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ELECTRIC CARS

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ELECTRIC CARS : OUTLINE

- Historical Background
- How an Electric Car Works?
  - Basic Principle
  - Motors
  - Controllers
  - Batteries and Chargers
  - Braking
  - Auxiliary Batteries and DC-DC converters
- Tesla Roadster
- Challenges and Future
- References
Electric cars were prevalent in early 20th century, when electricity was preferred in automobile propulsion.

Advances in internal combustion technology, especially the electric starter, the greater range of gasoline cars, quicker refueling times, and growing petroleum infrastructure, along with the mass production of gasoline vehicles reduced prices of gasoline cars to less than half that of equivalent electric cars, which led to the decline of electric propulsion.

The energy crisis of 1970s and 1980s brought a renewed interest in electric vehicles.

Further the global economic recession of late 2000s called to abandon the fuel inefficient SUVs, in favor of small cars, hybrid cars and electric cars.
Electric car by Siemens, 1904
Ref: Bundesarchiv Bild (German Federal archive) through en.wikipedia.org

Thomas Edison with a car made by Detroit Electric, 1907-1939
courtesy of the National Museum of American History through en.wikipedia.org
Historical Background cont.

Tribelhorn, 1902 - 1919
Ref: en.wikipedia.org/wiki/Tribelhorn

The Henny Kilowatt, 1961
Ref: en.wikipedia.org/wiki/Henney_Kilowatt

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Vanguard Sebring Citicar, 1974
Ref: www.austinev.org/evalbum through en.wikipedia.org

Saturn EV -1, General Motors, 1996
Ref: en.wikipedia.org/wiki/General_Motors_EV1
Chevrolet Volt, 2007
Courtesy:
en.wikipedia.org/wiki/Chevrolet_Volt

Tesla Roadster, 2008
Ref: www.teslamotors.com/roadster

Historical Background cont.
ELECTRIC CARS: HOW THEY WORK?

Basic Principle

- An Electric car is powered by an Electric Motor rather than a Gasoline Engine.
- The Electric Motor gets its power from a controller.
- The Controller is powered from an array of rechargeable batteries.

Courtesy: [http://auto.howstuffworks.com/electric-car](http://auto.howstuffworks.com/electric-car)
MOTORS

- Electric cars can use AC as well as DC motors.
- DC motors run on a voltage ranging roughly between 96 to 192 volts. Most of them come from Forklift Industry.
- DC installations are simpler.
- Another feature of DC motors is that they can be overdriven for short periods of time (up to a factor of 10), which is good for short bursts of acceleration.
- One limitation is the heat build up. May lead to self destruction.
- Due to these limitations and other advantages provided by AC motors (like better torque and speed output, for same weight and size), DC motors are not used.
- Any of the industrial 3 – phase AC motors can be used.
- They allow the use of regenerative braking.

Forklift Motor
Courtesy: DIY Electric car blog

AC Motor
Courtesy: DIY Electric car blog
The controller delivers a controlled voltage to the motor, depending upon potentiometer output.

PWM controls the speed.
DC Voltage control using PWM

DC Controller

Controllers continued......
AC Controller

Controllers continued......

Courtesy: howstuffworks.com
AC Controller

- An AC controller creates 3 pseudo sine waves which are 120 degree apart (3-phase AC).

Using six sets of power transistors, the controller takes in 300 volts DC and produces 240 volts AC, 3-phase.
BATTERIES AND CHARGERS

- Lead acid batteries used, until recently.
- A weak link in the electric cars.
- Heavy, Bulky, limited capacity (12 – 15 kilowatt hours), slow charging rate, short life and expensive.
- NiMH batteries give double the range and last 10 years, but expensive.
- Lithium ion and NiMH batteries likely to be used if their prices can be made competitive with lead acid batteries.
## Batteries and Chargers

<table>
<thead>
<tr>
<th>Battery type</th>
<th>Energy/weight Watthours/Kg</th>
<th>Energy/Volume Watt-hours/L</th>
<th>Power/weight Watt/kg</th>
<th>Energy/US$ Watt-hr/$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead- acid</td>
<td>30-40</td>
<td>60-75</td>
<td>180</td>
<td>4-10</td>
</tr>
<tr>
<td>Nickel – Zinc</td>
<td>60-70</td>
<td>170</td>
<td>900</td>
<td>2-3</td>
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<tr>
<td>Lithium-Ion</td>
<td>160</td>
<td>270</td>
<td>1800</td>
<td>3-5</td>
</tr>
<tr>
<td>Lithium-Polymer</td>
<td>130-200</td>
<td>300</td>
<td>2800</td>
<td>3-5</td>
</tr>
</tbody>
</table>

Courtesy: en.wikipedia.org
BATTERIES AND CHARGERS

Courtesy:
howstuffworks.com
BATTERIES AND CHARGERS

- Charging done from power grid (household/charging station).
- A good charger monitors battery voltage, current flow and battery temperature to minimize charging time.
- 120/240 Volts.
- Part of the controller/separate box.
- Magna – charge inductive charging system.
Charger: Working

- **Voltage Outlet:** 240/120 V AC.
- **Battery Requirement:** DC Voltage.
- AC to be converted to DC.
- Rectification needed.
MAGNA-CHARGE SYSTEM

- Consists of two parts:
  - **Charging station mounted to a wall**: Sends electricity to the car through an ‘inductive paddle’. **One half of transformer**.
  - **Charging System in the trunk of car**: Second half of the transformer. Completed with inserting of the paddle.

Batteries and Chargers continued.....
Equalizing

- An electric vehicle has a string of batteries.
- Closely matched, but not identical.
- Weaker batteries need more recharge.
- Weak battery gets weaker.
- Solution is “Equalizing”. Gently overcharge the cells to make sure that weakest cells are fully charged.
BRAKING

- Regenerative braking along with conventional friction braking.
- Motor as a generator.
- Recaptures car’s kinetic energy and converts it to electricity to recharge the batteries.

The electric motor reverses direction, becoming a generator (dynamo) which then stores the energy in the vehicle’s battery.

Courtesy: howstuffworks.com
AUXILIARY BATTERIES AND DC-DC CONVERTERS

- A 14 volt battery which provides power for accessories, like headlights, radios, fans, computers, airbags, wipers, power windows etc.
- Runs motor controller logic and power electronics.
- To charge the Aux. Battery a DC – to – DC converter converts the voltage from main battery array (say 300 volts) to 14 volts.

Courtesy: http://www.coolcircuit.com
Typical converters used

BUCK CONVERTER

Continuous Mode

BOOST CONVERTER

Courtesy: en.wikipedia.org
**ELECTRIC CARS: TESLA ROADSTER**

- **Acceleration:** zero to 60 mph in about 3.7 seconds.
- **Dimensions:** 155.4 inches long, 73.7 inches wide, 44.4 inches tall with a 92.6-inch wheelbase.
- **Weight:** 2,500 pounds (subject to change due to safety regulations).
- **Top Speed:** Over 130 mph.
- **Range:** 245 miles Per Charge.
- **Battery Life:** Useful battery life in excess of 100,000 miles.

Courtesy: www.teslamotors.com
TESLA ROADSTER: VEHICLE ARCHITECTURE

- Air conditioning Systems
- ESS (Battery Pack)
- Transmission
- Motor
- PEM (Power Electronics Module)
- Computer, navigation systems and other accessories

Ref: Brian Randall Tesla presentation 2008
TESLA ROADSTER: ESS (BATTERY PACK)

- 6831 standard 18650 Laptop Li-ion cells.
- Supplies ~375V to motors, heating and air conditioning systems.
- Cooling system.
- Current capacity of each cell: 2100 mAh.
- Energy stored = 2100 mAh * 3.7 V * 6831 = 53kWh.
- Weight ~ 450 Kg.
- Energy/Weight ~ 120.
- Can be recharged easily with 110/220 V outlet.

Courtesy: www.teslamotors.com
Battery Energy Density

Double the density in 10 years

⅓ the price in 10 years

Ref: Brian Randall Tesla presentation 2008
**TESLA ROADSTER: MOTOR**

- **3 - phase 4 pole AC motor**
- **Torque:** 273 lb-ft at 0 – 5400 RPM.
- **Horsepower:** 288 HP (215 KW) at 5000-6000 RPM.
- **Max Torque:** 350 Nm at 0 RPM (zero lag).
- **Max Speed:** 13500 RPM.

Ref: Brian Randall Tesla presentation 2008

Courtesy: www.howstuffworks.com
CHALLENGES AND FUTURE

- **Battery Problems**
  - Long recharging time - refueling required only minutes.
  - Battery weight - 100 pound Lead acid batteries = 1 pound of gasoline.
  - Battery costs.

- **Range concerns**
- **Price**
- **Consumer acceptance**
- **Market**
Challenges continued

➢ **Air conditioning**
  - Inefficient air conditioning solutions have a more pronounced effect on Electric vehicles than on gasoline vehicles.
  - This reduces the driving range.
  - Peltier Thermoelectric cooler.
  - Masterflux Compressor.

Ref: [http://www.electric-motors-price.info/vehicle-air-conditioning/](http://www.electric-motors-price.info/vehicle-air-conditioning/)

Ref: [http://www.peltier-info.com](http://www.peltier-info.com)
Strengths

- Energy Efficiency

**Diesel Car**
- Energy Conversion efficiency = 66 miles per gallon
- Diesel Engine
  - 66 miles per gallon

**Electricity Production**
- 1 gallon biodiesel
- Diesel generator
  - 21.9 kWh per gal

**Electric Car**
- Energy Conversion efficiency = 96 miles per gallon
- Electric car
  - 4.4 miles per kWh

96 miles

Ref: Brian Randall Tesla presentation 2008
Running Costs
- 0.03 – 0.04 $/mile.
- Extremely low as compared to gasoline cars.
- Motors last long.

Reduced maintenance
- No motor oil or oil filters to change.
- No Smog equipment to check.
- No Engine Servicing required.

Environment friendly
- Zero emissions.
- Very low sound.
FUTURE DEVELOPMENTS

❖ Improved Batteries
  ✓ Lithium Polymer.
  ✓ Zinc Air Batteries.
  ✓ Lithium Cobalt Metal Oxide.

❖ Hydrogen Economy

❖ Other Storage methods
  • SuperCapacitors (Electric Double layer Capacitors).
  • Flywheel Energy Storage.

❖ Hybrid Vehicles

❖ Solar Vehicles

SuperCapacitors

NASA G2 Flywheel
Courtesy: [en.wikipedia.org/wiki/flywheel](en.wikipedia.org/wiki/flywheel)
Solar Electric Vehicles Courtesy: en.wikipedia.org

Ford Escape Hybrid
Courtesy: en.wikipedia.org

Chevrolet Volt Hybrid
Courtesy: en.wikipedia.org
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- [www.manzanitamicro.com](http://www.manzanitamicro.com).
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- [www.austinev.org/evalbum](http://www.austinev.org/evalbum).
Questions ???
THANK YOU