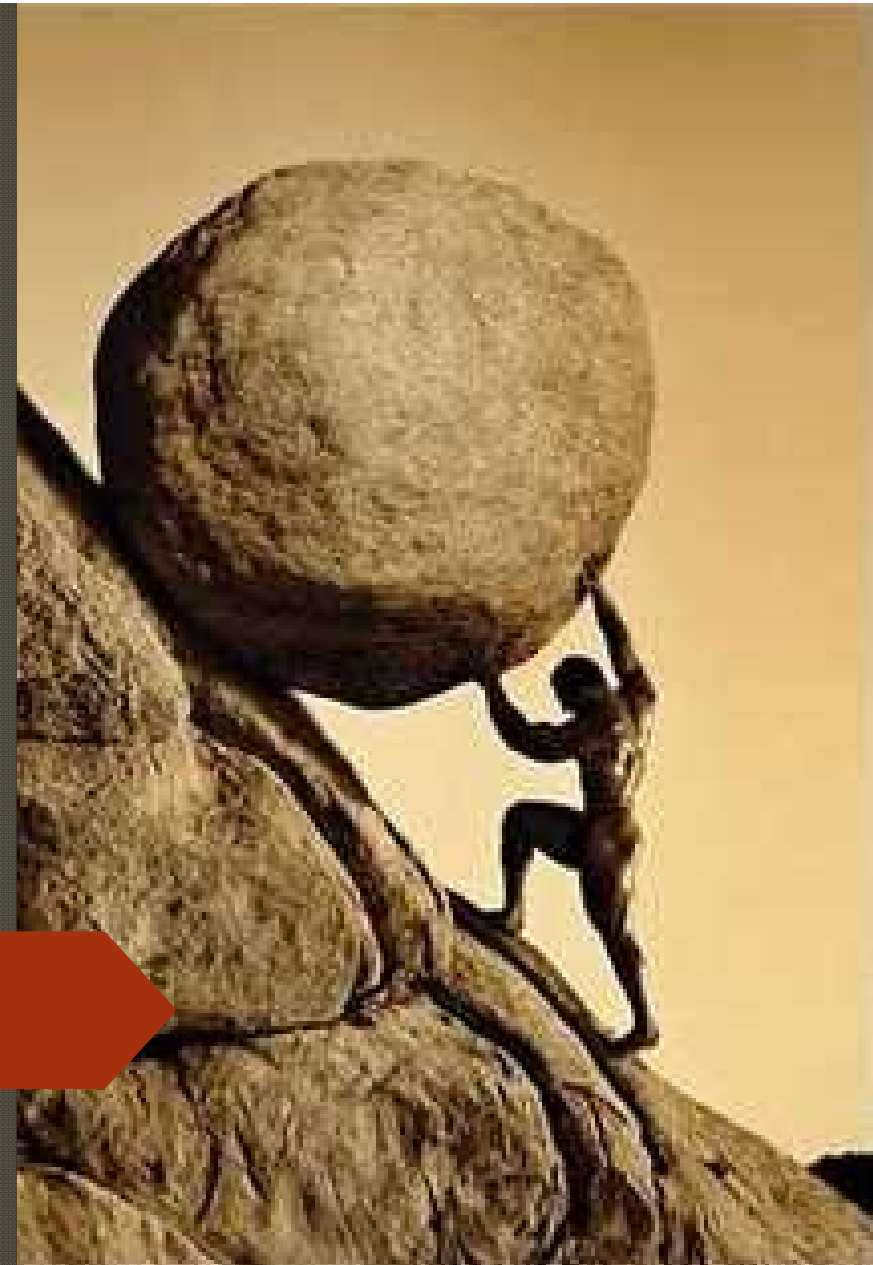


India's Energy Vision: A case of Electric Vehicles

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Electrical Vehicles

- India has negligible Electrical Vehicles today
 - 200 million ICE vehicles

But do we even have enough electricity?

- Conventional power and / or
- Solar panels on 0.5% of Rajasthan can generate all power required by 400M vehicles

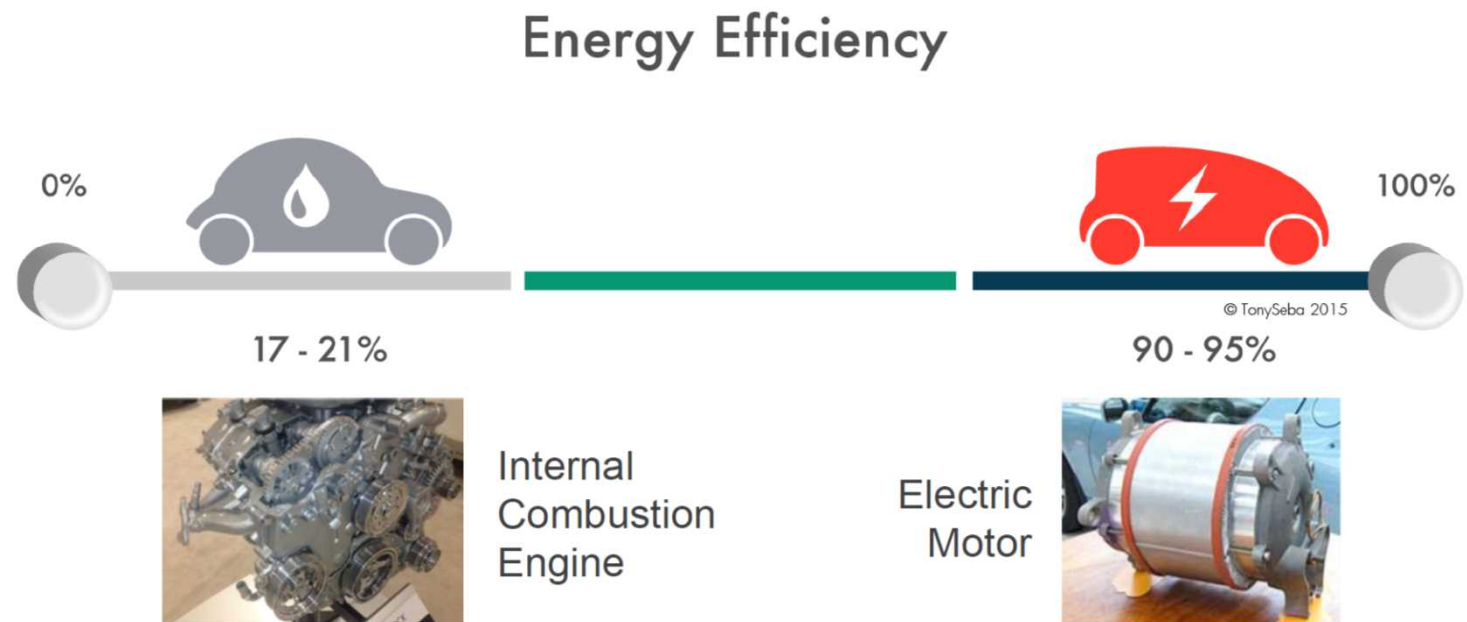


By 2030

- All its vehicles will become Electrical
 - 400 million vehicles

EVs more efficient as compared to ICEV

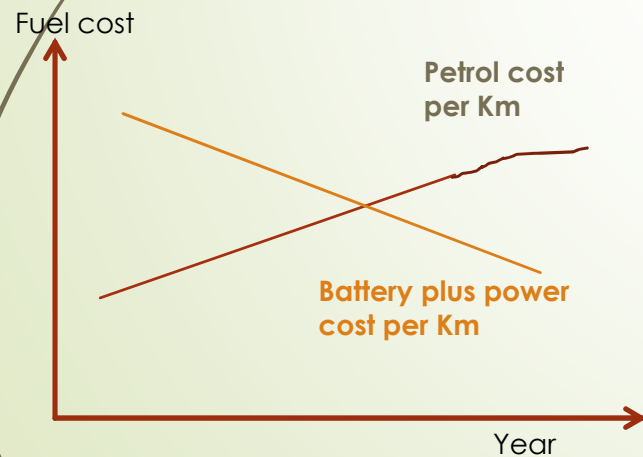
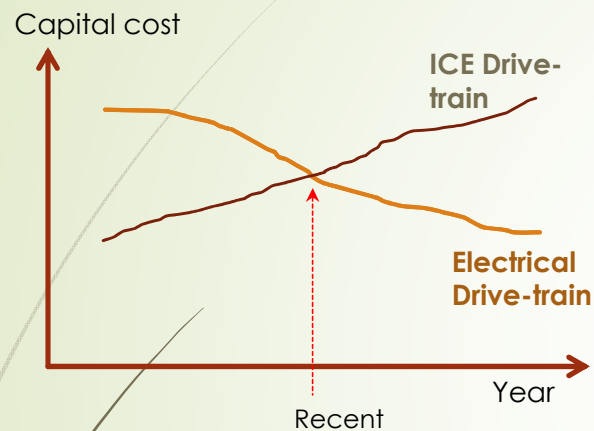
1. Electric Motor - 5X more Energy Efficient



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Sources: ICE - DOE, EM Wikipedia, Image Sources: ICE - Tony Seba, Electric - BradMerritt.com

Costs In 100K Volumes



EV Future in India

- Cost of IC Engine Vs electrical drive-train **without batteries**
 - ICE-DT cost goes up year after year (inflation) while EDT cost goes down (R&D, Moore's law and SW)

crossed over recently: Gap to widen year after year

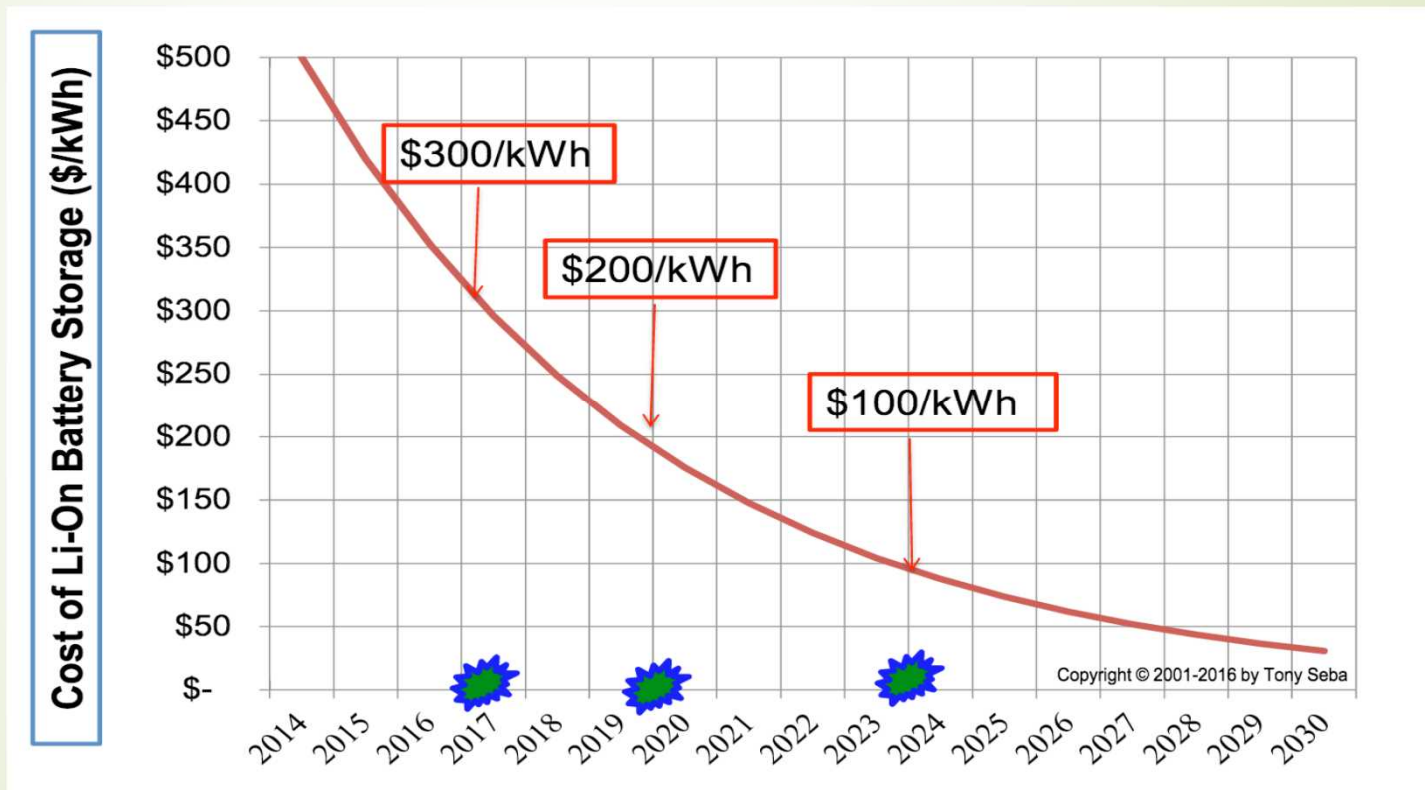
Battery should be treated as fuel

Fuel costs

- Total cost of battery per Km (depreciation, interest, maintenance and charging) lower than **Petrol cost per km**
 - Battery R&D enhancing charge-discharge cycles and reducing costs continuously
- Crossover took place recently **for vehicles which drive 200 kms a day (200,000 kms in 5 years)**
 - Easy for taxis and Buses, may not happen so fast for personal transportation vehicle

But even EV capital costs with storage will soon become lower than that of ICEV

EV Storage
also enables
balancing of
load for
electricity
companies



EVs are more Reliable and make economic sense

EVs: 100X fewer Moving Parts

ICE (Gas) Vehicle

2,000+ moving parts (1)

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



Electric Vehicle (EV)

18 moving parts (1)



▶ EVs **10X-100X** cheaper to maintain!

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Source: (1) Baron Funds, (2) Tesla Blog

- ▶ 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?
 - ▶ Huge employment (**Make in India**)
 - ▶ Innovation and Start-up (**Start-up India**)

Large Opportunity: Innovation to make it affordable in Indian Context

- Auto Industry: \$350B by 2030; India's oil bill: \$160B by 2030
- 50% to 70% of BOM for EV is different: new supply chain of over \$175 billion can be designed, developed and manufactured in India
 - Motors, controllers, batteries, chargers, dc-dc converters, electric brakes, electric air-conditioning, high efficiency Transmissions, light weight material usage
- Would require **out-of-box thinking** to come up with new solutions
- 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
 - **Economics and user-acceptability** should drive change

Infrastructure, Innovation and R&D

- Volumes will help and so will EV **technology evolution** in the world
 - But India's **lower affordability** and driving conditions require special developmental efforts
- Require Electric Charging Infrastructure viable in Indian Context
 - Battery Swapping Center in select sectors
- **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, Battery Chargers, Converters
 - **Air-conditioners (electric powered)**
 - System **Controller** and software, Intelligent controls and integrated Electronics, Light-weight materials and Telemetry, wireless charging
 - Battery swapping

It may look an impossible task today

- But Gains are huge
- India needs it
 - Has very little oil
 - Increasing pollution is a key problem
- Will help India' Power Sector
 - Will help India generate and use more renewable energy
- Challenges can be overcome, if there is a will