1987 – 2012

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INNOVATIVE TECHNOLOGIES IN RENEWABLE ENERGY STORAGE AND ITS APPLICATIONS IN ELECTRIC VEHICLES

Renewable Energy

Renewable energy is **energy** generated from natural **resources**—such as sunlight, wind, rain, tides and geothermal heat—which are **renewable** (naturally replenished).

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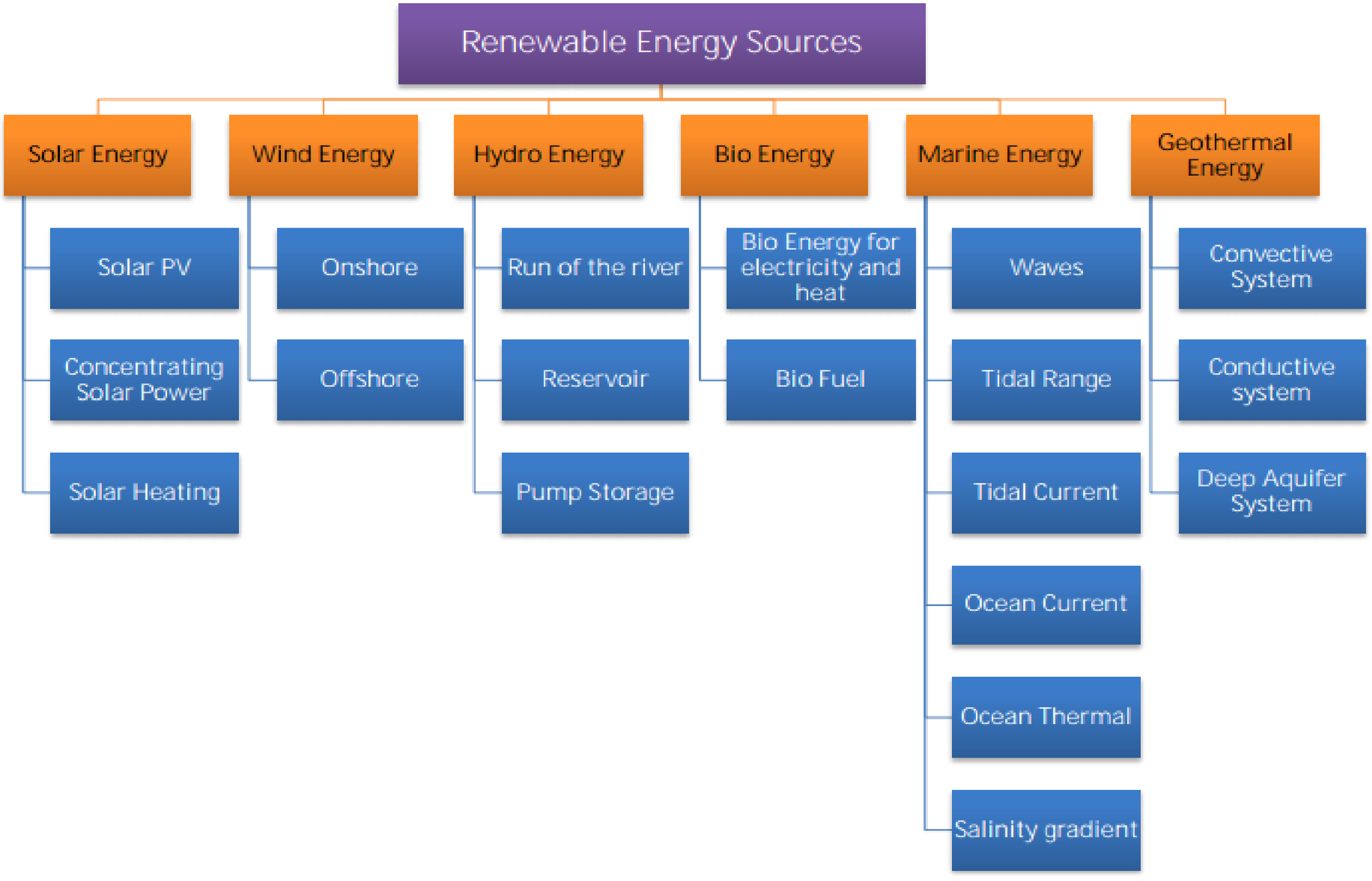
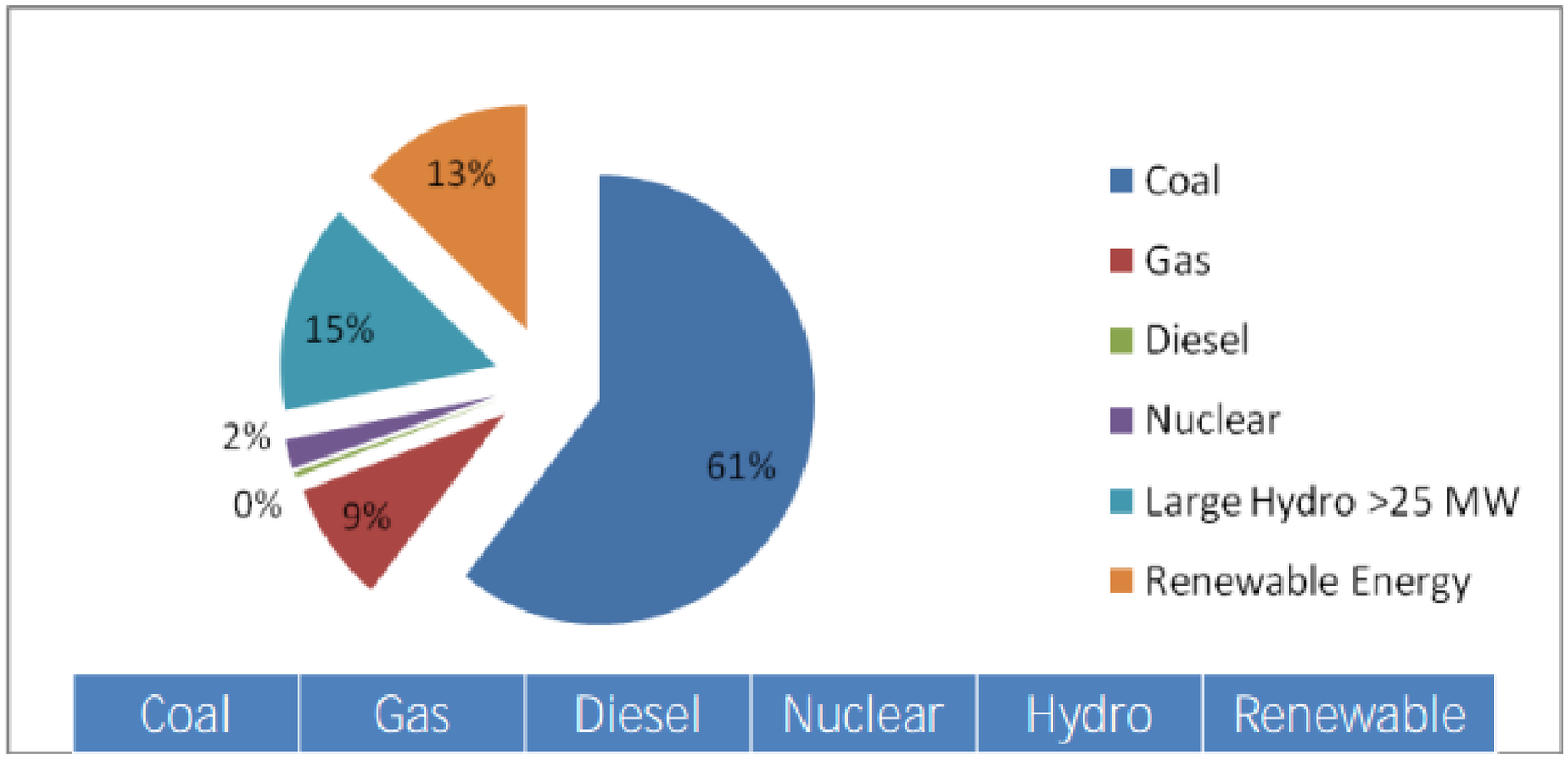
Overview of renewable energy sources



Overall Generation Mix : 284 GW (INDIA)

as on 31.12.2015



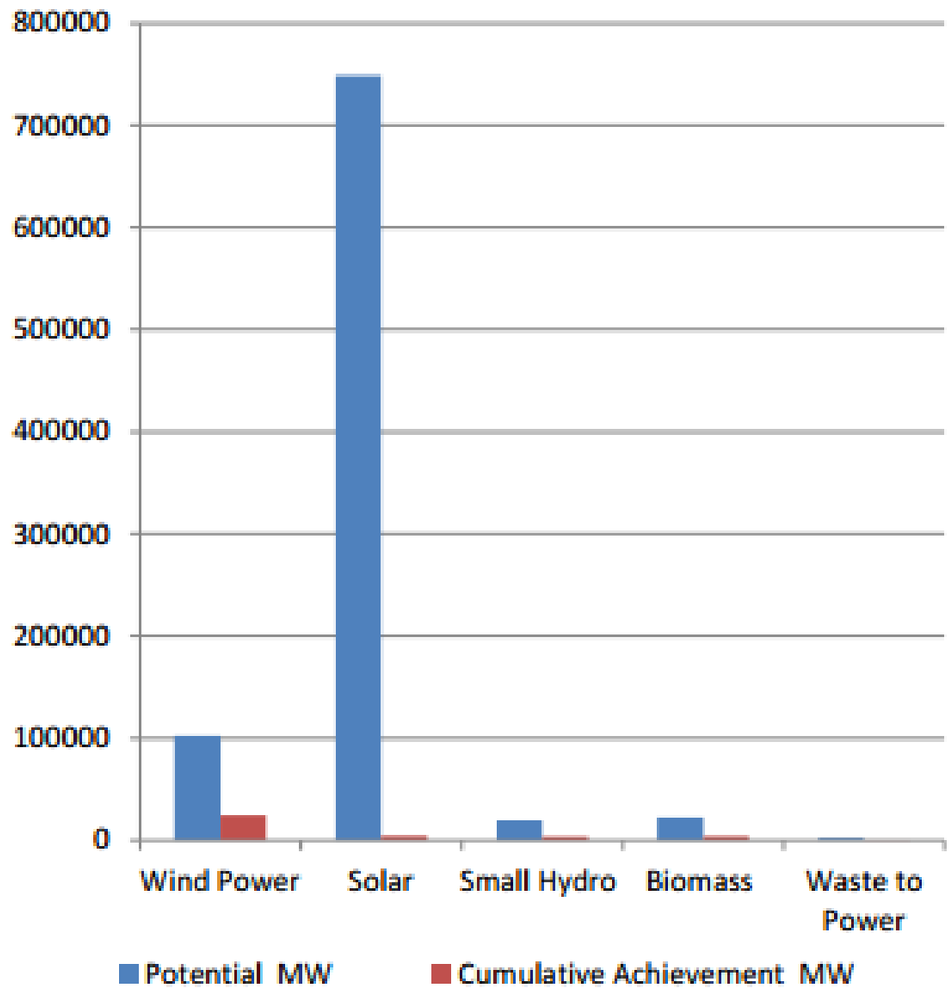
Coal	Gas	Diesel	Nuclear	Hydro	Renewable
173	24.5	1	5.78	42.6	37.4

Source: Central Electricity Authority (CEA), 2015

Potential & Achievement of RE in India

(as on 31.12.2015)

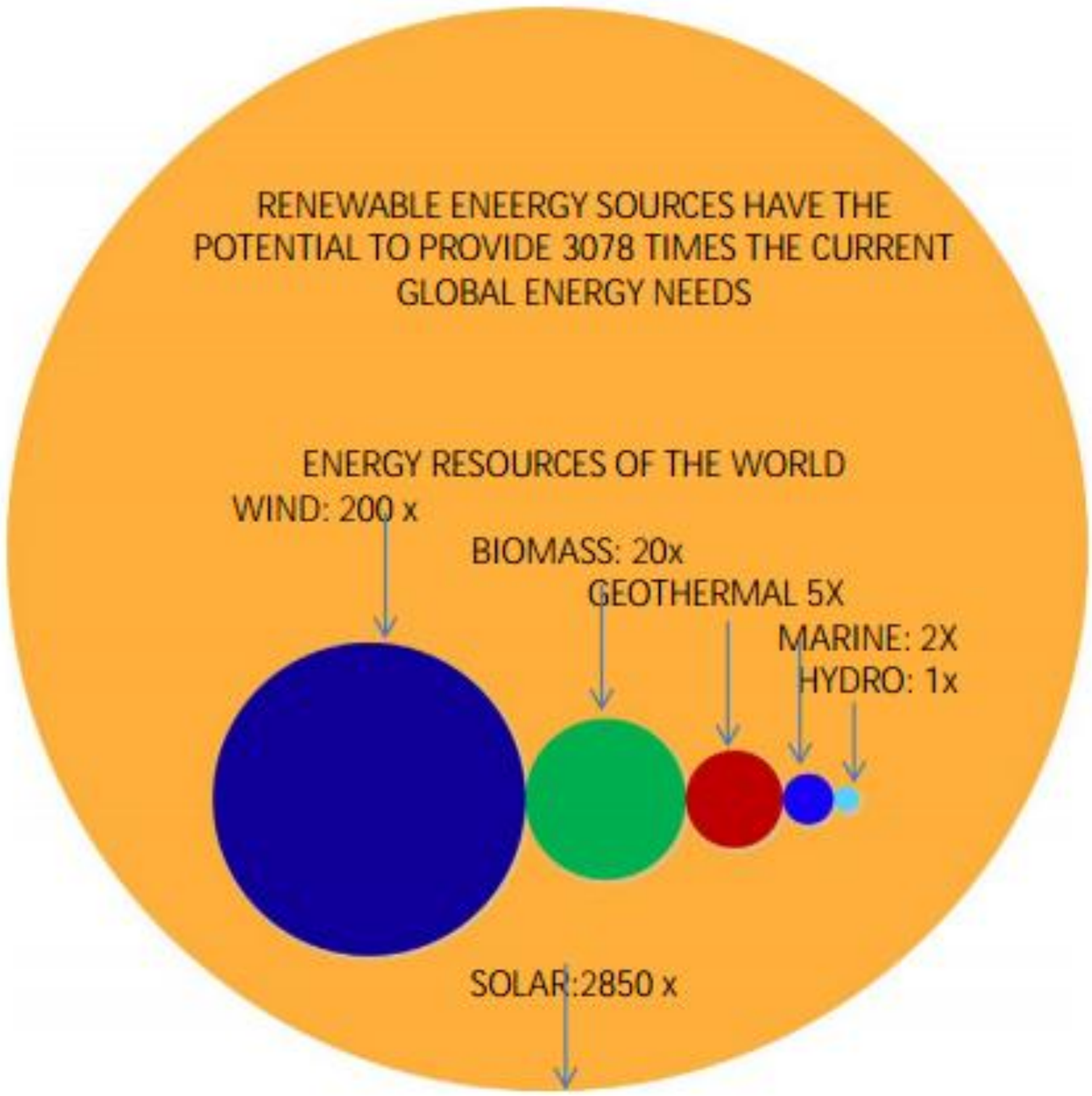
Sector	Potential MW	Cumulative Achievements MW
Wind Power	1,02,772	25,088
Solar Power	7,48,990	4,879
Small Hydro Power	19,749	4,177
Bio-Power	22,536	4,551
Waste to Power	2,554	127
Total	8,96,602	38,822



Huge untapped RE potential is available in India

Source : Ministry of New and Renewable Energy

Energy resources of the world



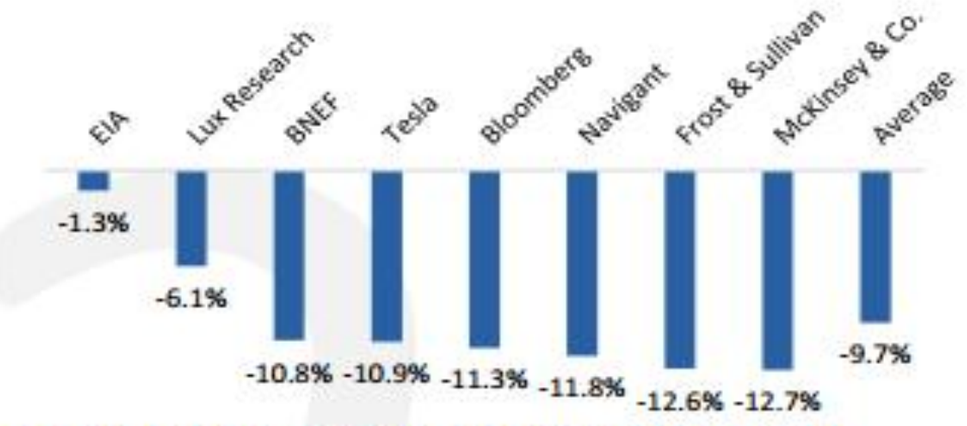
Source: RE-thinking 2050, (www.erec.org)

Need to promote Energy storage for large scale integration of RE

Key forces driving adoption of energy storage globally

Higher Renewables Penetration

Battery Price Decline per annum (Li-ion)



There are over 32 applications of storage however, only a few of these are viable now

Market Services

- Electric Energy Time-Shifting
- *Frequency Response*
- *Frequency Regulation Up*
- *Frequency Regulation Down*
- Ramping
- Real-Time Energy Balancing
- Synchronous Reserve (Spin)
- Non-Synchronous Reserve
- Black Start

Capacity Products

- System Electric Supply Capacity
- Local Electric Supply Capacity
- Resource Adequacy

Generation Services

- Intermittent Resource Integration (Ramping & Voltage Support)
- Variable Energy Resource Shifting, Voltage Sag, Rapid Demand Support
- Supply Firming

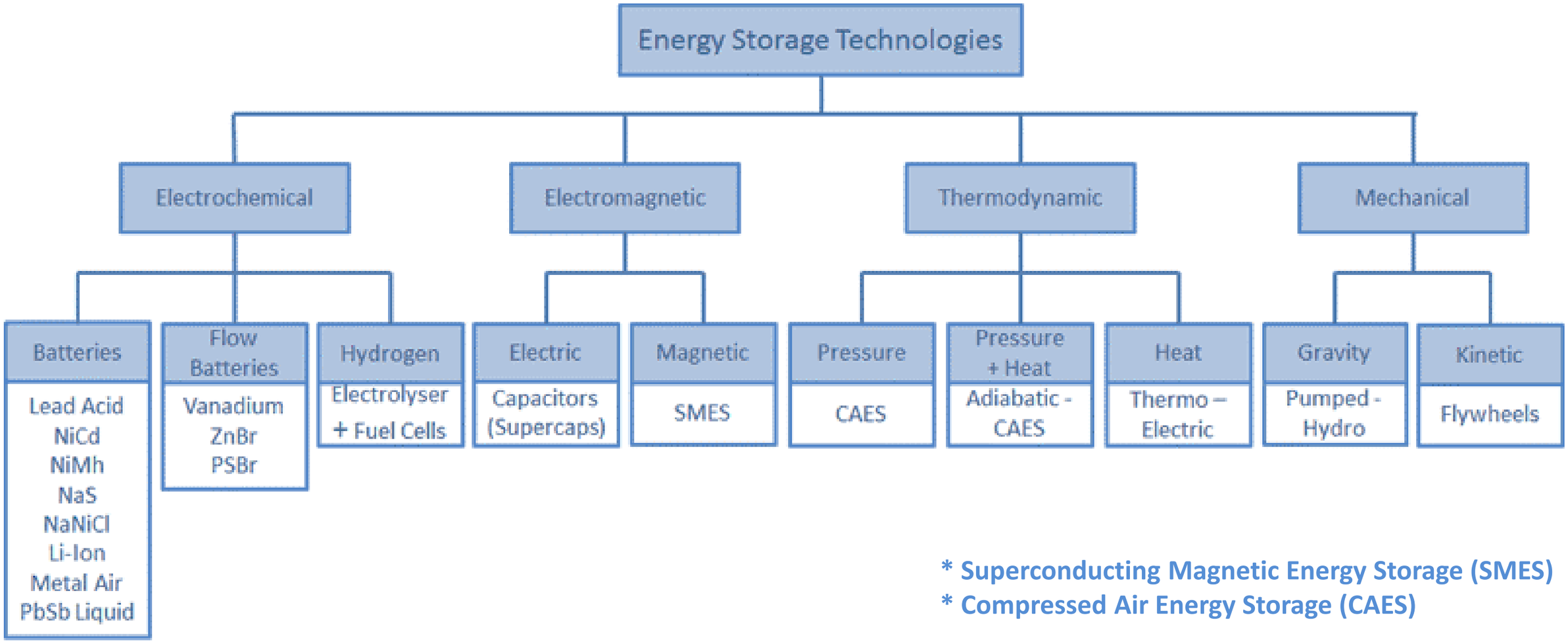
Transmission/Distribution

- Peak Shaving: Load Shift
- Transmission Peak Capacity Deferral
- Transmission Operation
- Transmission Congestion Relief
- Distribution Peak Capacity Deferral
- Distribution Operation (Voltage/VAR Support)

Additional Grid Benefits

- Reduced fossil fuel use
- Increased renewables
- Grid Reliability
- Faster build time
- Modularity/incremental build
- Mobility
- Flexibility of purpose
- Optionality
- Locational flexibility
- Multi-site aggregation
- *Demand charge reduction*
- UPS / Reliability
- Self-consumption

Energy Storage Technology



*** Superconducting Magnetic Energy Storage (SMES)**
*** Compressed Air Energy Storage (CAES)**

Li-ion batteries

- Li-ion batteries are secondary batteries.
- The battery consists of a anode of Lithium, dissolved as ions, into a carbon.
- The cathode material is made up from Lithium liberating compounds, typically the three electro-active oxide materials,
  - Lithium Cobalt-oxide ($LiCoO_2$)
  - Lithium Manganese-oxide ($LiMn_2 O_4$)
  - Lithium Nickel-oxide ($LiNiO_2$)

LITHIUM-ION BATTERY
PRODUCTION SOLUTIONS

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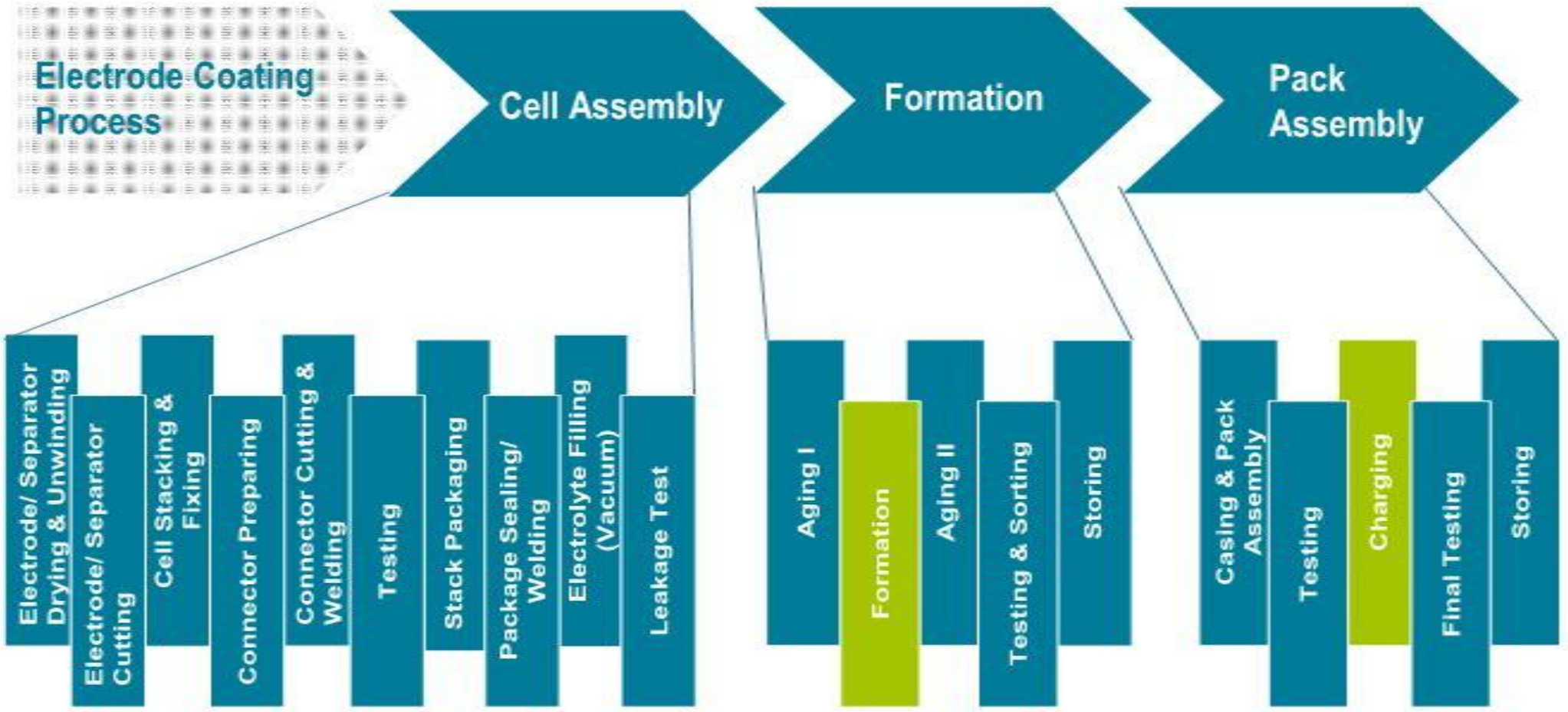

Manz Products and Technologies

Manz Technology Partners

Manz - Approved Suppliers

LITHIUM ION BATTERY (Video)

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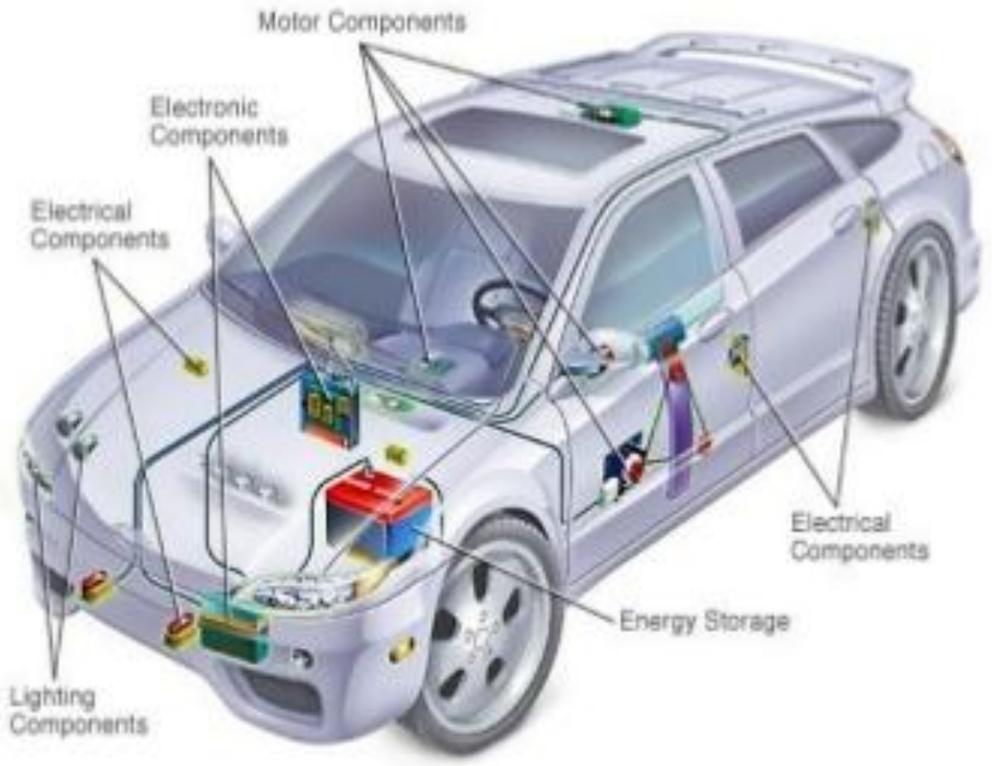
Application of Lithium Ion Battery in Electric and Hybrid Cars

Lithium-ion battery pack in a Nissan Leaf.

Electric Vehicles



Components

- Motor
- Controller
- Charger
- DC/DC Converter
- Contactors Batteries

- Electric cars are automobiles, which are powered by the electric engine and electric energy.

- EVs, are vehicles that are powered by an electric motor instead of an internal combustion engine.

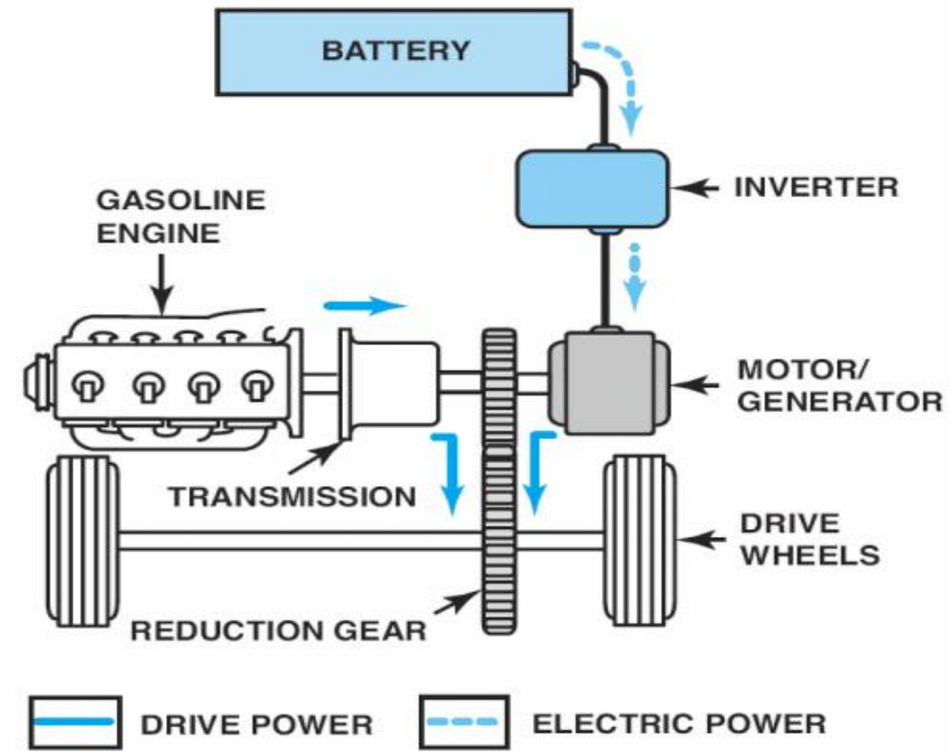
Hybrid Vehicles

- A hybrid is anything that uses two or mores sources directly or indirectly to provide propulsion

- Classification of Hybrid Vehicles :
  - Parallel Hybrid
  - Series Hybrid

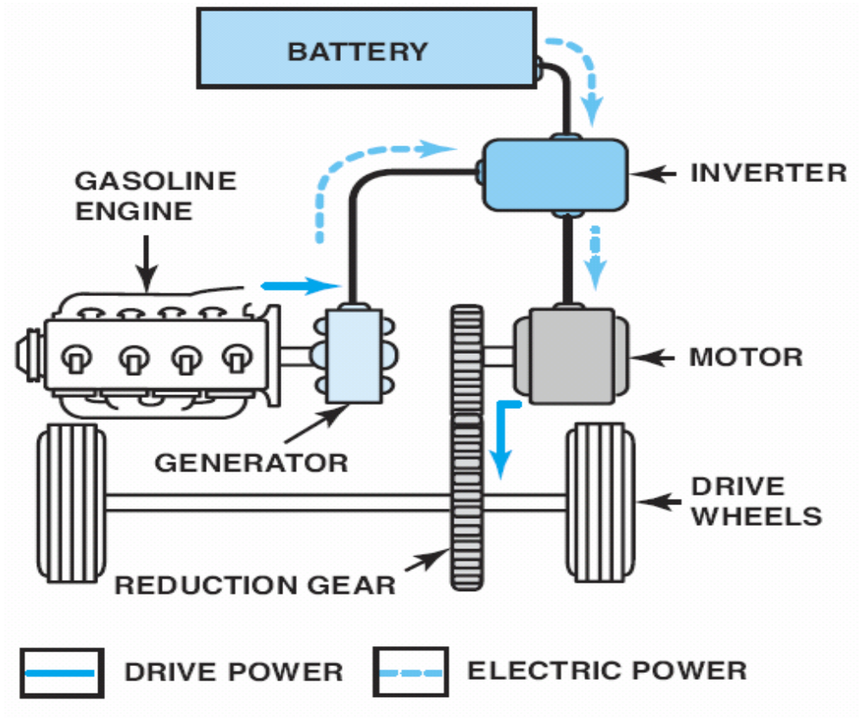
.

Parallel Hybrid



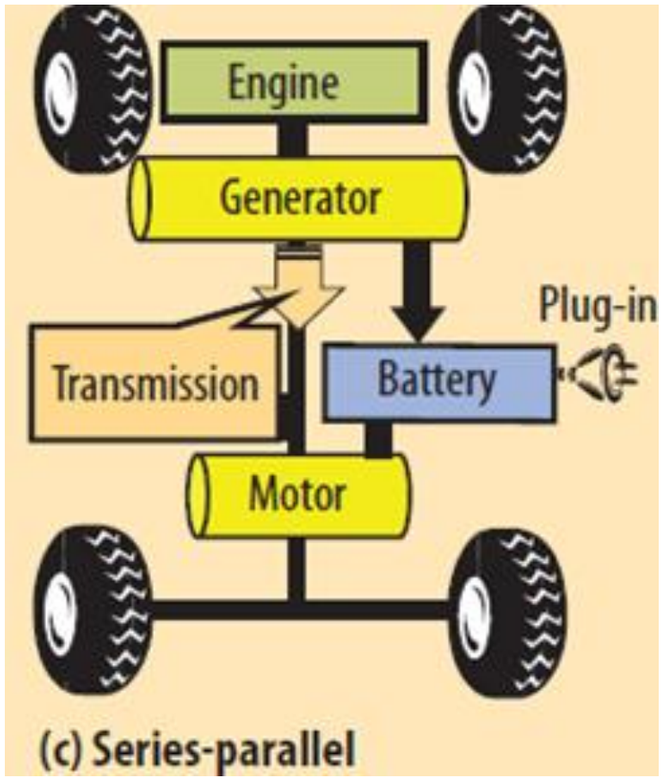
- Has a fuel tank that supplies gas to the engine like a regular car
- It also has a set of batteries that run an electric motor
- Both the engine and electric motor can turn the transmission at the same time.

Series Hybrid



- The fuel tank goes to the engine, but the engine turns a generator
- Then the generator can either charge the batteries or power an electric motor that drives the transmission
- The gasoline engine does not directly power the car

Series/parallel hybrid



(c) Series-parallel

- Merges the advantages and complications of the parallel and series.
- Engine can both drive the wheels directly and be effectively disconnected from the wheels .
- Example :The Toyota Prius ,new Ford Escape Hybrid.
- Engine operates at near optimum efficiency more often.
- This system incurs higher costs than a pure parallel hybrid.
- It needs a generator, a larger battery pack, and more computing power to control the dual system
- It has potential to perform better.

Manz supplies ZSW research centre with lithium-ion battery production line

BMW i8

Motivation To Embrace Electric Vehicles

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Domestic Policy Goals

- Reduce dependence on foreign oil
- Job creation
- Economic Growth (energy sources local)

Global Impact

- Europe to mitigate climate change
- China to balance growth with pollution
- Governments around the world have allocated funding for clean technology

Energy Independence

- Local energy sources reduce price volatility
- Reduce export of dollars, particularly to unstable regions of the world

- Reduce dependence on few key regions – roughly half of the EU's gas consumption comes from only three countries (Russia, Norway, Algeria)

Developing Nations

- Lower-cost conventional vehicles support economic development goals.
- Urban air pollution and rising oil imports to be the main driver of electrification
- China has stated its goal of reducing the carbon intensity of its economy.
- Lack of Infrastructure (grids) is a huge factor.

Climate Change

- Global support for climate change has gained momentum with Europe leading the way.
- Transportation accounts for roughly 15% of energy related CO2 emissions globally.
- In 1992, the United States ratified the United Nations' Framework Convention on Climate Change (UNFCCC), which called on industrialized countries to make voluntary efforts to reduce greenhouse gases.
- EU energy policy provides affordable energy while contributing to the EU's wider social and climate goals

Drivers for growth of electric vehicles in India

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Policy objectives

- Master plans for most cities in India target **60-80 per cent public transport** ridership by 2025-2030 (Center for Science and Environment)

Market size

- India is the **2nd** largest two-wheeler market (**80 million** in 2010) in the world after China
- Two-wheelers will continue to remain mode of choice in 2035 (UNEP, DTU and IIM-A)

Environmental

- **Thirteen** out of 20 cities in the world with **highest air pollution** are in India
- Low carbon scenario with 'highest' EV penetration shows 50 percent drop in PM 2.5 by 2035 (UNEP, DTU and IIM-A)

Allied opportunities

- With the Government of India targeting **100 GW of solar by 2022**, electric vehicles can improve reliability and utilization of renewable by acting as storage

Drivers for growth of electric vehicles in India

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However

- **Rollback** of previous subsidies with delay in implementing NMEMP highly detrimental to industry
- Number of electric two-wheeler makers has **fallen (75%)** from 28 in 2011-12 to seven in 2014-15
- Total electric vehicles sold in 2014-2015 has **decreased (84%)** from 100,000 in 2011-12 to approx 16,000 in 2014-15
- Infrastructure and market development cost for EVs (hybrid) vehicles estimated at **Rs 23,000 crore ($3 Billion)** over 8 years

Source: Society of Manufacturers of Electric Vehicles India (2015)

Electric vehicles in India – Opportunity Indicators

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Market size of auto rickshaws

(Source: WRI)

Tier I cities	50,000 +
Tier II cities	15,000 to 30,000

2012
229 Million Trips

→

2031
482 Million Trips

Number of buses (in thousands)

Source: data.gov.in

Year	Public sector	Private sector	Total
2012	131.8	1544.7	1676.5
2011	130.6	1473.2	1603.8

- **Total Market Size** – 80 Million (2010) , 10% growth every year
- Approx. **500,000 electric** two-wheelers (2012)
- Electric two-wheeler market in India < **1 percent** of two-wheeler market

Source: Society of India Automobile Manufacturers (2014)

Electric vehicles in India – Policy Progression

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2015 — FAME India - **Faster Adoption and Manufacturing** of (Hybrid & Electric) Vehicles in India

2014 — India becomes **member** country of Electric Vehicles Initiative (EVI)

2013 — **National Electric Mobility Mission Plan 2020**

2011 — **National Mission on Electric Mobility (NMEM)**

FAME India – Faster adoption and manufacturing of (Hybrid & Electric) vehicles in India

Components of Scheme	2015 – 2016 INR Cr. (million USD)	2016 – 2017 INR Cr. (million USD)
Technology Platform (+ testing infra)	70 Cr (10.8)	120 Cr (18.6)
Demand Infrastructure	155 Cr (24)	340 Cr (52)
Charging Infrastructure	10 Cr (1.5)	20 Cr (3.1)
Pilot Projects	20 Cr (3.1)	50 Cr (7.7)
IEC / Operations	5 Cr (0.7)	5 Cr (0.7)
Total (INR)	260 Cr (40.3)	535 Cr (83.1)
Grand Total (INR)	**795 Cr (123 million USD)**	

National Electric Mobility Plan (NEMMP) 2020

- Target of deploying **5 to 7 million** electric vehicles in the country by 2020
- Emphasizes importance of government incentives and coordination between industry and academia
- Target of 400,000 passenger battery electric cars (BEVs) by 2020 ~ avoiding **120 million barrels of oil and 4 million tons of CO2**
- Lowering of vehicular emissions by **1.3 percent** by 2020
- Total investment required –INR 20,000 – 23,000 cr (approx 3 billion USD)

Incentives for electric vehicles in India

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Demand side incentives announced under FAME India

Vehicle Segment	Minimum incentive (INR)	Maximum incentive (INR)
2 wheeler scooter	1800 (30 USD)	22,000
Motorcycle	3500	29,000
3 wheeler Auto-rickshaw	3300	61,000
4 wheeler cars	11,000	1,38,000
LCVs	17,000	1,87,000
Bus	30,00,000 (47,000 USD)	66,00,000
Retro Fitment Category	15 % or 30,000 if reduction in fuel consumption is 10-30%	30 % of Kit price or 90,000 if reduction in fuel consumption is more than 30 %

- Availed by buyers upfront at the point of purchase
- Manufacturers Reimbursed by Department of Heavy Industries

Concessions in custom duties (up to 31/03/2015)

- Exemption of basic customs duty on lithium ion automotive battery
- Exemption of customs duty on parts of hybrid and electric vehicles
- Concessional excise duty of 6% to specified parts
- Excise duty reduced to 10% in latest interim budget of 2014

State-level incentives

- Exemption of VAT
- VAT waiver for window
- Reduction in VAT

Challenges and barriers to growth of Electric Vehicles in India

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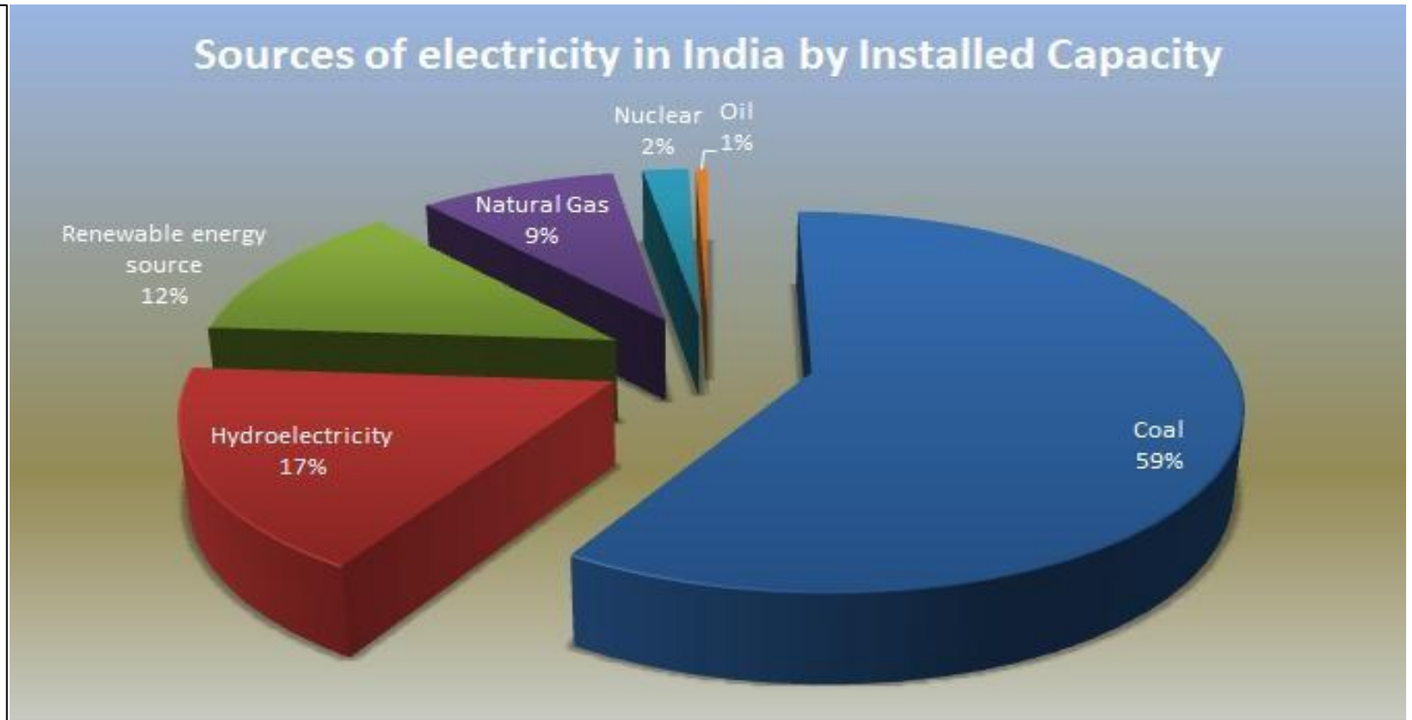
India **does not have Lithium ion** reserves to support a large domestic market for electric vehicles

Lack of clear policies for supporting the growth of supply, manufacturing and recycling of batteries

India's electricity mix is dominated by **fossil fuels** – low carbon benefits Need to be rationalized

Safety concerns / perceptions around electric vehicles

High local taxes and low prices of oil



VAT on EVs	State (Source: SMEV, India)
12-14 per cent	Uttar Pradesh, Punjab, Chandigarh and Goa
5 per cent	Maharashtra (+4.5 per cent Octroi)

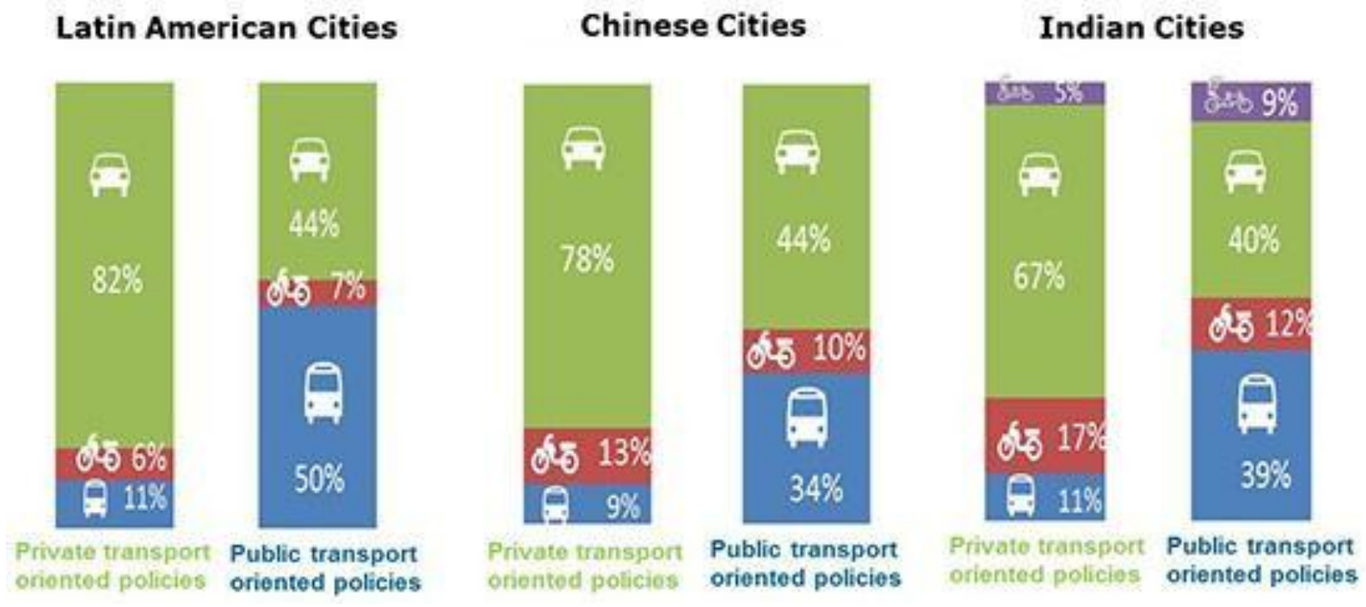


Image source: International transport forum

Business model for e-rickshaws in India

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OPPORTUNITES

1. Existing presence of about **250,000** e-rickshaws operating in 6 states including Delhi-NCR, Bihar, West Bengal and Orissa

2. **Business model advantage**
   - Set of 4 batteries cost ~ 24,000 INR (375 USD) and last for 6 months
   - Scrap value of batteries 4,000 INR (63 USD)
   - Cap-ex every 6 months is 20,000 INR (311 USD) effectively 2 dollars per day
   - Earnings up to 16 dollars per day

3. One overnight recharge can run for **80 km**

Source: Interviews with EV battery manufaturers

CHALLENGES

1. Fragmented market

2. Lack of government support
   - No recognition
   - Regulations are not clear
   - No incentives for recycling batteries

3. Fragmented market of battery suppliers -6-7 organized vs 60 unorganized battery suppliers

4. Despite advantage e-ricks not used openly due to Delhi High Court ban

5. Problem of charging (using electricity) for commercial use at domestic rates

- In March 2015 the Motor Vehicles (Amendment) Bill was cleared establishing battery-powered e-rickshaws as a valid form of commercial transport
- 3 wheeled vehicles run by battery power of no more than 4,000 Watts
- 4 passengers, luggage of 50 kg and with a single trip under 25 kilometers
- 22,000 licenses granted, insurance can be obtained for e-rickshaws, minimum 8th pass criteria removed

Electric vehicle case studies from India

Mahindra E20

1. India's first completely electric vehicle, manufactured in green facility
2. Offers innovative battery rental scheme - *Goodbye Fuel Hello Electric (GFHE)*
3. On road price of INR 4.79 lakh (approx. 7542 USD) and fixed energy fee of INR 3,000 (47 USD) per month for 5 years / 50,000 km
4. Sold only **1000** units in the past 15 months (target of **500 units per month**)
5. Plans to expand to Europe and South Asian countries where EV sales are picking up and government incentives are available

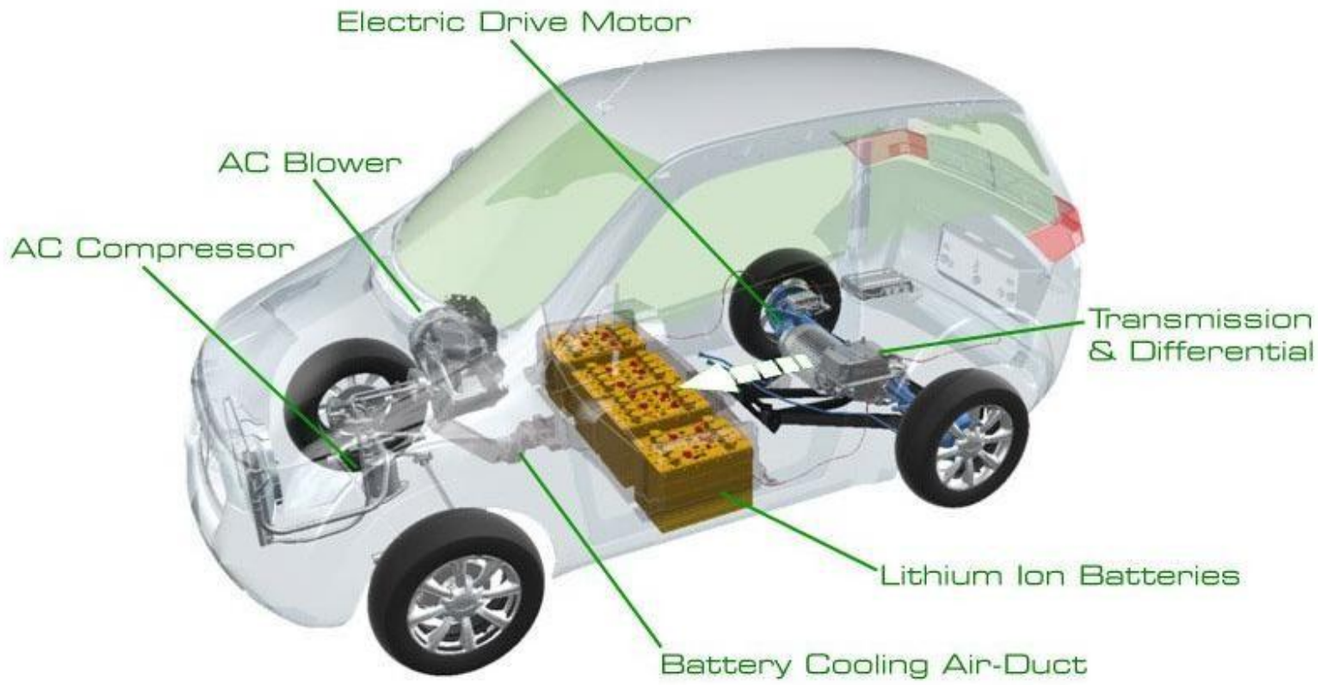
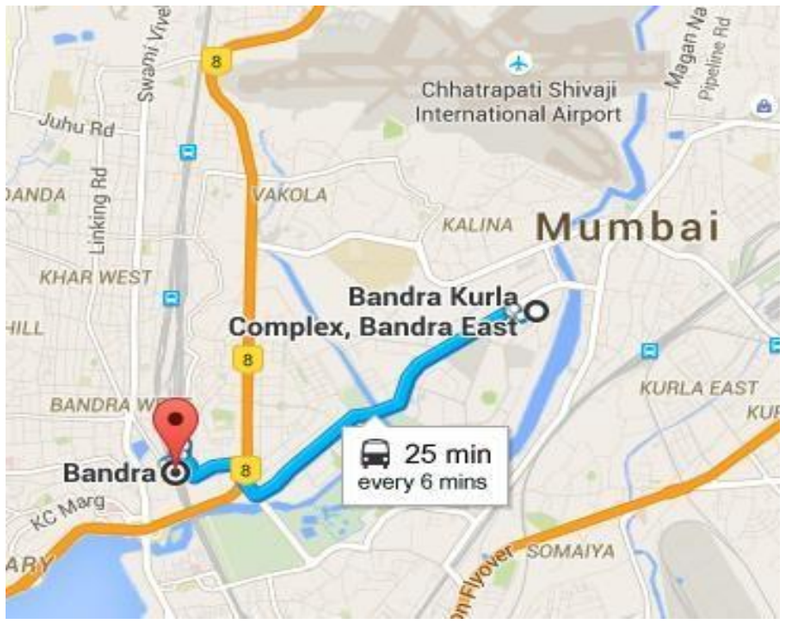


Image source: Mahindra and Team BHP

Green shoots for EVs in India?

Image source: Times of India



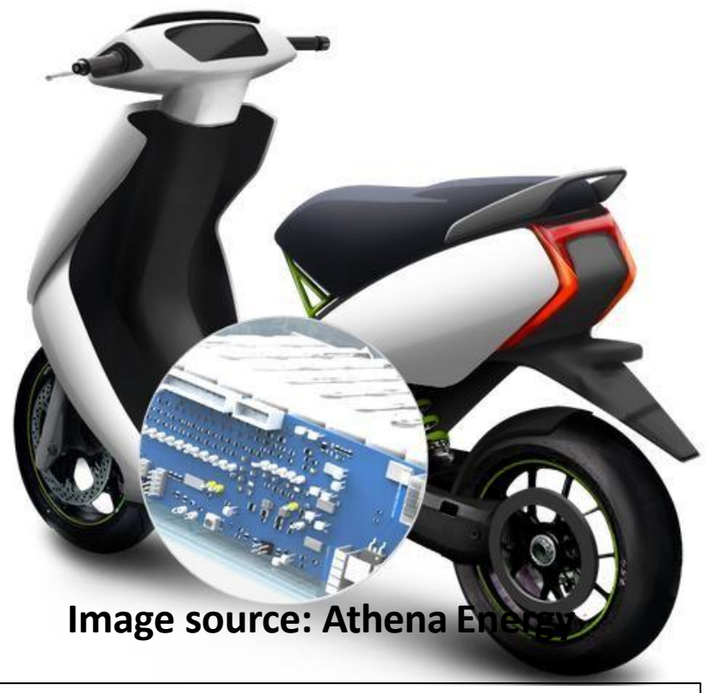


Image source: Athena Energy

Bangalore Municipal Corporation

- First trial of electric bus in India in Mar 2014
- Bangalore Municipal Transport Corporation proposed exemption of road tax and VAT for electric vehicle
- Project shelved as corporation is cash strapped and cannot afford a 3 crore INR (472,106 USD) bus

Mumbai Metropolitan Regional Authority (MMRDA)

- Apr 2015 – Floated RFP for 25 AC electric / hybrid buses from Bandra Kurla Complex to 3 railway stations

New Delhi Municipal Corporation

- Proposes to operated three-wheeler electric vehicles from Metro stations

Athena Energy (2016)

- IIT Madras based startup aiming to launch redefined electric scooter in 2016
- Lithium-ion battery with digital battery management targeting
  - 8 times faster charging
  - 10 times longer battery
  - 75 percent lighter battery

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