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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 : HISTORICAL BACKGROUND

- 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 Seimens, 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

Tribelhorn, 1902 - 1919

Ref: en.wikipedia.org/wiki/Tribelhorn

The Henny Kilowatt, 1961

Ref: en.wikipedia.org/wiki/Henney_Kilowatt

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

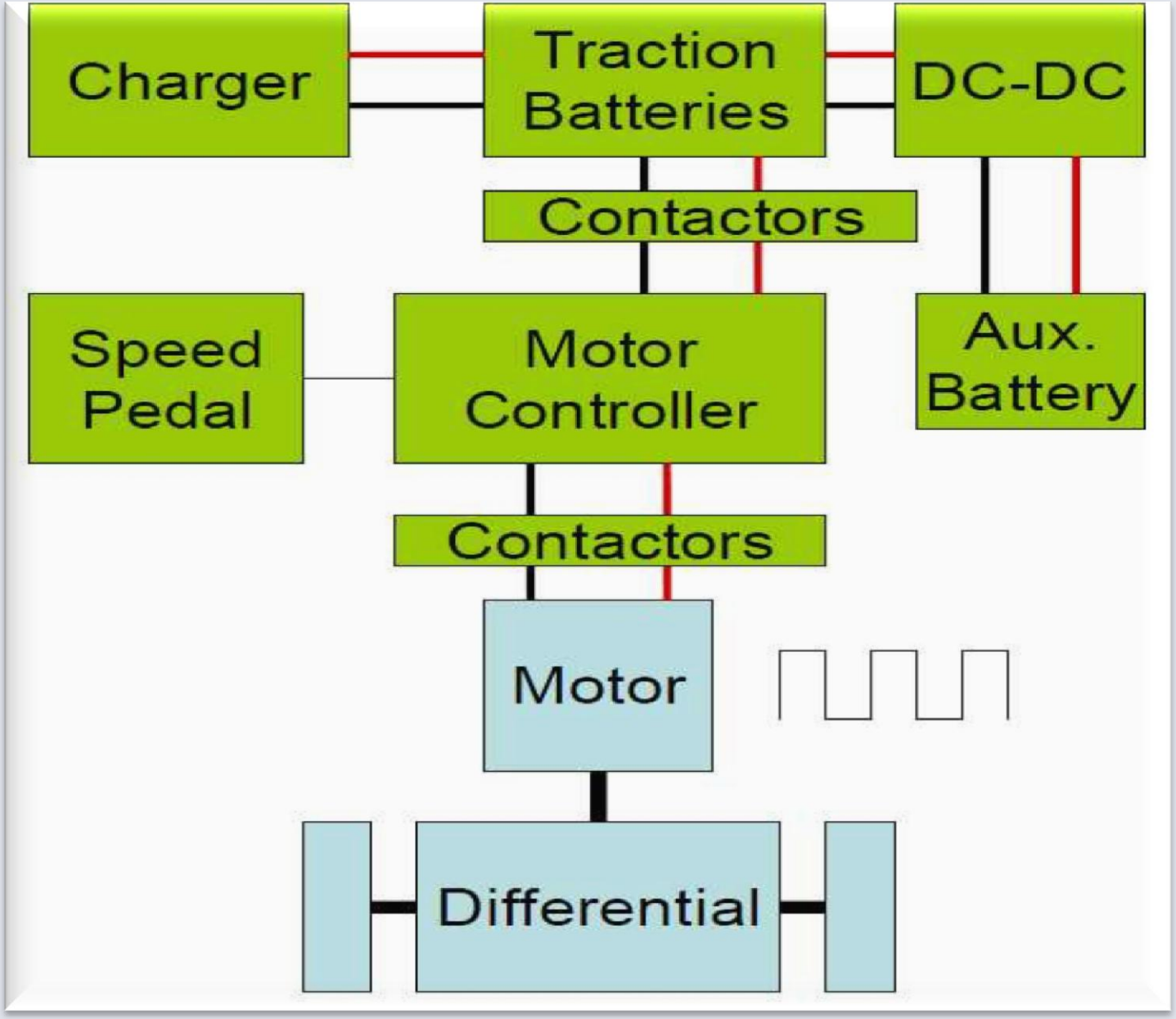
Ref: www.teslamotors.com/roadster

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



Courtesy: Oregon Electric Vehicle Association

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.

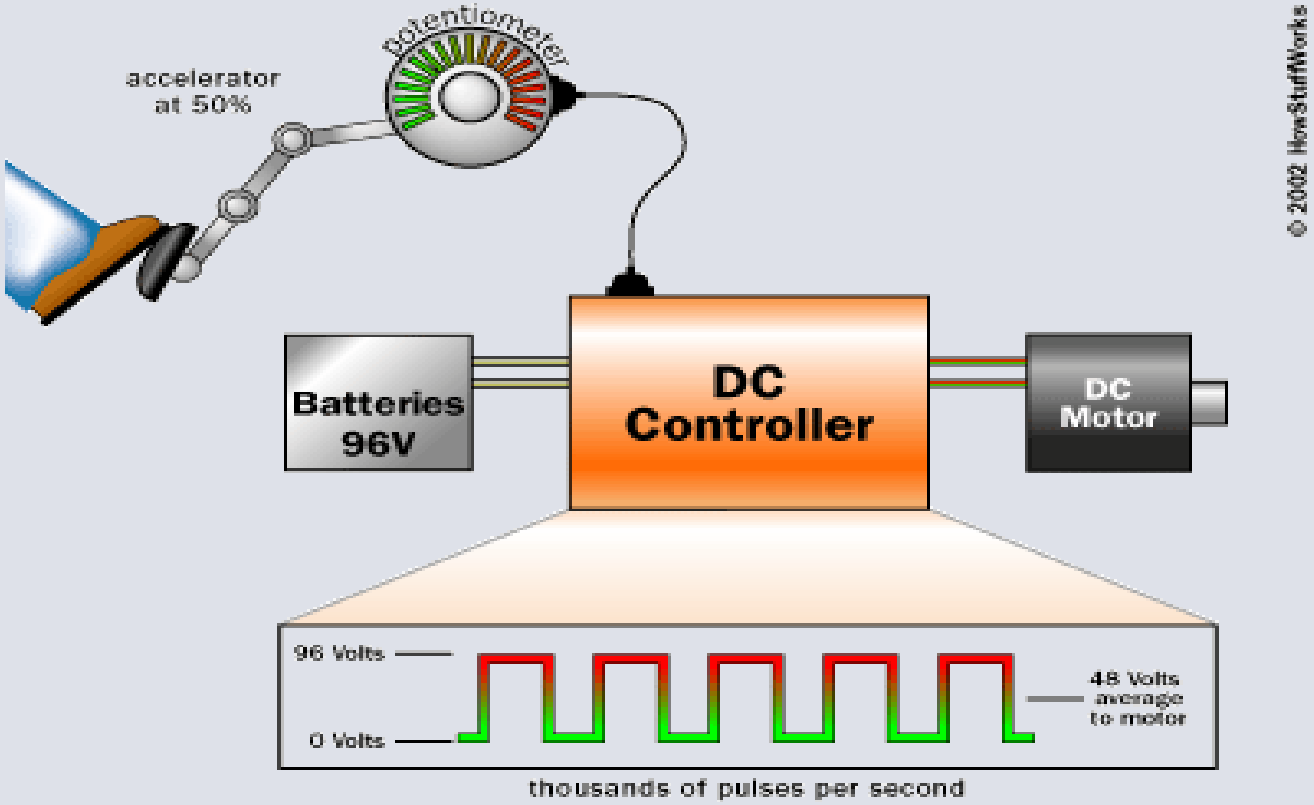
Forklift Motor

Courtesy: DIY Electric car blog

AC Motor

Courtesy: DIY Electric car blog

CONTROLLERS

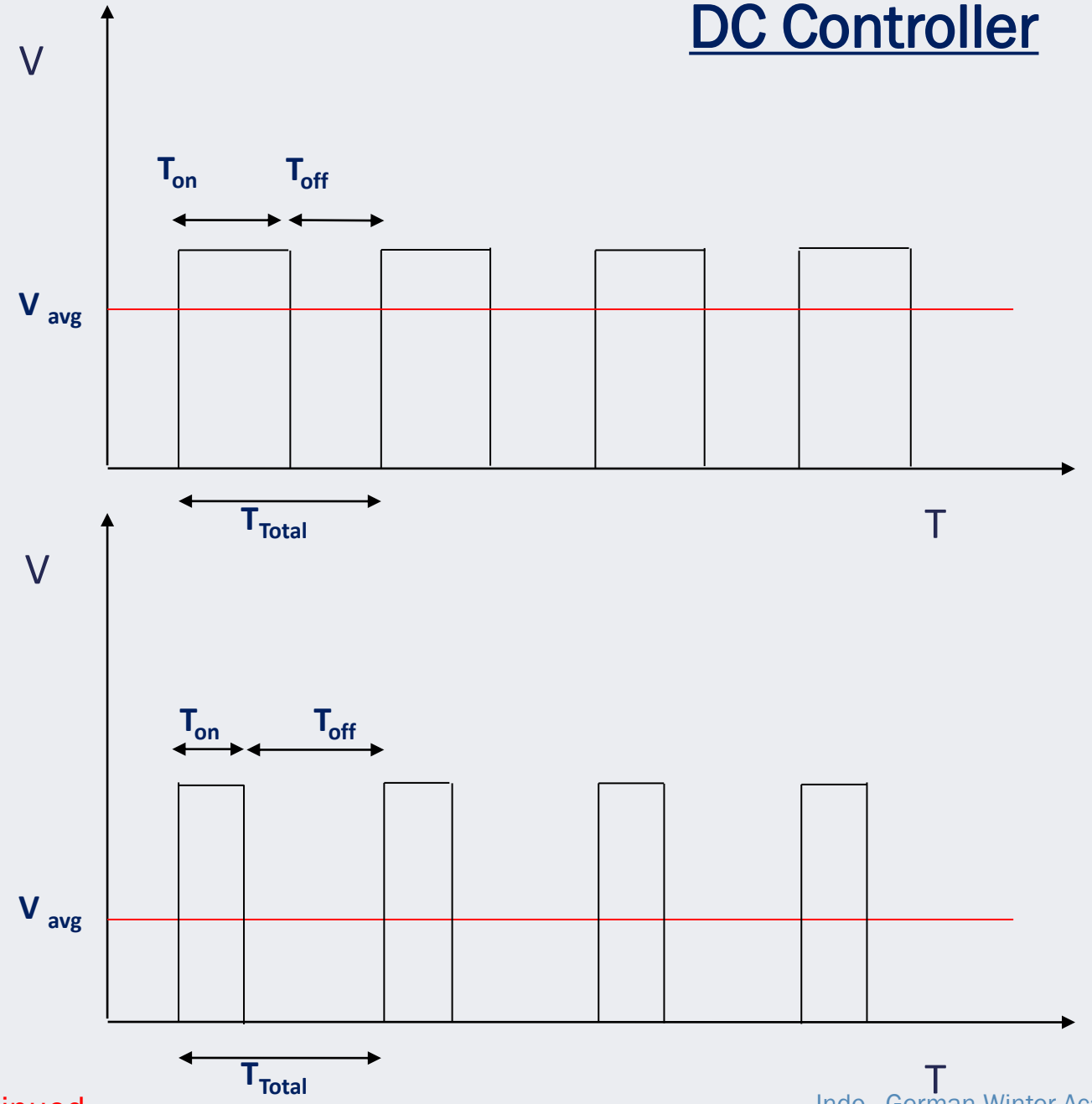


Courtesy. : howstuffworks.com

- The controller delivers a controlled voltage to the motor, depending upon potentiometer output.
- PWM controls the speed.

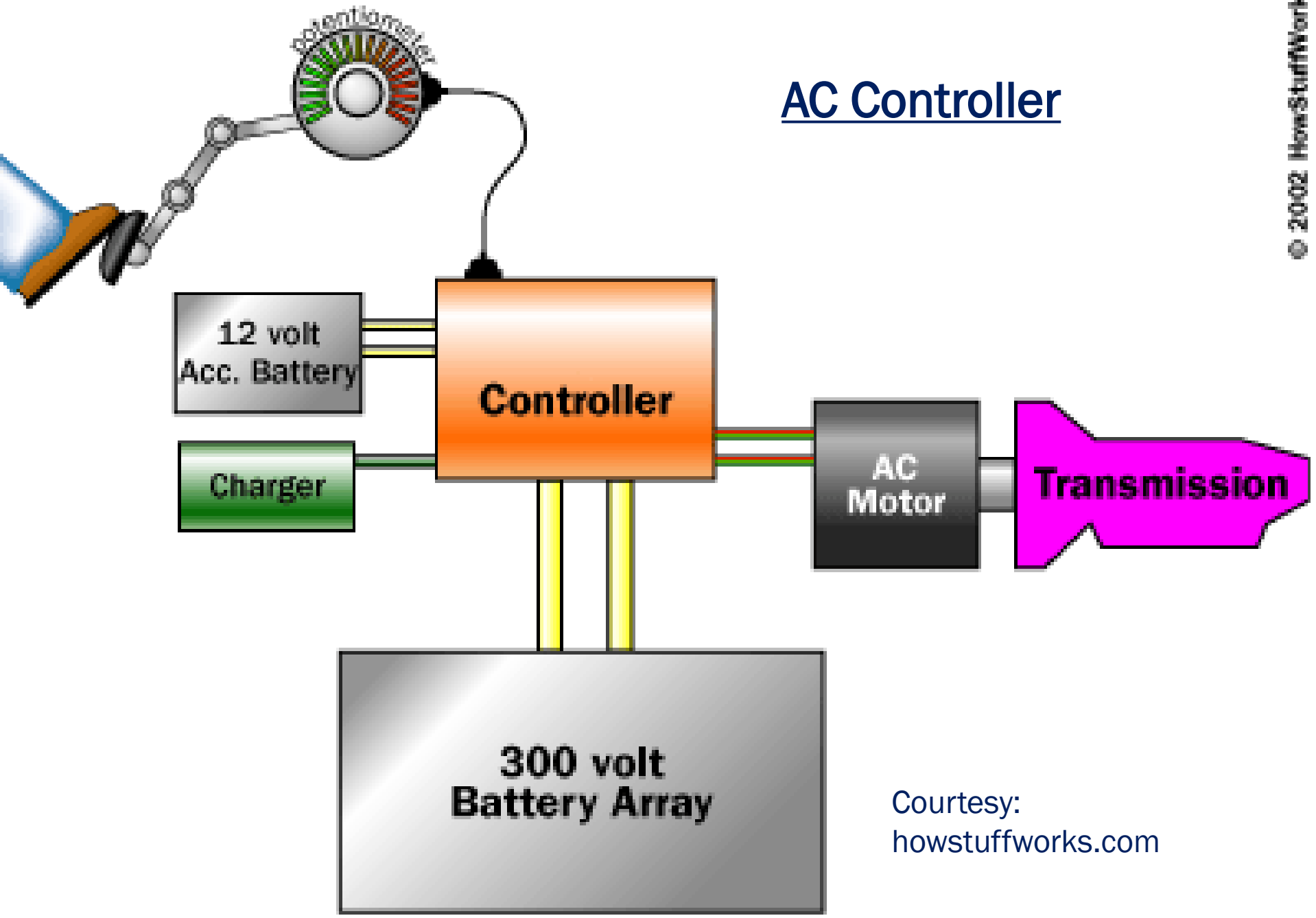
DC Controller

DC Voltage control using PWM



Controllers continued.....

AC Controller

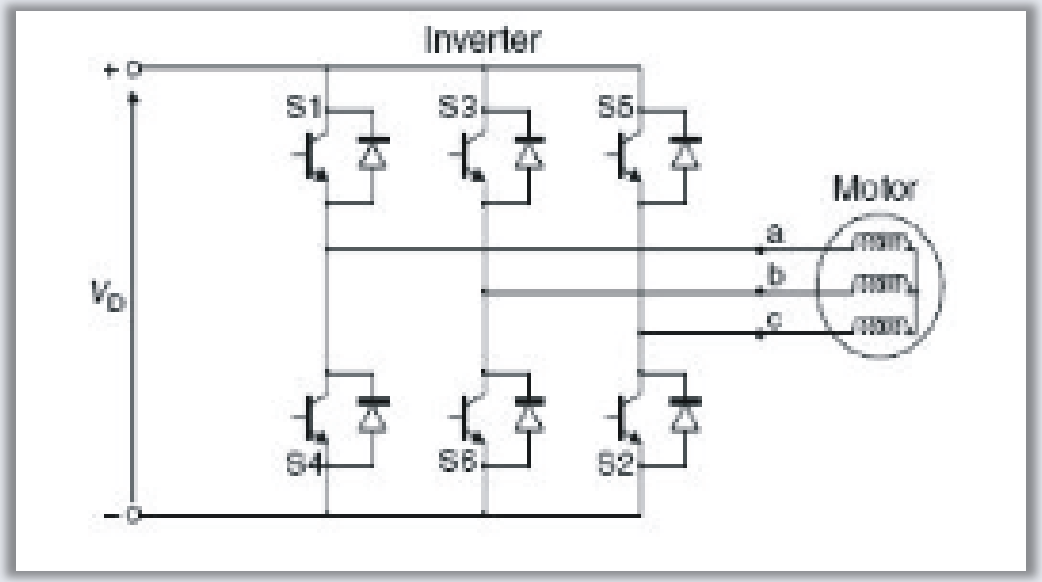


Courtesy:
howstuffworks.com

Controllers continued.....

AC Controller

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



A three phase inverter

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

BATTERIES AND CHARGERS

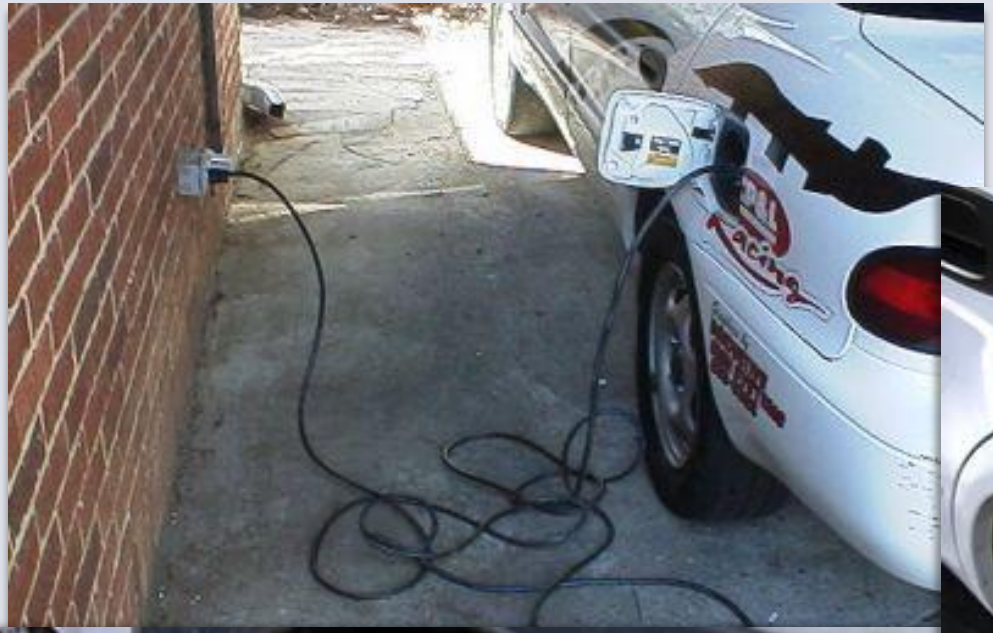
- Lead acid batteries used, until recently.
- A weak link in the electric cars.
- Heavy, Bulky, limited capacity (12 – 15 kilowatt hours), slow charging rate, short life and expensive.
- NiMH batteries give double the range and last 10 years, but expensive.
- Lithium ion and NiMH batteries likely to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

BATTERIES AND CHARGERS

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

Courtesy: en.wikipedia.org

BATTERIES AND CHARGERS



Courtesy:
howstuffworks.com

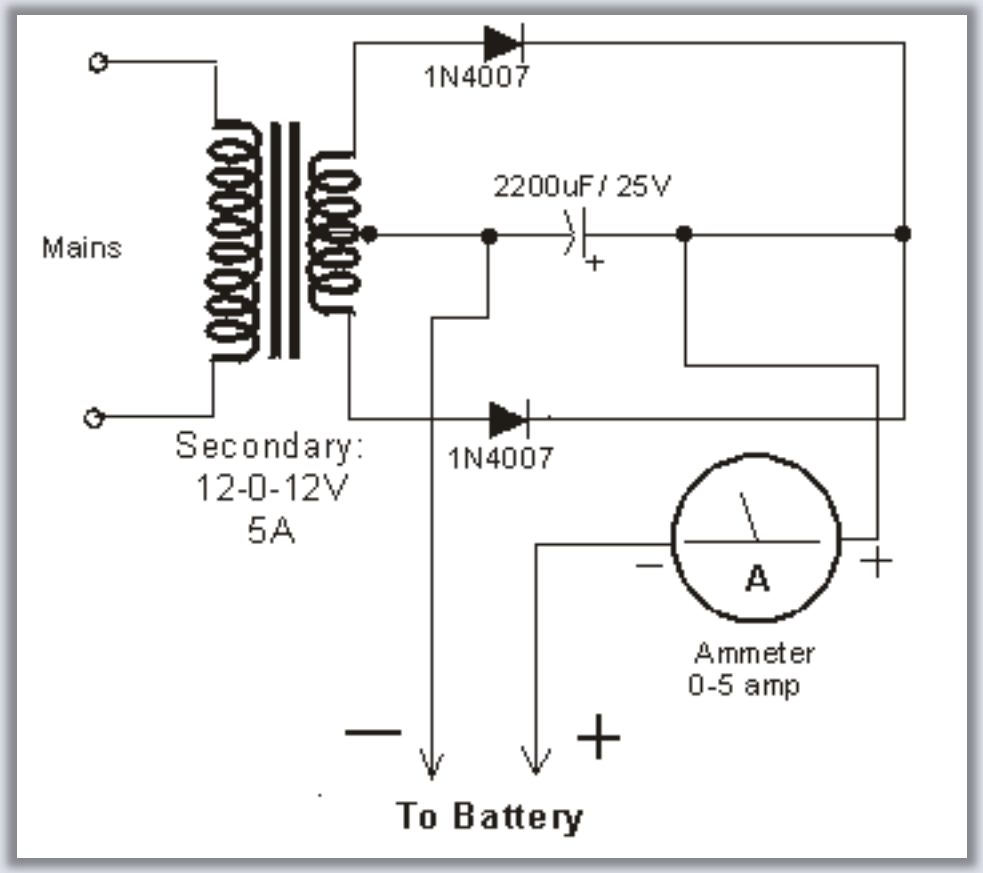
BATTERIES AND CHARGERS

- 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.

DeltaQ Charger
Courtesy: www.delta-q.com

Manzanita Micro PFC
Courtesy: www.manzanitamicro.com

Charger : Working



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

Batteries and Chargers continued.....

MAGNA-CHARGE SYSTEM

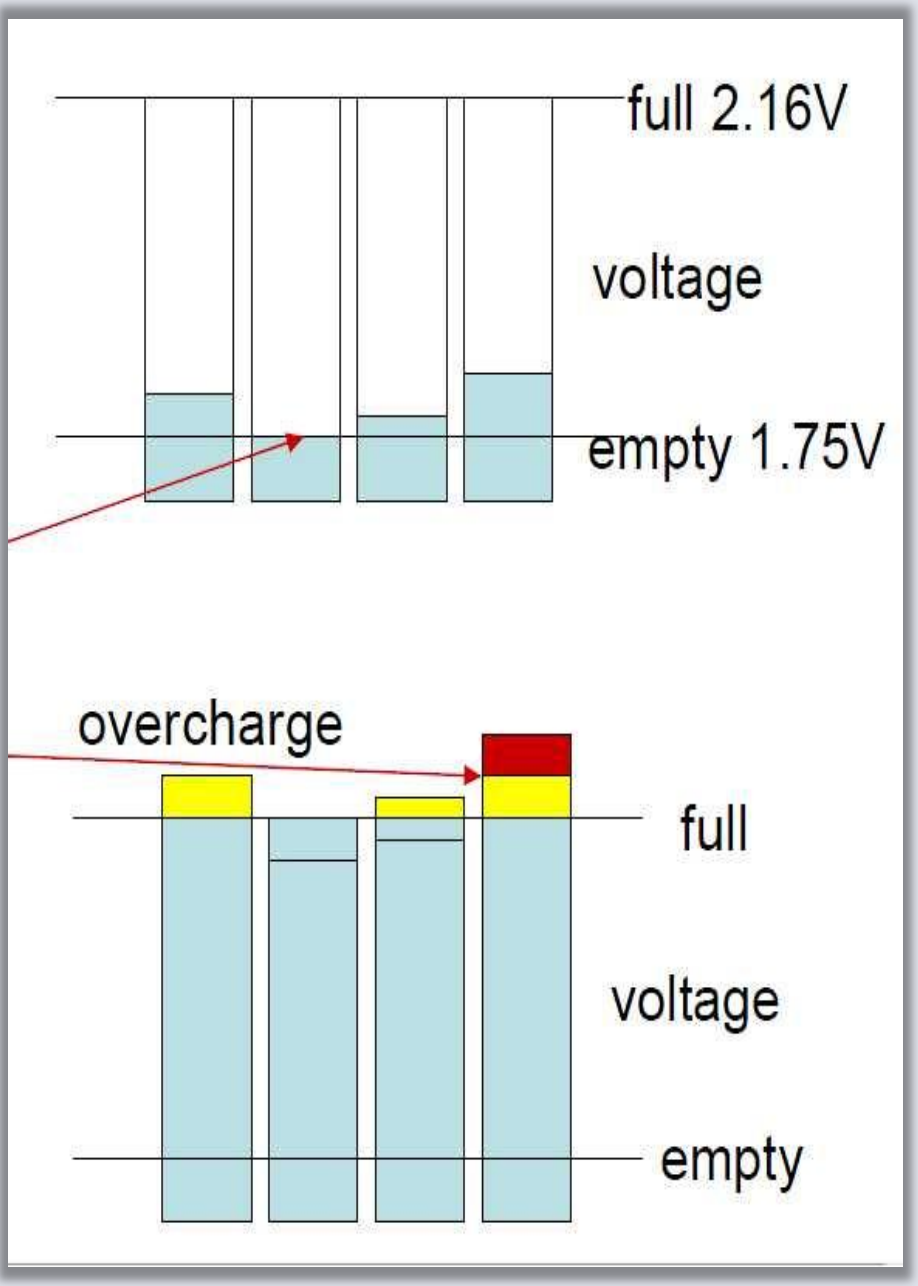
- Consists of two parts:
  - ✓ **Charging station mounted to a wall** : Sends electricity to the car through an ‘inductive paddle’. **One half of transformer.**
  - ✓ **Charging System in the trunk of car** : **Second half of the transformer.** Completed with inserting of the paddle.

Courtesy: howstuffworks.com

Batteries and Chargers continued.....

Equalizing

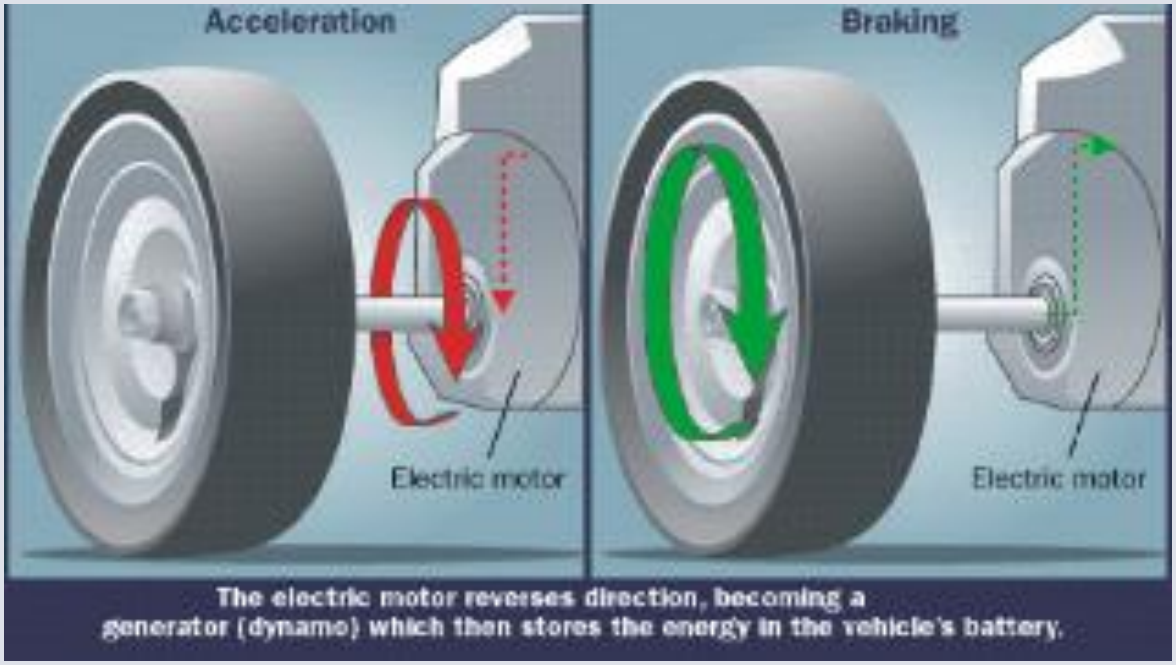
- An electric vehicle has a string of batteries.
- Closely matched, but not identical.
- Weaker batteries need more recharge.
- Weak battery gets weaker.
- Solution is “Equalizing”. Gently overcharge the cells to make sure that weakest cells are fully charged.



Batteries and Chargers continued.....

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.

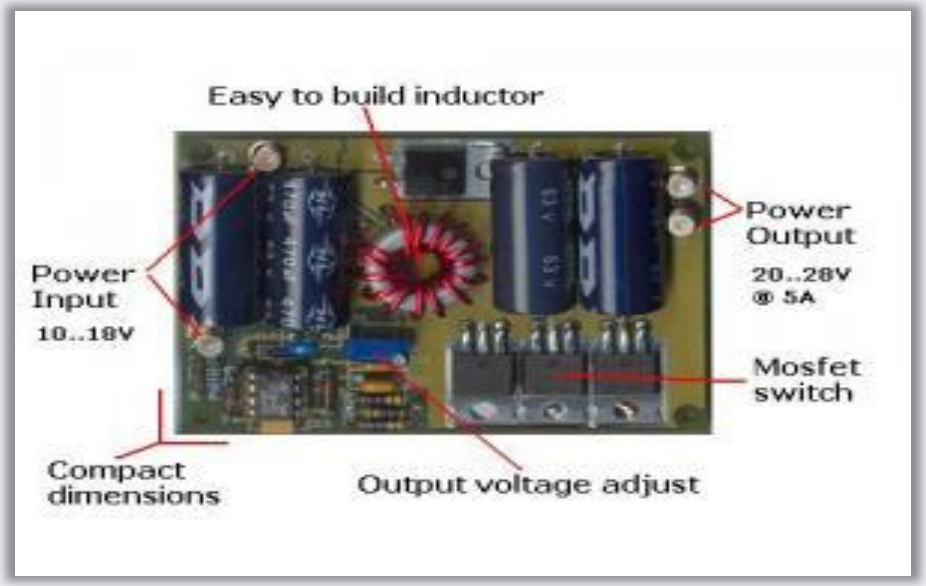


Courtesy:
howstuffworks.com

AUXILIARY BATTERIES AND DC-DC CONVERTERS

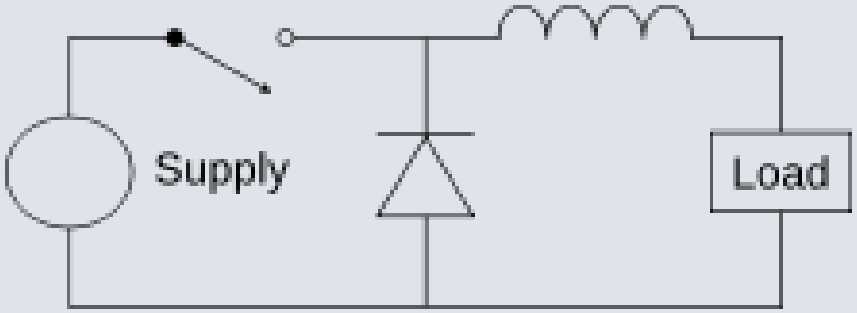
- A 14 volt battery which provides power for accessories, like headlights, radios, fans, computers, airbags, wipers, power windows etc. .
- Runs motor controller logic and power electronics.
- To charge the Aux. Battery a DC – to – DC converter converts the voltage from main battery array (say 300 volts)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

Courtesy:
http://www.coolcircuit.com

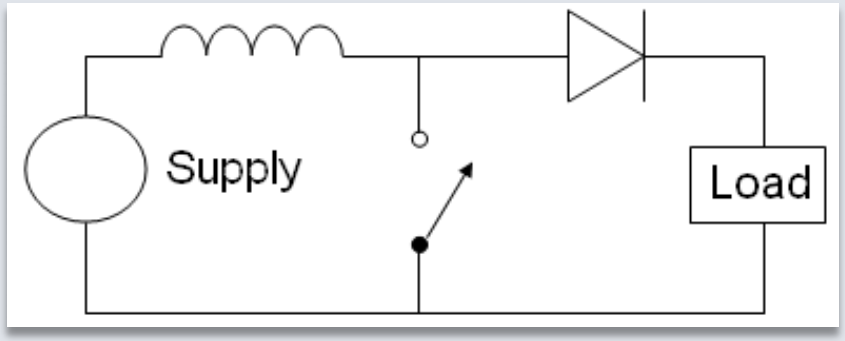


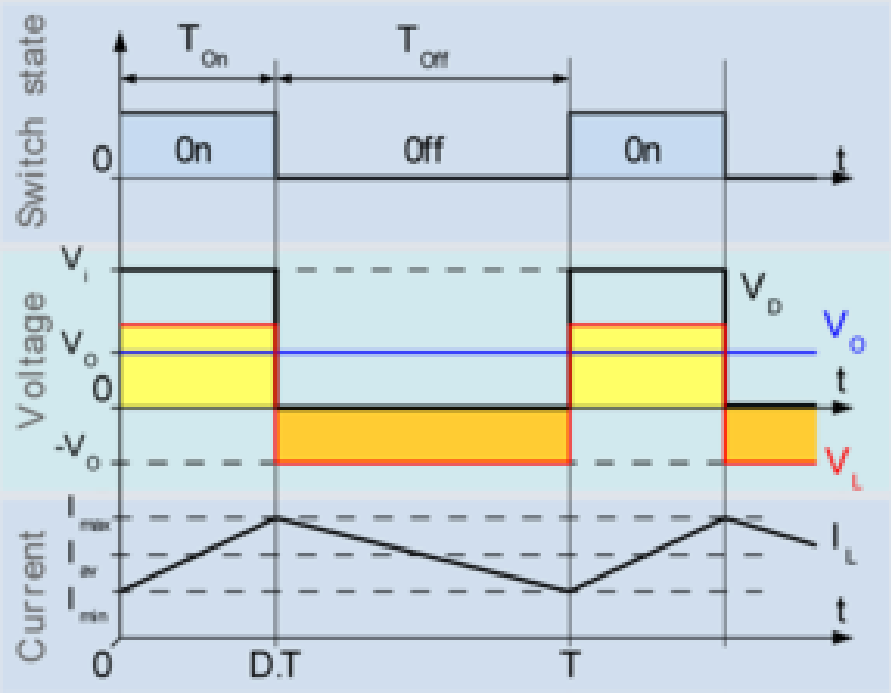
Typical converters used

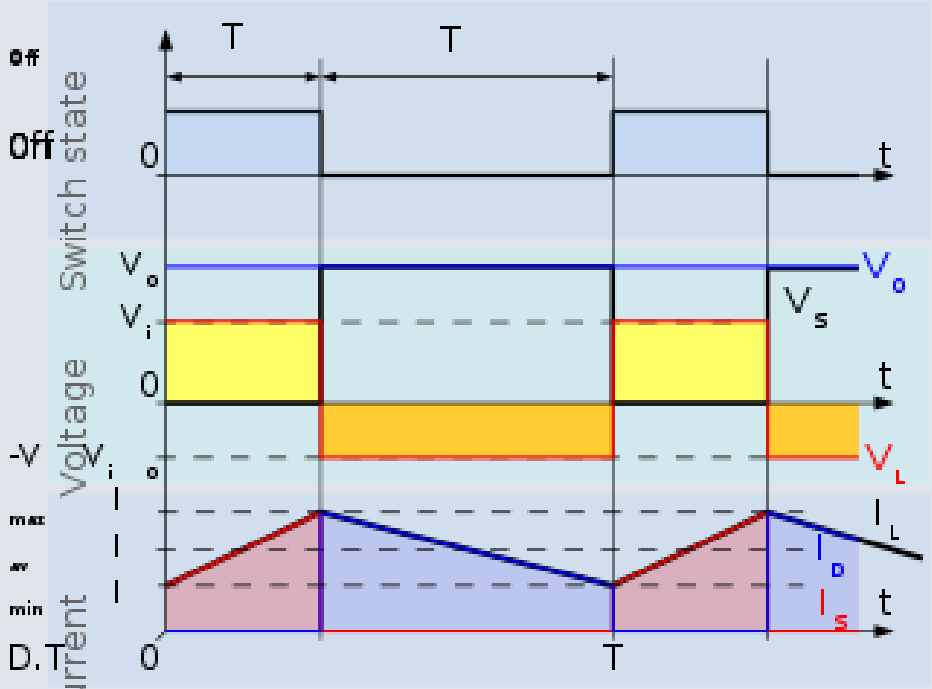
BUCK CONVERTER



BOOST CONVERTER







Courtesy: en.wikipedia.org

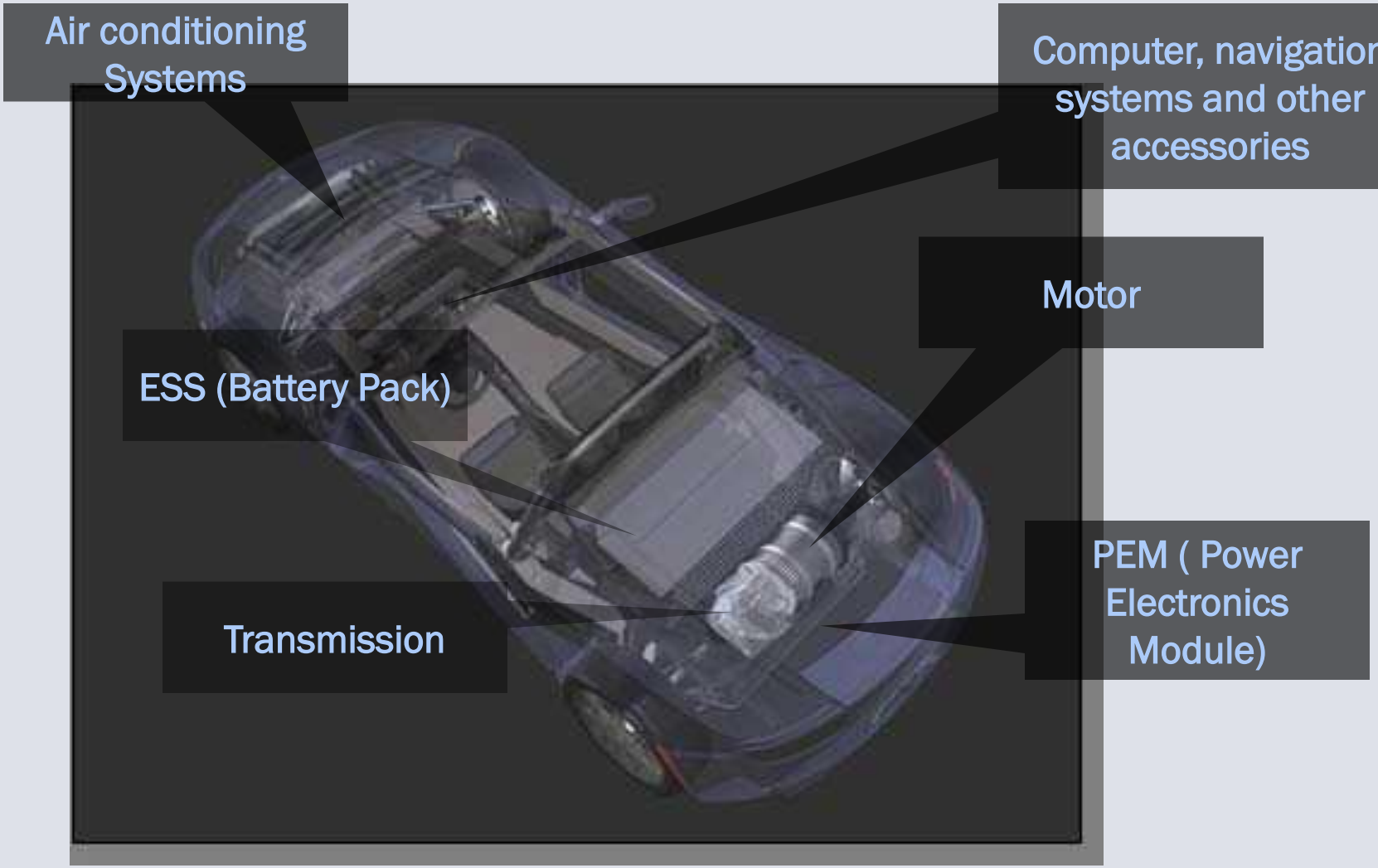
Continuous Mode

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

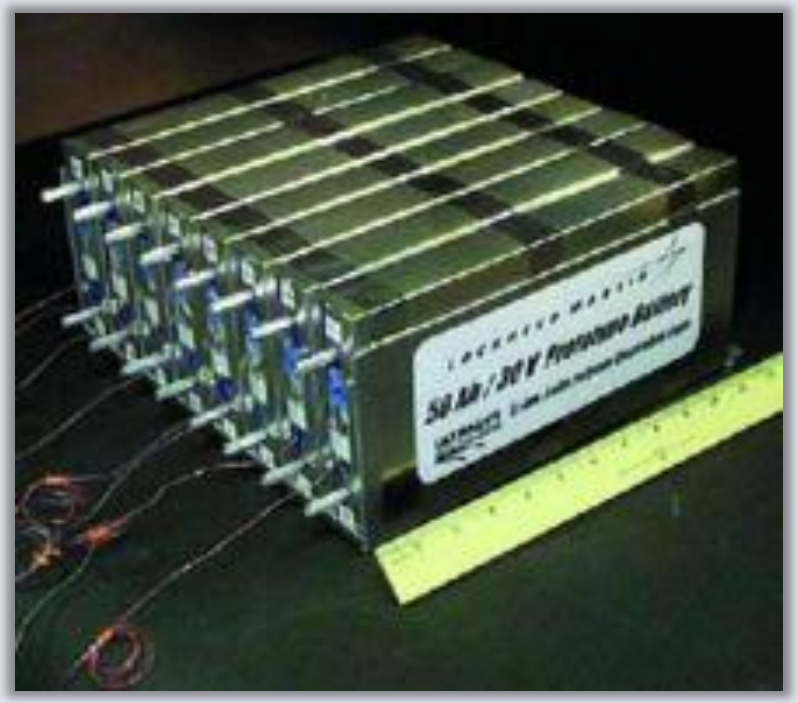
TESLA ROADSTER: VEHICLE ARCHITECTURE



Ref: Brian Randall Tesla presentation 2008

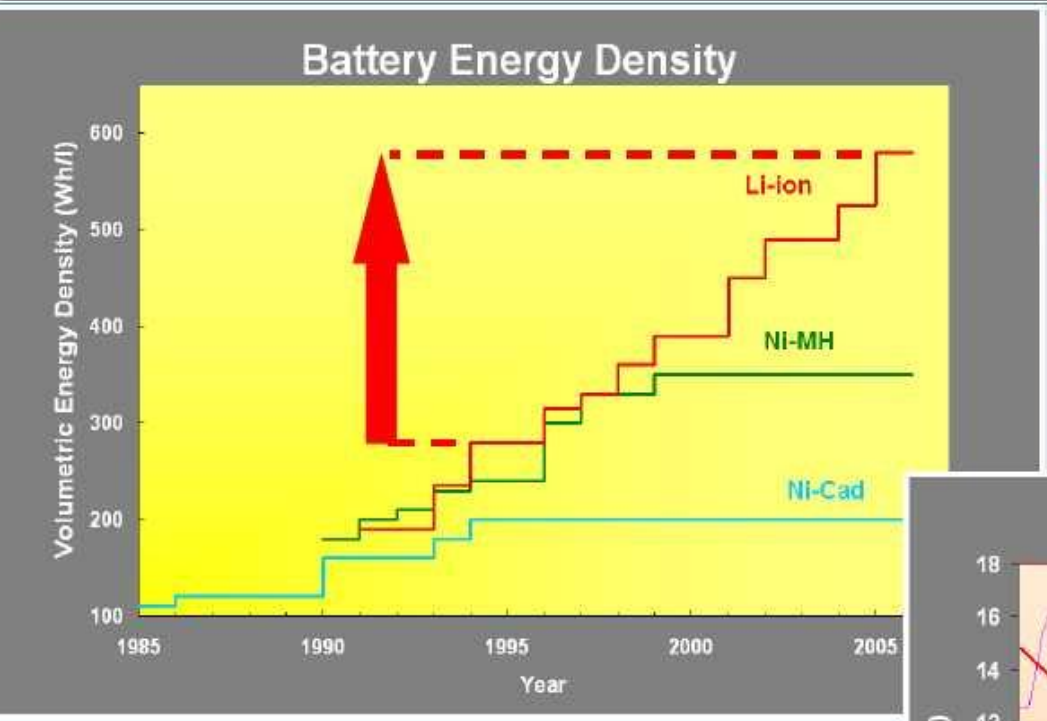
TESLA ROADSTER: ESS (BATTERY PACK)

- **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.**



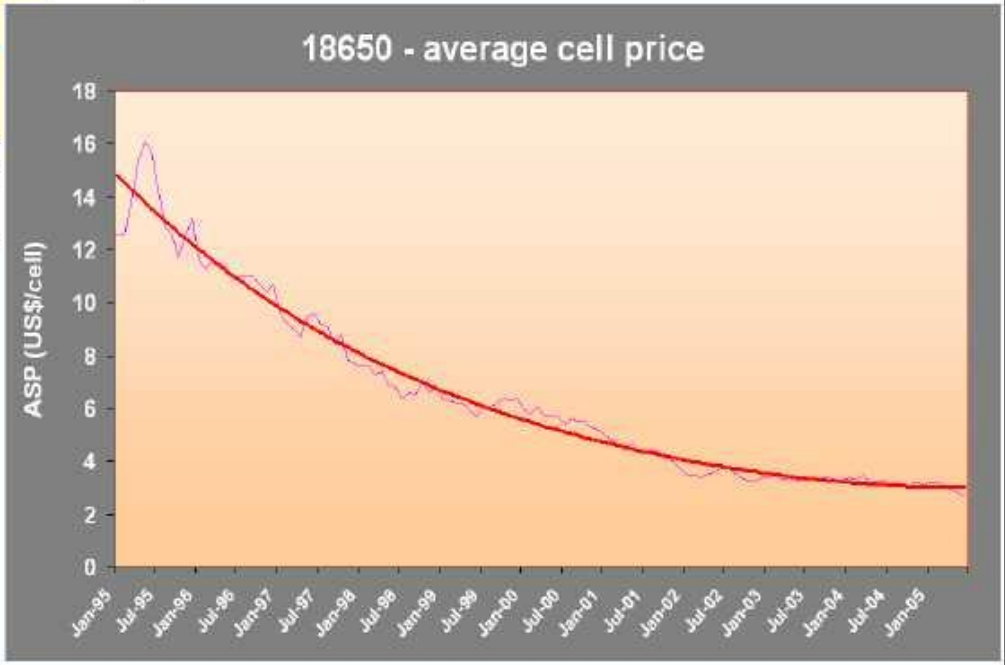
Courtesy: en.wikipedia.org/wiki/tesla_roadster

Courtesy: www.teslamotors.com



Double the density in 10 years

¼ the price in 10 years

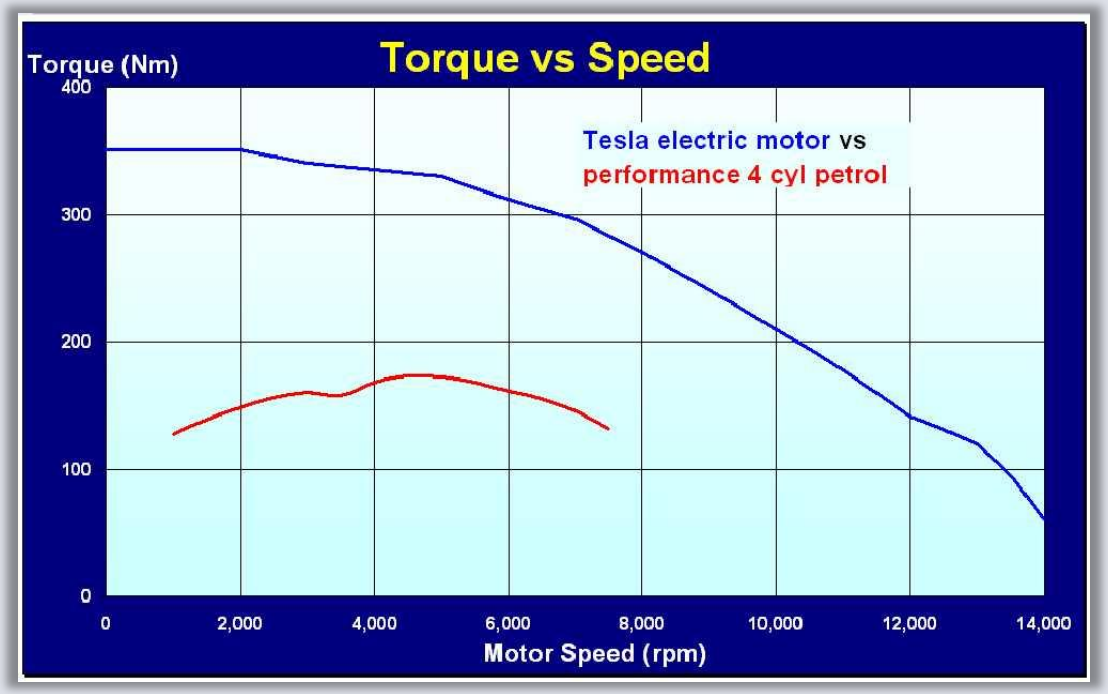


Ref: Brian Randall Tesla presentation 2008

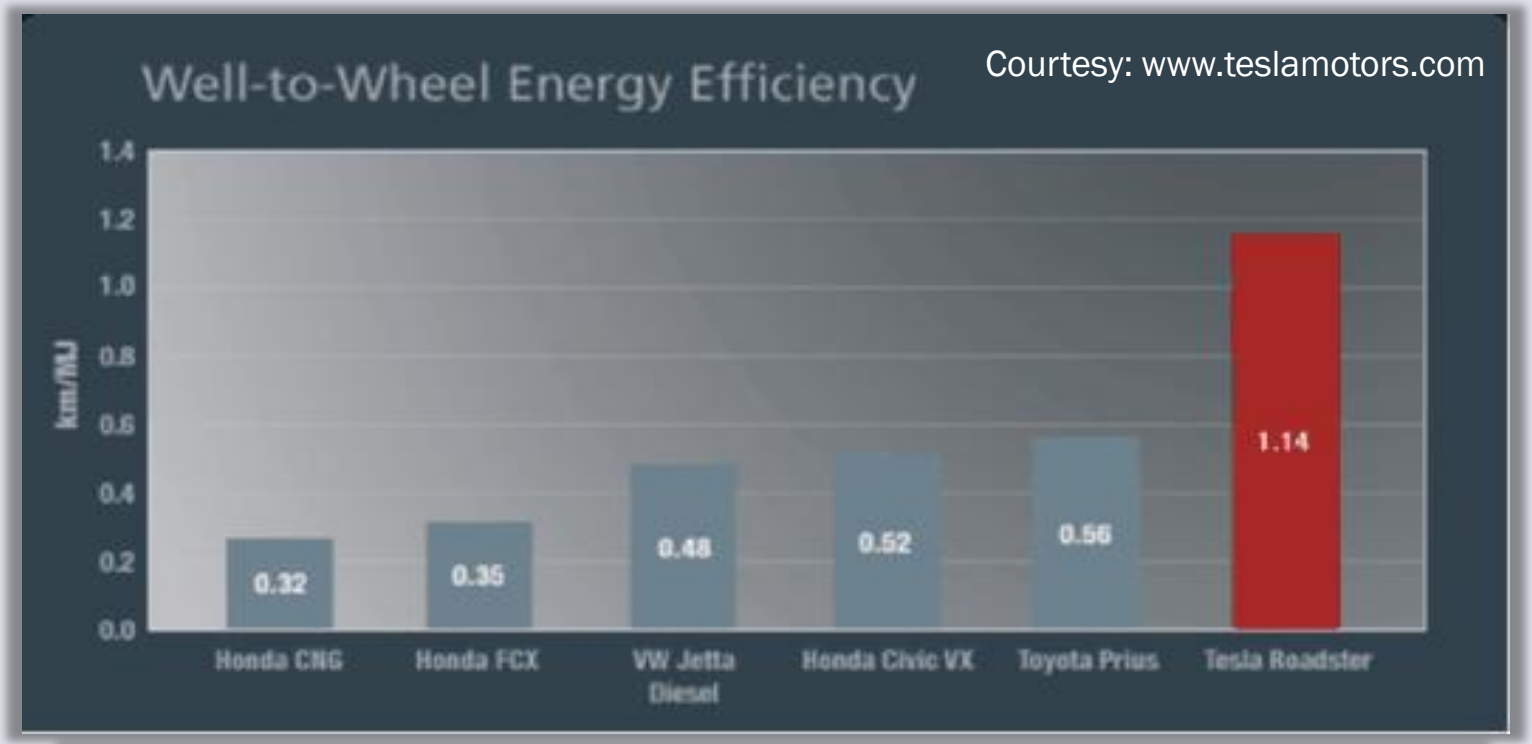
TESLA ROADSTER: MOTOR

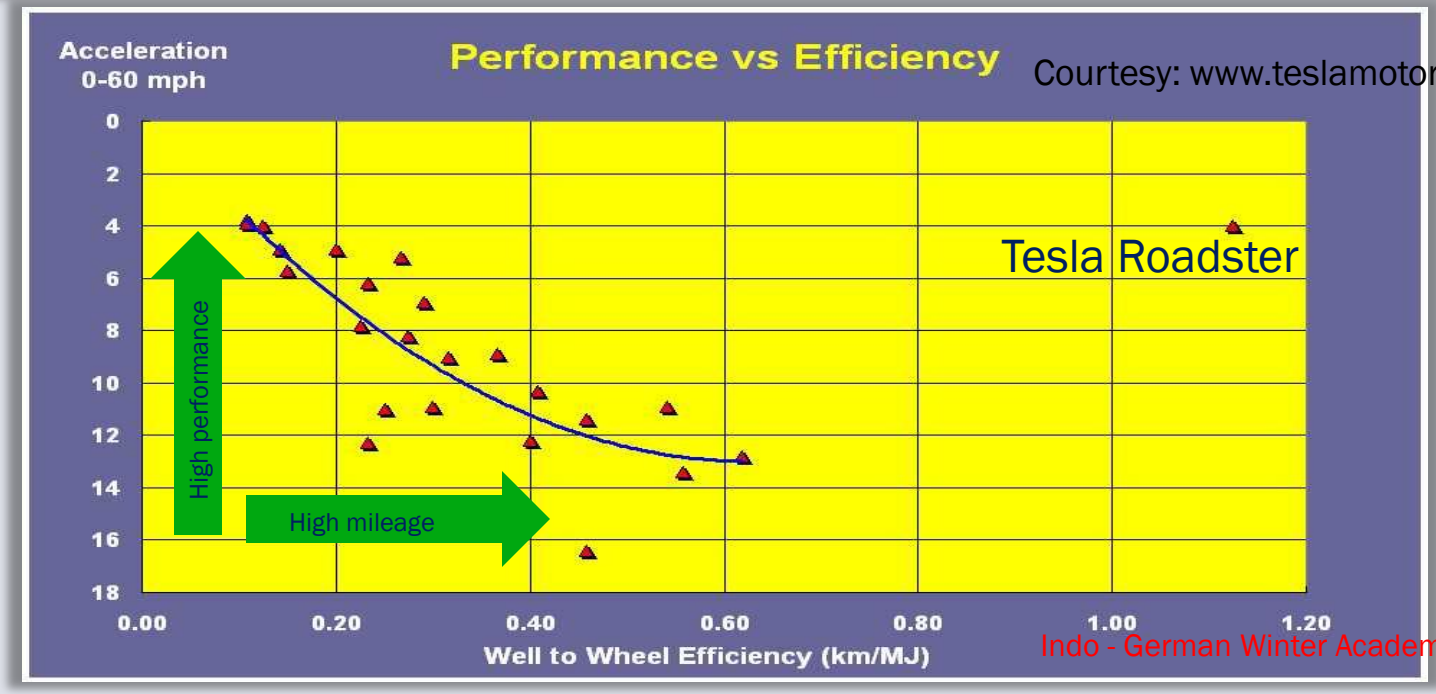
- 3 – phase 4 pole AC motor
- **Torque:** 273 lb-ft at 0 – 5400 RPM.
- **Horsepower:** 288 HP(215 KW) at 5000-6000 RPM.
- **Max Torque:** 350 Nm at 0 RPM (zero lag).
- **Max Speed:** 13500 RPM.

Courtesy: www.howstuffworks.com



Ref: Brian Randall Tesla presentation 2008

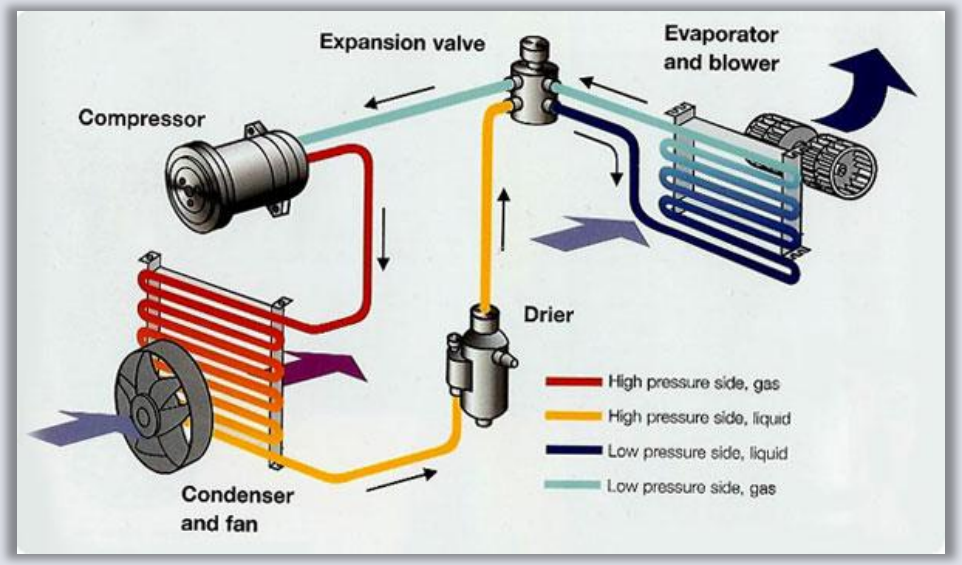

Well-to-Wheel Energy Efficiency
Courtesy: www.teslamotors.com
km/MJ
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.32
0.35
0.48
0.52
0.56
1.14
Honda CNG
Honda FCX
VW Jetta Diesel
Honda Civic VX
Toyota Prius
Tesla Roadster


Acceleration 0-60 mph
Performance vs Efficiency
Courtesy: www.teslamotors.com
0
2
4
6
8
10
12
14
16
18
Tesla Roadster
High performance
High mileage
0.00
0.20
0.40
0.60
0.80
1.00
1.20
Well to Wheel Efficiency (km/MJ)

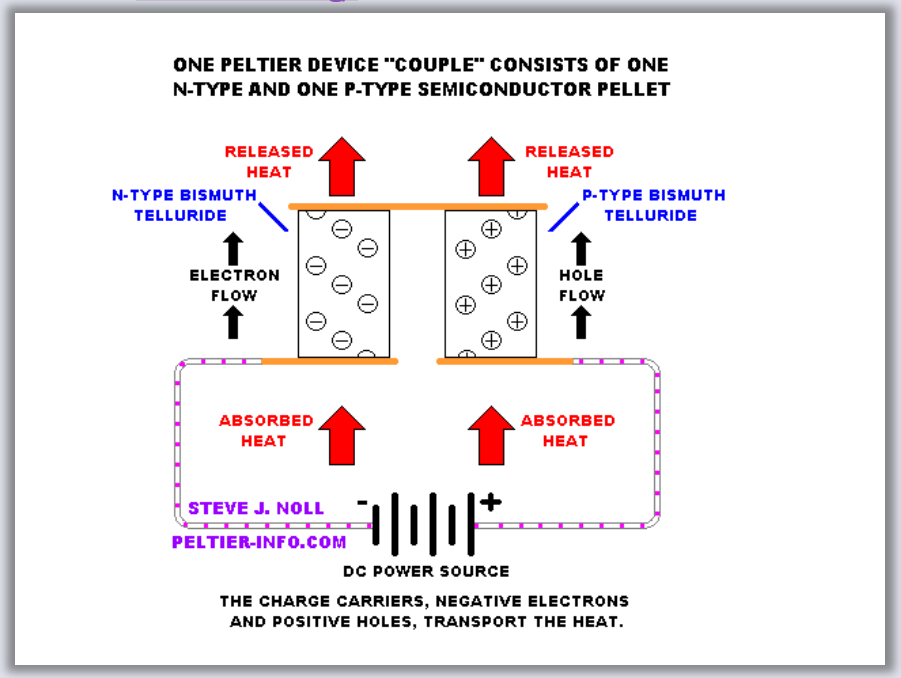
CHALLENGES AND FUTURE

- ***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***

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



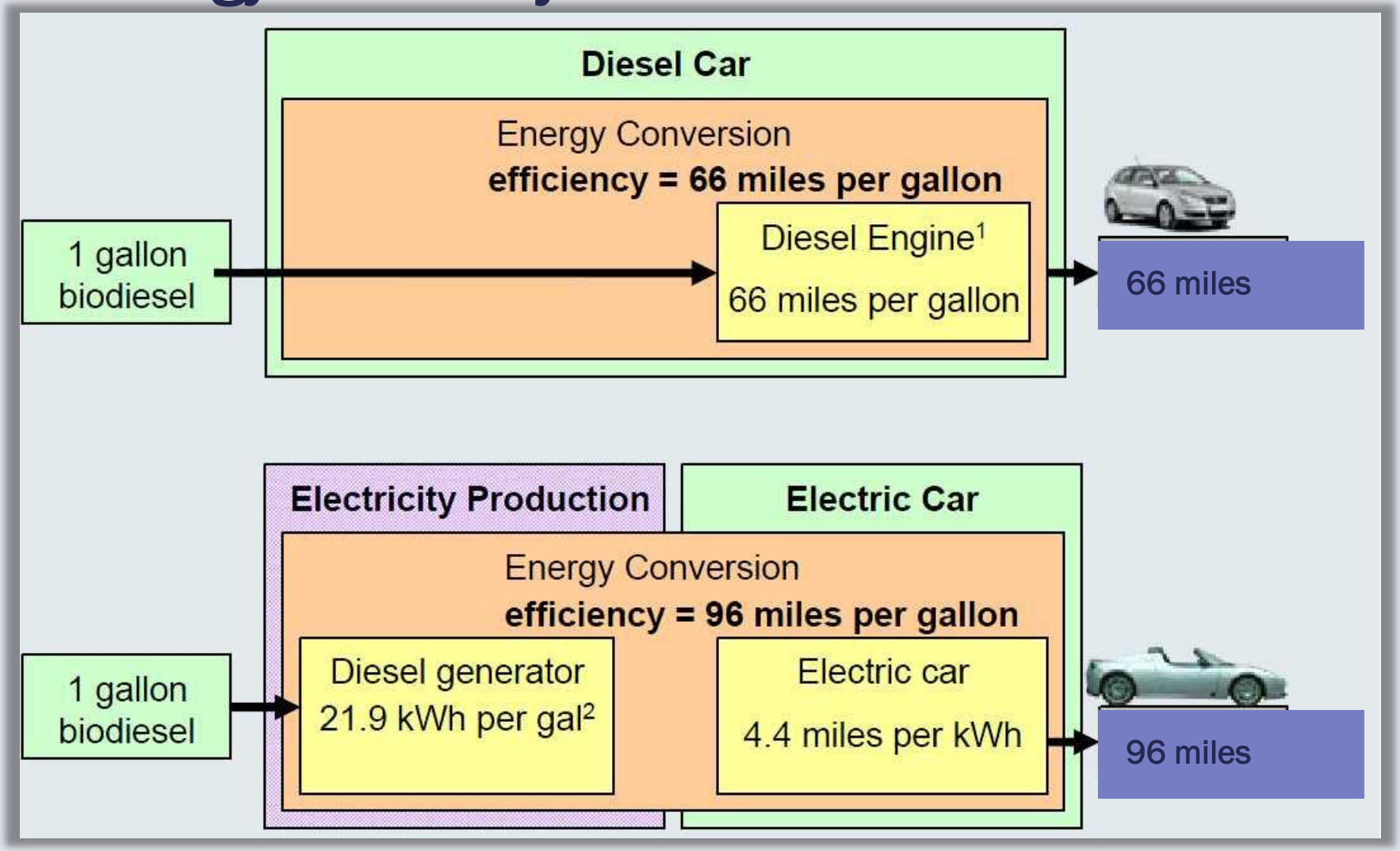
Ref: http://www.electric-motors-price.info/vehicle-air-conditioning/



Ref: http://www.peltier-info.com

Strengths

➢ Energy Efficiency



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
Courtesy: http://en.wikipedia.org/wiki/Electric_double-layer_capacitor

NASA G2 Flywheel
Courtesy. 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.
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- www.austinev.org/evalbum.
- http://www.peltier-info.com.

Questions ???

THANK YOU