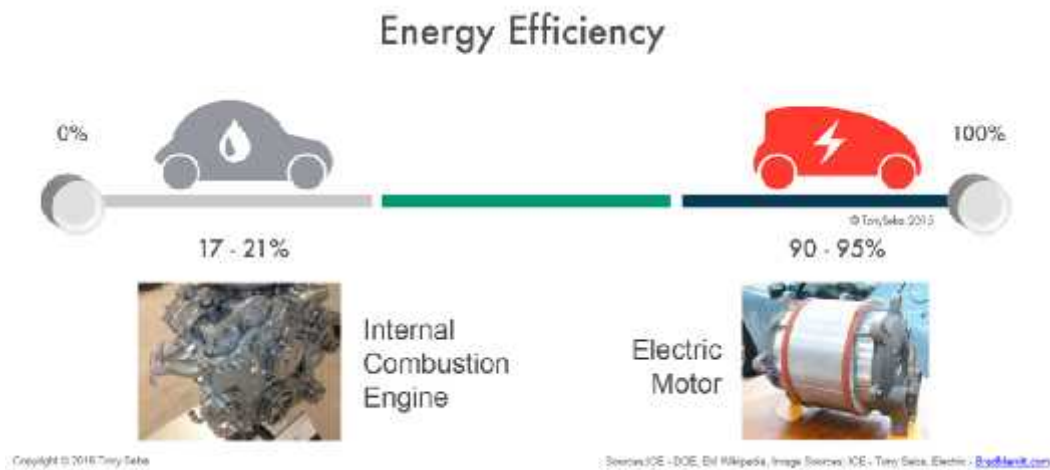
Driving Electric Vehicle program for India

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EV is the future & Connected Transport

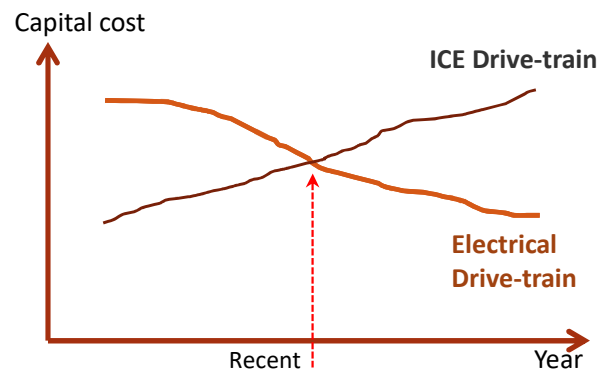
- Electric Motor: 5 times more energy efficient as compared to IC Engine
- Electric Vehicles are far more Reliable
 - Have 100X fewer moving parts



ICE (Gas) Vehicle	Electric Vehicle (EV)
2,000+ moving parts (1)	18 moving parts (1)
	
EVs 10X-100X cheaper to maintain!	

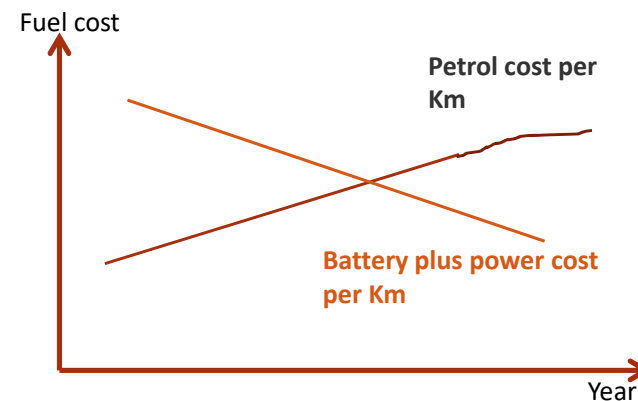
Transmission, driveshaft, clutch, valves, differentials, pistons, gears, carburetors, crankshafts

EV Costs in Volumes



- Cost of Electric Drive Train lower than that of ICE Drive-train
 - EV costs driven by R&D, Moore's law and SW
 - Gap to widen year after year

Battery should be treated as fuel



- Battery cost per Km (depreciation, interest and charging) lower than Petrol
 - for taxis and buses (200,000 kms in 5 years), but not for personal transport
 - R&D drives down battery costs continuously



- Storage Costs falling rapidly
 - Will make EV capital cost (including battery) lower than that of ICE Vehicle in near future

EV Storage will also enable grid-balancing

- Promote use of power during off-peak times
- Will help Renewables grow

But do we have enough Electricity in India?

- 200M vehicles like to grow to 330M by 2030
- Even if thermal power was not available
- Solar panels on 0.5% of Rajasthan can generate all power required by 330M vehicles

Pollution

- EV with Renewable Energy: ZERO pollution
- EV with coal plant
 - no tail-pipe emission, ZERO CO, HC, NOx, PM
 - CO₂ emission less than that for petrol and diesel vehicles

And Naturally Connected

Large Opportunity

Auto Industry

	Today	2030 estimate
GDP	7.1%	\$350 billion
Oil Bill	\$80 billion	\$160 billion

- 50% to 70% of BOM for EV is different: new supply chain of over \$175 billion needed
 - Motors, controllers, batteries, chargers, dc-dc converters, electric brakes, electric air-conditioning, high efficiency Transmissions, light weight material

EV will happen in India too!

- But will India land up importing EVs, subsystems and batteries instead of oil in future?
- Or will India drive its EV program and Manufacture EVs and most subsystems in India?
 - driving Make in India (Huge employment) and leveraging Innovation and Start-up (Start-up India)

Innovation and R&D

- Have to develop technology which will be **usable and affordable** in Indian context and take it all the way to commercialisation at scale
 - Products must make economic sense in India and not depend on subsidies

R&D in select areas to drive performance and affordability

- Motors and drivers: **reduce kW/km power usage**
- Battery: Cells, cells to pack, Battery engineering, BMS, Converters
- Battery Chargers and Battery swapping
- Air-conditioners (electric powered)
- System **Controller and software**, Intelligent controls and integrated Electronics, Light-weight materials and Telemetry, wireless charging

Early program

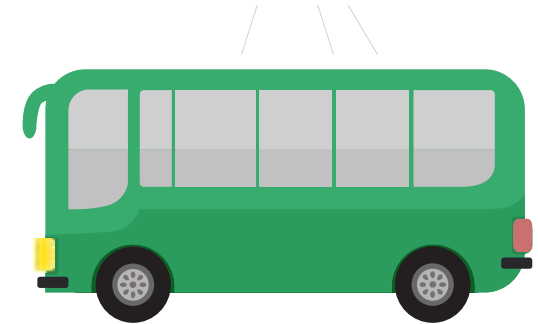
- Define Public Battery Charger Specs for 2/3/4-wheelers and get it developed
 - Support some 500 Public Chargers each in some 10 cities
 - Going forward, ensure that Charger installation is viable business and proliferate using STD-PCO model
- Get Government to hire only EV four-wheelers
 - Encourage taxis (say Ola / Uber and others) to adopt EV taxis



- Work out technical specs and financial models for leasing 3-wheelers
 - get 100,000 three-wheelers in a city and lease vehicles on daily rental
- Define Specs for Battery Swappers and rent batteries on km usage basis
 - Can be also used by 2-wheelers
 - start in parallel in other cities with some lag

Zero-rate GST for all EVs and EV sub-systems for three years rather than providing subsidies





Intra-city buses with Battery Swapping

- Drive capability of 40/ 50 kms from depot to depot (to keep battery costs low)
 - with battery swapping at depots
 - Work out business models for buses leased to operators
 - Start with 2 cities and expand to others

In 2 to 3 years

- Expand the program to some 50 cities and towns
- Electric two-wheelers, autos, cars and buses can become financially viable
 - Set the stage for acceleration as EVs is accepted as Future

Stage set for large scale Manufacturing

Batteries



- Cell to pack (25% value): early production in India
 - Can expand to several hundred start-ups
- Cell manufacturing (75% value)
 - Chemistry changing rapidly: Manufacturing plants must adopt to new Battery Chemistry with minimal additional capital

Motors

- Would drive up vehicle efficiency
 - Focus on Switched Reluctance Motors: eliminate dependency on rare-earth magnet import

Battery Chargers and Swappers

- Industry can proliferate within 5 years
- Large subsystem industries
 - Very large number of charging and swapping stations

Air-conditioners

- Vehicle air-conditioners draw power from vehicle battery and therefore limit range
 - Need higher efficiency





Become a Leader

By 2030 all vehicles in India can become Electric

\$150 billion new industry with Batteries, solar, charging and swapping stations, Motors and drivers, Telemetry

In small size segment, India can produce the best and most cost-effective and most energy-efficient electric car

- Can be a leader